WaterStrategyMan
EVK1-CT-2001-00098

DELIVERABLE D1

THE RANGE OF EXISTING CIRCUMSTANCES

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August 2002

Contents

1. Introduction

This deliverable summarises key issues relating to the availability, demand and management of water in the selected countries (Spain, Portugal, Italy, Israel, Cyprus and Greece). Although a survey conducted on country level can only give a crude picture of the overall situation, this report is aimed at identifying typical issues in water management in Southern Europe.

It provides the basis for selecting representative regions and for the formulation of specific principles and targets for the paradigms to be identified. The following issues will be discussed in detail.

- Identification of water availability, use patterns and water shortage conditions in Southern Europe
- Analysis of existing institutional and legal frameworks in water deficient regions
- Identification of the existing water management policies and their compatibility with the targets of integrated water management and a sustainable use of the resource

Based on this information a set of representative regions are to be selected in the countries participating.

This deliverable is organised in the following way: The first section briefly describes water availability, water quality and institutional frameworks with regard to water management in the countries in Southern Europe. The key issues with regard to management approaches and the responses to the driving forces imposed by a water deficit are described in the next section. Section three gives a brief summary of the key issues. Individual country reports provided by the case study groups in the project are supplied in the appendix.

It must be noted that the analysis paradigms in the regions are part of deliverable D4 and D5. The regional information is therefore not included in this report.

2. Key Issues in Water Management

1.1 Introduction

Aridity is commonly described using the UNESCO moisture index that was defined in 1979 to classify regions according to their available water resources (UNESCO World Map of Arid Zones, 1979). It is defined as the average annual precipitation *P* related to the potential evapotranspiration *PET* obtained by the Penman Monteith formula.

Depending on this index four classes have been identified:

- Hyper-arid zones (P/PET < 0.03). Deserts in the strict sense of the term.
- Arid zones (0.03 < P/PET < 0.20). Sub-deserts or semi-deserts
- Semi-arid zones (0.20<= P/PET < 0.5). Steppes, prairies, certain types of savannah and a large part of the Mediterranean vegetation. These are zones where precipitation varies greatly from year to year
- Sub-humid zones (0.5 < P/PET < 0.75). The limits between these zones and the wet and semi-arid zones are highly variable and subject to fluctuations

It must be noted however that aridity cannot be seen per se as a pressure on water resources because aridity itself does not describe a demand for water. There are many situations where the aridity index is very low but the water demand and hence the pressure on water resources does not exist.

1.2 Water availability

Long-term annual average rainfall values on country level are depicted in Figure 1. As can be seen, average annual rainfall ranges from 400mm per year in Greece and Israel to more than 800mm in Portugal and Italy. These figures however may be completely misleading as they do not account for both temporal and spatial variations of rainfall. In Israel, for example, rainfall is around 400mm on average but ranges from only 30mm to more than 700mm.

The average yearly precipitation in Portugal is about 960 mm, varying from more than 2000 mm in the northern region to less than 600 mm in Guadiana's basin.

The temporal pattern of rainfall in all regions is strongly seasonal with most of it coming in two seasons.

Potential evapotranspiration ranges from some 400mm in Italy to more than 1600mm in Cyprus. Again, the figures may be misleading since they do not account for the variation in time and space (Figure 1).

Based on the figure given above and the definition of the aridity index, the countries participating can be classified as follows (keeping in mind the flaws of average figures:) Greece and Cyprus are semi-arid countries with the aridity index being 0.4 and 0.3 respectively. All other countries are semi-humid countries with aridity indices between 0.5 in Italy, 0.6 in Israel and Portugal and 0.7

in Spain. The situation looks entirely different if the selected regions are considered (see deliverable D4 and workshop proceedings D3).

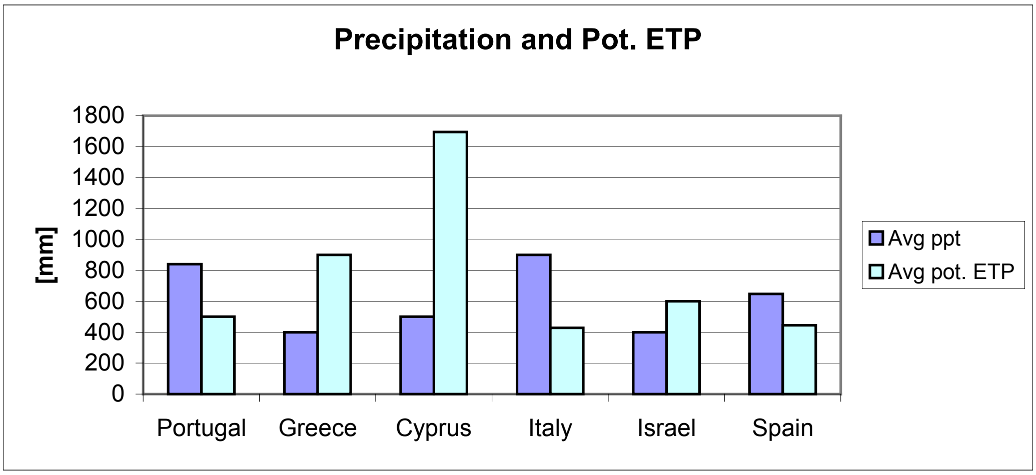

Figure 1: Long-term average values of annual precipitation and potential evapotranspiration

1.3 Water use

With regard to the use of water, the most striking characteristic in the regions in Southern Europe is the dominant use of water for irrigation purposes (Figure 2). With Italy being the only exception the share of water used for agriculture is more than 50 per cent in all countries. It accounts for 80% of the water demand in Spain, 85% in Greece , some 70% in Cyprus, 47% in Italy, 35% in Portugal and 57% in Israel.

On a country-wide scale, the water used for tourism plays a minor role. However, the pressure that this demand is exerting on the resource in some regions is considerably high. Water demand trends on a country-wide level are not discussed here but the demand is steadily increasing in most of the regions. As well as the availability of water the demand is highly dependent on the season.

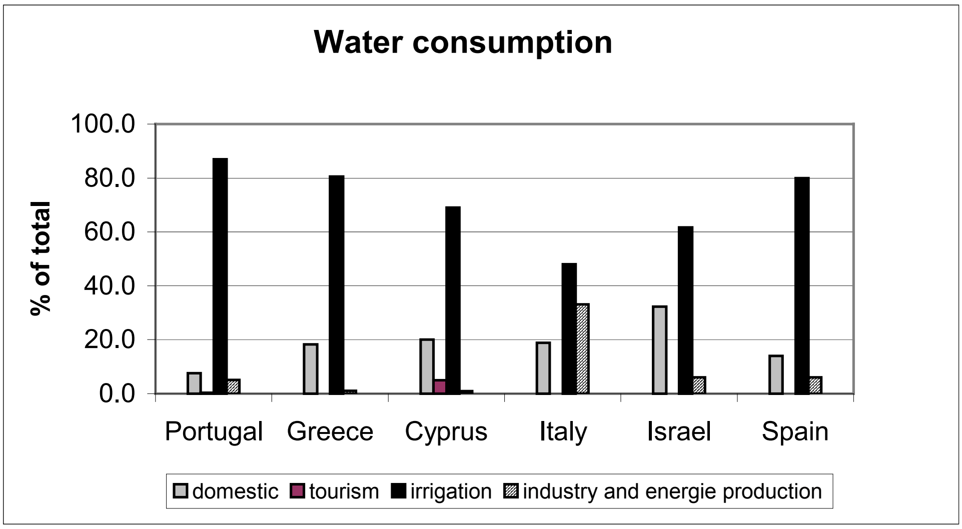

Figure 2: Water use per sector (county level)

1.4 Water quality

Water quality problems are one of the major problems in all regions.

The quality of groundwater resources is deteriorating for two main reasons. In areas with intensive agriculture, agrochemicals such as nitrates and pesticidesare the main pollutants (in Cyprus, the North of Italy, and Spain). In addition, seawater intrusion and the resulting salinity plays an important role in regions where the groundwater from aquifers close to the sea is abstracted in excess of its recharge rate so that the water table is continuously lowered. Particularly, seawater intrusion is evident in Cyprus, Spain and in the coastal aquifer of Israel.

The quality of surface water is generally weak in areas where untreated waste water is discharged into the river system. The number of people connected to waste water treatment plants (WWTP) is low (only 45% in the Thessaly region of Greece) and the capacity of the existing WWTP's often do not suffice for the polluted charges.

1.5 Institutional Framework

Although the institutional framework with regard to water management is not comparable within the countries, there are a couple of common issues. These commonalties can be summarised as follows:

- A competency and institutional overlapping hampers the efficient implementation and enforcement of legislation related to water resources
- The decision making process is generally long and tends to be over-bureaucratic
- conflicts related to transboundary management of water resources; examples are the shared rivers between Portugal and Spain and the utilisation of the mountain and coastal aquifers between Israel and the Palestinian Authority
- a lack of water management plans and other efforts which are required for implementation of the Water Framework Directive (WFD) and other provisions by the EU legislation.

2.1. Pricing policy

The price of water used for domestic purposes varies considerably across the regions. The average household budget for domestic water is for example about €100 in Cyprus, some €231 in Greece and €350 on Canary Islands (Spain). A common issue in all regions is price and the average household budget for water used in agriculture respectively which tends to be much lower than for domestic uses due to heavy subsidies.

Prices for domestic use of water are some 0.34US$ in Israel, whereas agricultural users pay between 0.07 to 0.37 US$ per m^3. Cost recovery, one of the basic principles of the WFD with regard to economical analysis, is poor in most regions. In Portugal it ranges from 23% in Guadiana to 40% in Riberas do Algarve.

3. Countries participating

In total, thirteen water deficient regions in six countries (Greece, Italy, Israel, Spain, Portugal and Cyprus) have been presented. The selected regions are depicted in Figure 3.

It has been agreed that Israel, although initially considered as one region, should be studied on the basis of two regions within the country. The reason for this is that the range of existing circumstances in the country is too wide to be used for the purpose of the case studies.

Figure 3: Selected case study regions in the seven countries

4. Main questions addressed by the project

The Water Strategy Man project is primarily aimed at developing and evaluating water strategies for water deficient regions in Southern Europe. There are four specific goals of the project:

- A review of existing approaches in terms of Integrated Water Resources Management (IWRM), demand management, sustainability indicators and development strategies,
- The study of the differences between water quantity and water quality with regard to water management,
- The highlighting of the importance of the regional and cultural context and
- The development of alternative IWRM options and long-term scenarios for water deficient regions.

The project has a duration of 3,5 years and consists of four phases: The first phase (diagnostic phase) will identify a set of representative regions in Southern Europe and will define representative paradigms for water deficient regions which will form the theoretical framework for developing analysing and evaluating water management options.

At the end of phase one, six water deficient regions will be selected and conceptualised as paradigms.

In phase two (analysis phase) a consistent methodology for analysing and evaluating different water allocation scenarios and water management options will be developed that will encompass the entire range of the selected paradigms.

The strategy formulation phase is aimed at comparing and identifying appropriate plans, actions and policies that apply to the paradigms.

The main objective of phase four, the synthesis and dissemination phase is the synthesis of the results from the previous project phases. Based on the six identified paradigms, widely acceptable guidelines and protocols are to be formulated in order to implement the European Water Framework Directive (WFD) timely and efficiently. The WFD essentially aims at improving the quality of aquatic ecosystems and at basing the utilisation of water resources on the principle of sustainability.

Each of the four project phases is organised in several work packages. Their structure in interdependence in the project is depicted in the following figure.

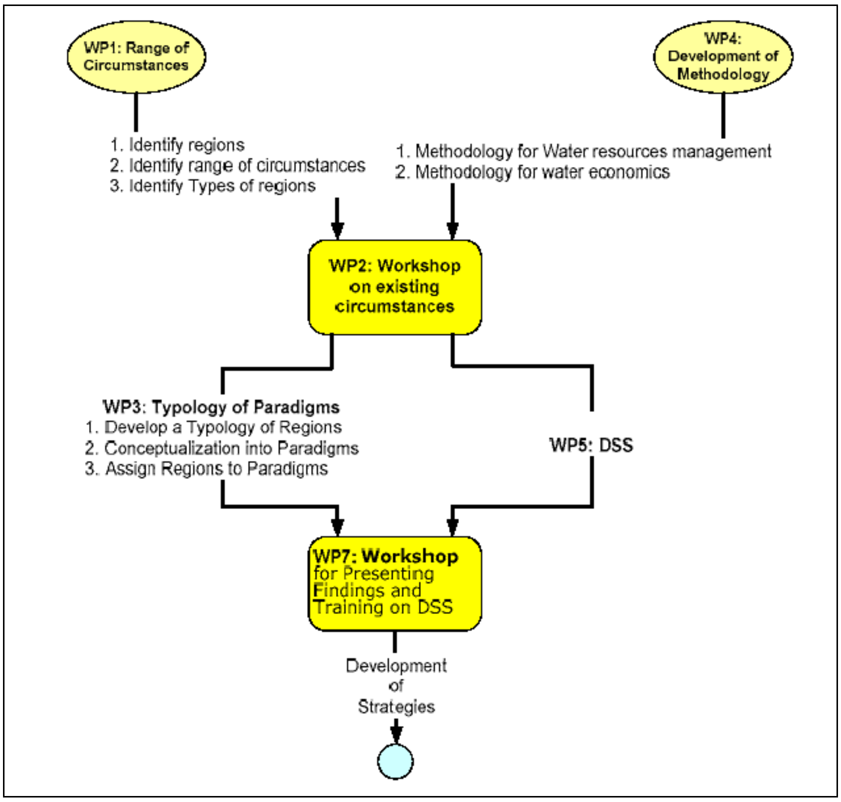

Figure 4: Structure of the work packages and their interaction

5. Summary of country reports

The summary of the key issues in water management in the countries is classified according to the DPSIR approach

The Driving force-Pressure-State-Impact-Response (DPISR) model is an extension of the PSR model and was developed in the 70s by Anthony Friend. The approach has been adopted by the EEA.

Drivers can be for example the economic activities in the country and its spatial distribution as well as the market prices for fuel and transport.

Pressure indicators describe the parameters that directly cause environmental problems. Examples are toxic emission, heavy metal pollutants, etc.

Impact indicators describe the ultimate effects of a change of the state. Examples are the number of people affected by polluted drinking water etc.

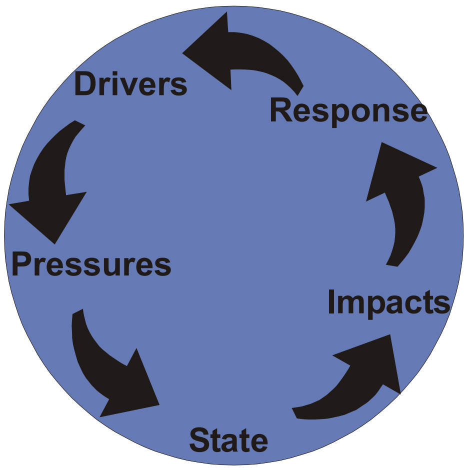

Figure 5 DPSIR model used by the European Environment Agency

In brief the following drivers, pressure, state impacts and responses can be identified for the countries participating:

Driving forces

- Precipitation is highly variable in time and space; aridity
- Intensive agriculture is the dominant water user
- Competing users (tourism and agriculture)
- Increasing demand

Pressures

- High dependence on rainfall
- Limited natural supply

- Dependence on transboundary/imported water
- Highly seasonal demand pattern
- Conflicting users

State

- (Seasonal) water deficits
- Serious water shortage conditions

Impacts

- Agrochemical pollution
- Deterioration of water quality- both surface water and groundwater; partly sea water intrusion
- Ecosystem degradation
- Low cost recovery
- Poor public participitation

Responses

- Regulation of water use
- Conjunctive use of groundwater and surface water
- Construction of storage reservoirs
- Artificial groundwater recharge
- Desalination
- Reuse of water
- Interbasin water transfers/ water transfer by ships
- Subsidies for water used for irrigation
- Demand reduction measures

6. Appendix: Country reports

1 Cyprus

2 Greece

3 Italy

4 Spain

5 Israel

6 Portugal

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EVK1-CT-2001-00098

Report on Cyprus:

Range of circumstances and region analysis

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8/06/2002

Preface

This is a report for the range of circumstances and existing water resources analysis of Cyprus and it constitutes the contribution of Cyprus to the deliverable D1 of Work Package 1 of the WaterStrategyMan project. The Report contains:

1. An overview of the government-controlled part of the country, comprised of a brief review of the climate, geomorphology, geology, land use, aridity and demography and an analysis of the current situation regarding the demand and supply, and the legal, institutional and administrative framework of water management in the country.

2. A summary matrix and an analysis of the extended range of circumstances and conditions in three selected areas for study, namely the Akrotiri, the Germasogeia, and the Kokkinochoria, as candidates and representative areas for the selection of Paradigms is further provided.

Contents

Abstract

Cyprus's water resources are highly developed with the most economically viable plans already implemented. A comprehensive approach to water management has been adopted involving conjunctive use of surface and groundwater and addressing the interrelationships between demands for domestic and irrigation water. Demand management is used to control consumption. The techniques include pricing, rationing, increased irrigation efficiency through automated irrigation systems and water conservation measures.

Nonetheless, Cyprus continues to face, due to current drought conditions, an increasingly serious water shortage. Exploiting the remaining scarce water resources will be expensive. The main implication of this shortage is that irrigation's water consumption may have to decline if Cyprus is to continue to rely more on conventional rather than non-conventional sources of water. Already two desalination plants are in operation producing a daily total of 90000 cu. m. and a third plant is envisaged for commissioning by 2004. Difficult policy decisions will be necessary.

Cyprus has always been confronted with the problem of inadequate water both for its domestic and its irrigation needs arising from its traditional inclination towards agriculture and the booming tourism industry. The problem of inadequate water for domestic water existed in the past because infrastructure did not keep pace with the expanding urban areas. This problem was being further exacerbated in times of drought. Today, and after most of the water resources of the island have been developed, the problem still persists. This is due to the increasing number of tourists and the high seasonal demand for water, the increased standard of living and the drought conditions experienced in the last few years.

Due to climatologic conditions and development, Cyprus will always be short of water. Land availability on the island surpasses water availability. The result is that despite considerable ground and surface water development, only a small proportion of the land is irrigated. In total, the irrigated land does not exceed 20 percent of the total cultivated land. The competing demands for domestic and agricultural purposes, the degradation of certain groundwater areas and the ongoing drought all serve to exacerbate the problem.

New legislation for the protection of water and a new proposed law for water resources management under one Entity together with the implementation of the EU Water Framework directive give a new impetus to the local efforts for water management.

In the text that follows an overview of the existing water conditions and circumstances for the whole country is presented. Finally and after analysing all major hydrologic regions, and on the basis of specific indices, three regions are selected as representative of water deficient regions, either due to climatologic reasons, complicated circumstances, increased demand or inappropriate and inefficient water resources management. These are the Akrotiri aquifer area, the Germasogeia river water system and the Kokkinochoria area. The range of circumstances in these three regions is analysed, and presented in table form.

Introduction

The Mediterranean Islands have seen growing pressure on water resources, with increasing demand and costs, for agricultural, domestic, tourism and industrial consumption. This has brought about the need to maximize and augment the use of existing or unexploited sources of freshwater. The Mediterranean islands and mostly the southern Mediterranean countries are suffering from water scarcity due to structural and seasonal water shortages and high rates of population growth associated with a high tourism influx.

Cyprus is an arid to semi arid island state situated in the northeastern Mediterranean. The renewable freshwater resources are highly constrained. These are characterized by a strong spatial and temporal scarcity caused by the seasonal distribution of precipitation, and the topography.

Although a large number of various water supply investments and interventions have been made such as surface water dams, groundwater exploitation, interbasin water transfers, desalination and reuse of tertiary treated effluent, Cyprus is still a long way from reconciling the demand to the availability of water.

Currently and after a long sequence of relatively dry years all the aquifers have been exploited far beyond their safe yield with the result of most of the coastal aquifers being sea intruded to extents of up to 2 kilometers, the yield of the wells has dropped considerably and strategic reserves have been totally depleted.

Most of the economic sites for surface water dams have been used up and additional reservoirs have prohibitively high costs to develop.

Irrigation efficiencies are quite high being in the range of 75% or higher and thus no serious additional saving can be expected.

Presently Cyprus has brought into use non-conventional water resources such as desalination to cope with domestic supply of the major urban and tourist areas and the reuse of tertiary treated effluent to meet part of the irrigation demand. In addition it has high in its water policy the water demand management and water conservation practices in its effort to balance water demand to supply.

Currently, Cyprus has embarked in the modernization of its water legislation and its harmonization with European directives.

Drought sequences may cause water shortage problems anywhere in the island but certain areas face long term water shortage mainly due to lack of water availability or increased demand or even due to ineffective management practice. In the report that follows a general overview of the island's water resources and demand is given followed by a brief description of three selected areas, the Akrotiri, the Germasogeia and the Kokkinochoria where water scarcity, overexploitation and management problems are evident.

Table 1: Summary of Cyprus's physical characteristics

NATURAL CONDITIONS AND INFRASTRUCTURE (THE PHYSICAL ENVIRONMENT) **Regional Context**	
Background	**Description**
Climate	Cyprus has an intense Mediterranean climate with the typical seasonal rhythm strongly marked with respect to temperature, precipitation and weather in general. Hot dry summers from mid-May to mid-September and rainy, rather changeable, winters from November to mid-March are separated by short autumn and spring seasons of rapid change in weather conditions. At latitude 35° North, Longitude 33° East, Cyprus has a change in day length from 9.8 hours in December to 14.5 hours in June. The central Troodos massif, rising to 1951 metres a.m.s.l., and to a less extent the long narrow Kyrenia mountain range, with peaks of about 1000 metres a.m.s.l., play an important part in the meteorology of Cyprus. The predominantly clear skies and high sunshine amounts give large seasonal and daily differences between temperatures of the sea and the interior of the island that also cause considerable local effects especially near the coasts. In summer the island is mainly under the influence of a shallow trough of low pressure extending from the great continental depression centred over southwest Asia. It is a season of high temperatures with almost cloudless skies. Precipitation is almost negligible but isolated thunderstorms sometimes occur which give precipitation amounting to less than 5% of the total in the average year. In winter Cyprus is near the track of fairly frequent small depressions that cross the Mediterranean Sea from west to east between the continental anticyclone of Eurasia and the generally

low-pressure belt of North Africa. These depressions give periods of disturbed weather usually lasting from one to three days and produce most of the annual precipitation. The average precipitation from December to February being about 60% of the annual total.

The average precipitation for the year as a whole is about 500 mm but it was as low as 182 mm in 1972/73 and as high as 759 mm in 1968/69. The average precipitation refers to the island as a whole and covers the period 1961-1990. Statistical analysis of

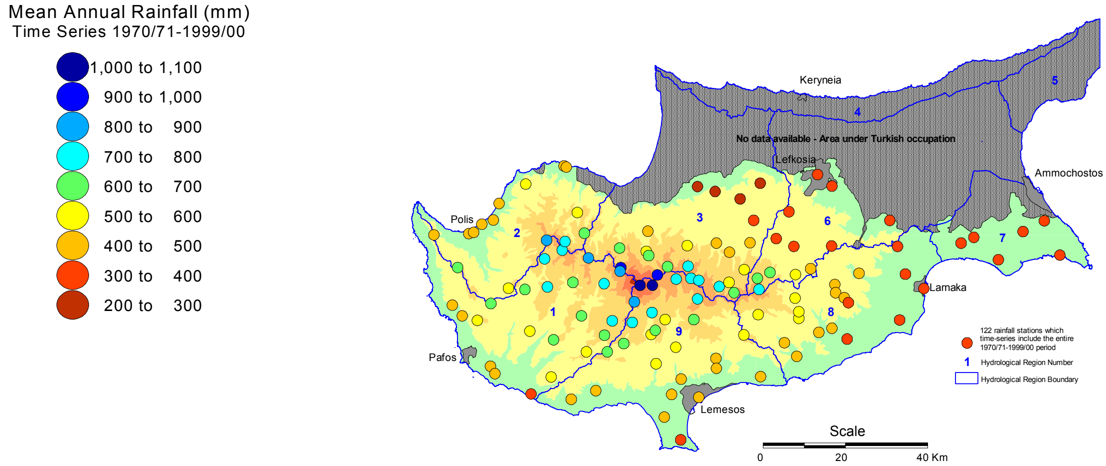


Fig. 1: Mean annual precipitation in mm over the period of 1971 to 2000

precipitation in Cyprus reveals a decrease of precipitation amounts in the last 30 years. The mean annual precipitation increases up the southwestern windward slopes from 450 millimetres to nearly 1,100 millimetres at the top of the central massif. On the leeward slopes amounts decrease steadily northwards and eastwards to between 300 and 350 millimetres in the central plain and the flat south eastern parts (the Kokkinochoria area) of the island. (Rossel 2001)

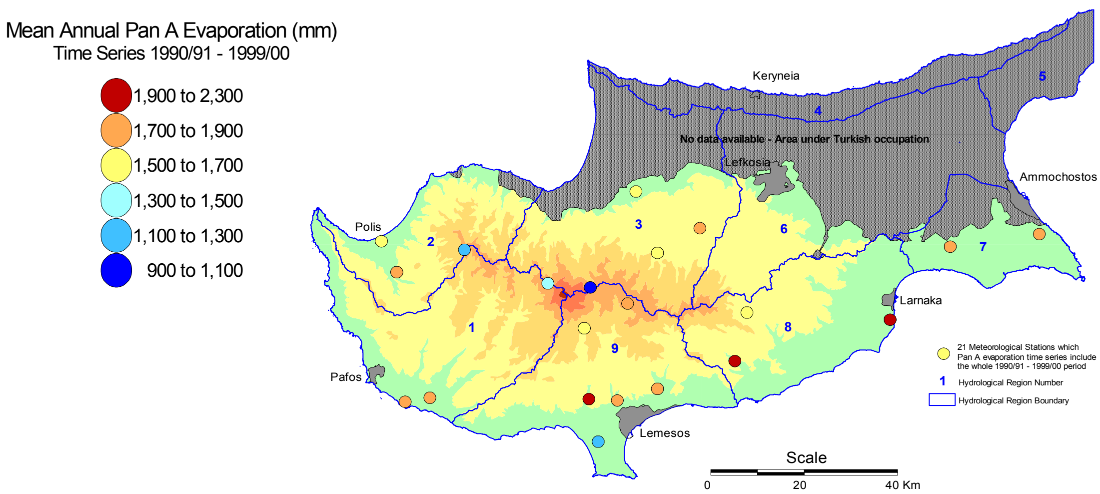


Fig. 2 : Mean annual Class A Pan evaporation in mm in 1991 to 2000

Geomorphology Two mountain ranges run east to west. The Troodos mountains cover approximately 3 500 km^2 in the west and rise to nearly 2 000 m. The Kyrenia mountain range along the northern coast covers 400 km^2 and rises to 950 m. In between these two mountain ranges lies the central plain of Mesaoria covering 2 500 km^2. The remaining land forms narrow coastal plains, which are good for agriculture. There are no perennial streams. Most of the winter streams traversing these plains originate in the Troodos Mountains, and have deep alluvial beds in which substantial volumes of groundwater can be stored.

Geology There are four major geologic belts that are roughly parallel to each other in an east - west direction. In a south-westward sequence these are:

1. The Kyrenia mountain range consisting mainly of limestone enveloped on either side by chalks and flysch deposits. The limestone constitutes the major aquifer in this belt. This Range is markedly elongate, narrow and runs slightly inland of and parallel to the north coast.
2. The broad Mesaoria Plain, which separates the Kyrenia from the Troodos Mountain range. Within this broad east - west belt are nearly horizontal sediments of Pliocene to Recent age. These consist of marl, calcarenites, calcareous sandstones and conglomerates interspersed with finer sediments. These coarser sediments form the only noteworthy aquifer at the western part of this particular region.
3. The Troodos Igneous Massif the central part of which is occupied by plutonic rocks. A sheeted intrusive complex constitutes the largest portion of the range and surrounds or occasionally intrudes the plutonic rocks. To these rocks, the Troodos Pillow Lava Series form a rough girdle. The Troodos massif has the shape of a rather squashed oval, eighty kilometers long, about thirty kilometers wide. It receives most of the available rainfall. The nature of its constituent rocks precludes deep percolation except along fracture zones, hence there is considerable runoff and its drainage includes the largest of Cyprus streams.
4. Calcareous sediments that overlap onto the igneous rocks of the massif form the foothills to the south and west. Within those, in the western part of the island are outcrops of the highly contorted and predominant shaly rocks of the Mamonia complex that form an aquiclude. Within the calcareous sediments, the Middle Miocene contains aquiferous sediments, conglomerates and gypsum deposits.

Along the coast and forming a distinct but discontinuous coastal plain, are rocks of the Plio-Pleistocene that although dominantly marly, they include lenses of coarser material forming aquifers that are of importance.

Extensive river gravel deposits that form good and readily exploitable aquifers in fill the V-shaped valleys cut by the rivers, beyond the steep gradients of the mountain areas.

Land use Some 60 per cent of the Island is arable of which 85 per cent is cultivated. Twenty per cent of the Island is forest most of which is owned by the State, principally of pines which are most extensive on Troodos. Extensive carob and olive tree plantations are located on the foothills of Troodos. Rain-fed vines cover large areas; mainly at elevations of 600 to 1200 m. Dry-land farming is practiced in the plains where wheat and barley are widely cultivated. Irrigated crops include citrus, deciduous trees, table-grapes, potatoes and vegetables. The soils are in general poor in nitrogen and phosphorus, but rich in potassium.

Aridity Index Cyprus may be subdivided into four main topo-climatic regions:

a) The high altitude areas (500 to 1950 m. amsl) of the Troodos mountain range that dominates the central part of the island (18% of the island). The mean annual precipitation is 690 mm varying from 400 to 700 mm at elevations of 500m to 1100 mm at the peak of the mountain. The mean annual evaporation varies from 1400 to 1700 mm at 500 m elevation to 1000 mm at the top. This area may be assigned an overall aridity index of 0.54 classifying it as "**Dry sub-humid**".

b) The slopes of the Troodos mountain Range at altitudes of 200 to 500 m. amsl (27% of the island) with a mean rainfall of 300 to 500 mm at the lower elevation and 400 to 700 mm at the higher elevations, the rainfall being higher at the western and southern slopes rather than at the northern and eastern slopes. The annual evaporation varies similarly from 1600 to 1900 mm at lower elevations to 1400 and 1700 mm at the higher ones. This area may be assigned an overall aridity index of 0.3 classifying it as "**Semi-arid**".

c) The Mesaoria Plain dominating the central eastern part of the island (20% of the island) at elevations of 0 to 200 m. amsl with an annual rainfall in the range of 290 to 350 mm and an evaporation of 1650 to 1850 mm. The area may be classified as "**Arid"** with an aridity index of 0.18, and

d) The coastal areas at 0 to 200 m elevation amsl, but including the Pentadactylos mountain range along the northern part of the island (35% of the island). The mean annual rainfall varies between 350 and 400 mm in the south-eastern and southern areas and 450 to 500 mm in the western and northern areas. The mean annual evaporation is in the range of 1700 to 2000 mm. Using the same Penmann-Monteith classification these areas may be termed as "**Semi-arid**" with an aridity index of 0.23.

Thus, the overall average aridity index is 0.295 classifying the climate of the whole island as **Semi-arid**.

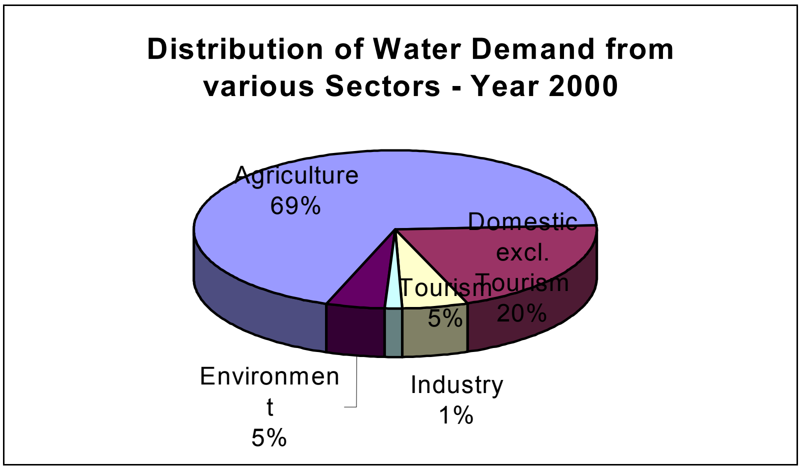
Permanent Population The present permanent population (based on the 1992 census and the population growth rate provided by the Department of Statistics –0.9% for the urban areas and 0.6% for the rural areas) within the government-controlled areas of Cyprus is **673 000** of which 74% lives in the main cities and suburbs and 26% in the rural areas. Although definite figures are not available for the Turkish Cypriots in the occupied part of the island, it is believed that at present they amount to some 88 000 after some 55 000 have left the island. The recorded tourist arrivals in Cyprus for 2001 were 2 777 000 with an average stay of 11.3 days

1. Overview of the country

1.1 Water Demand and Supply Status

The **Total Annual Water Demand** for the government-controlled part of Cyprus for the year 2000 is estimated to be 266 million m^3 (Mm^3) and is distributed as follows (FAO Project TCP/CYP/8921):

AGRICULTURE				**182.5 MCM**		**69%**
DOMESTIC				**67.5 MCM**		**25%**
	Inhabitants	53.4 MCM	79% of Domestic		20%	
	Tourism	14.1 MCM	21% of Domestic		5%	
	Total domestic	**67.5 MCM**	100%		**25%**	
INDUSTRY				**3.5 MCM**		**1%**
ENVIRONMENT				**12.5 MCM**		**5%**
TOTAL WATER DEMAND				**266 MCM**		**100%**



The projected annual water demand in million m^3 for the years 2005, 2010 and 2020 is as follows (The estimates being based on: 215 litres/capita/day for main towns, 180 litres/capita/day for villages and 465 litres/capita/day for tourist demand):

Sector of Demand / Year		2000	2005	2010	2020
Agriculture		182.4	182.4	182.4	182.4
Domestic					
	Inhabitants	53.4	58.4	63.2	73.5
	Tourism	14.1	18.0	22.9	30.8
Industry		3.5	5.0	6.0	7.0
Environment		12.5	14.0	16.0	20.0
TOTAL (Mm^3/a)		**265.9**	**277.8**	**290.5**	**313.7**

Agriculture, being the major water-consuming sector about 70%, contributes little on the GDP. On the other hand, tourism consuming about 6% of the total water demand of all sectors, contributes by over 20% on the GDP.

The recent consecutive dry years, have affected all the sectors of water use, particular the agriculture and domestic. During the year 2000, the average water shortage was 37.6% in agriculture and 23.4% in domestic. Such situation has led the Government to look for alternative sources of supply (desalination), at least for domestic purposes.

Water availability

Total water resources / availability

The island-wide water balance based on the average rainfall of the 1951- 1980 thirty-year period of 477 mm, and which is 95% of the long-term average of 500 mm, is presented here below. This period is chosen since this is the last for which rainfall data are available for the whole island, the northern part of the island being inaccessible after 1974.

The average annual water crop for this period amounts to 780 Mm^3.

Some 65 percent, or 510 Mm^3, of the total annual water crop appears as surface runoff. Of the total surface runoff only 45 percent, or 230 Mm^3, (29 percent of the total water crop) is lost to the sea. This indicates the high level of surface runoff utilization and control achieved in Cyprus over the last 40 years. It should be noted that a large proportion of the losses to the sea include overland flow and flow from minor streams which do not render themselves for regulation and control.

Some 27 percent, or 140 Mm^3, infiltrates into riverbed aquifers and coastal alluvial fans. Part of this water is drawn through wells and boreholes, and the remainder goes to the sea. 8 percent, or 40 Mm^3, of surface runoff is used diverted for spate irrigation in late winter or early spring, and especially during wet seasons.

A large quantity of the surface runoff is captured in surface reservoirs, which provide inter-annual storage. Thus, these reservoirs generally are able to hold two to three times the average annual flow of a stream. The island's total surface reservoir capacity is 300 Mm^3. Current use of stored water for irrigation and domestic supply is about 20 percent or 100 Mm^3.

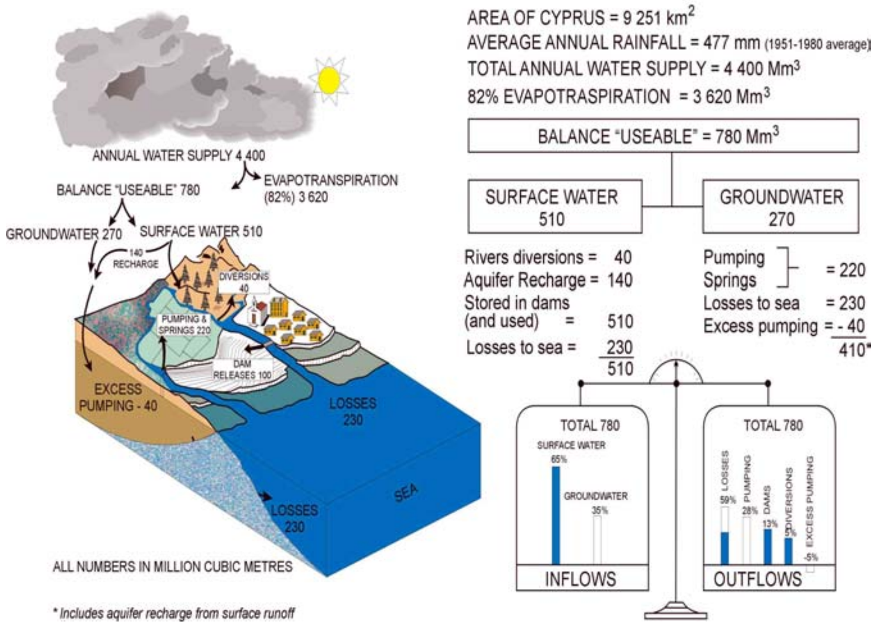
Excluding surface runoff the remainder of the annual water crop, or 270 Mm^3, is assumed to directly replenish the island's aquifers. Added to the direct recharge of 270 Mm^3, is surface runoff recharge of 140 Mm^3, amounting to a total recharge of 410 Mm^3 annually. Of the total annual replenishment 54 percent, or 220 Mm^3, is pumped for irrigation and domestic uses, with the remaining 56 percent, or 230 Mm^3, going to the sea. Where pumping exceeds recharge, a deficit of 10 percent, or 40 Mm^3, is created in certain aquifers. The result of long-term over-pumping has been sea-intrusion in certain major coastal aquifers.

Subsurface losses to the sea derive from minor aquifers during early spring when water is not needed for irrigation and from river delta deposits during winter. The major aquifers also lose a small proportion that is needed to control sea intrusion. Thus, it appears that Cyprus's water development is approaching its limits. Only improved water management and redistribution to water conserving uses would be able to provide additional water in the future. In a normal year, the water availability is sufficient to cover both domestic and irrigation demands, and keep a favourable water balance overall. The frequent occurrence of dry years though greatly affects the availability of water and on many occasions the water stored in the reservoirs, both surface and groundwater are far below the annual demands.

The average Annual Total Water Crop

For the period of 1951 to 1980 the average annual total water crop has been calculated on the basis of the catchment areas, the respective average annual rainfall and the corresponding percentage of net rainfall. For this period the Total Water Crop for the island amounts to 781 Mm^3. A recent study by FAO and the WDD for 31 watersheds and using the observed flows of the period of 1971 to 2000 shows a reduction by as much as 58% of the estimates based on the period of 1951 to 1980. This is attributed mainly to the reduction of rainfall over the same period compared to the periods before 1970. The mean annual precipitation of this period is 100mm or more lower than the mean of the older period at almost every location of elevation higher than 500 m.

WATER BALANCE FOR CYPRUS



The Surface Runoff

The surface runoff refers to the water flowing at the surface either appearing in streams and used either for spate irrigation, or stored in surface reservoirs and subsequently used, or recharging riverbed alluvial aquifers or alluvial fans on the coast and finally part of it being discharged to the sea. Overland flow that appears during storms and most of which is lost to the sea is also included under the same term. The Table below shows the surface runoff for each Hydrologic Region together with the allocation to various uses and amounts going to recharge or discharging to the sea.

Region		Catchment	Average	Surface	Surface Water Use (Mm^3)			
No	Name	Area (km^2)	Rainfall (mm)	Runoff (Mm^3)	Spate Irrig.	from Dams	to Recharge	Runoff to sea
1	PAFOS	1188	627	125	9	47	20	48
2	TYLLIRIA	745	585	59	2	10	7	39
3	MORFOU	1585	429	96	7	6	42	41
4	KYRENIA	455	490	16	0	0	9	7
5	KARPASIA	685	463	22	0	0	3	19
6	MESAORIA	1840	381	53	4	6	41	2
7	S.E. MESAORIA	546	341	4	0	1	0	3
8	LARNAKA	1050	439	39	4	18	10	7
9	LIMASSOL	1155	555	96	11	64	9	12
Total		9249		508	37	152	141	178
Island-wide average			478					

Of the total surface water resources only some 35 % are lost to the sea, which indicates the high utilization and control on surface runoff that has been achieved in the island through the water development schemes that have been put into operation in the last 35 years. This is more important if one considers that a large proportion of the losses to the sea contain overland flow and flow from minor streams which do not offer good opportunity for control.

Some 28 % is estimated to infiltrate the riverbed aquifers and the coastal alluvial fans, part of which is pumped through wells and boreholes and part finds its way to the sea through the subsurface.

Some 7 % is used directly from the surface runoff by diversions for spate irrigation in late winter or early spring, especially during wet seasons.

A large quantity of the surface runoff is captured in surface reservoirs, most of which have a capacity two to three times larger than the average annual flow of a stream to provide inter-annual storage. The total surface reservoir capacity in the island is 300 Mm^3. The quoted use of surface water from dams for irrigation and domestic supply refers to the rated yield of each reservoir. The total use of water from reservoirs, or from diversions to reservoirs, in an average year, is of the order of 30 %.

The Ground Water Resources

The balance of the annual Total Water Crop less the Surface Water Resources is assumed to replenish directly the aquiferous systems in the island some of which constitute the major aquifers and some are of lesser importance due to their small yield and extent.

To this direct recharge, the recharge from surface runoff is added to provide the total annual ground water replenishment that is considered as the safe yield of the aquifers.

The Table below lists, by Region, the estimated ground water replenishment due to surface runoff and direct from rainfall as well as the allocation of the ground water resources to usage and subsurface losses to the sea. The amounts of annual over-pumping are also indicated.

Region		Ground Water Recharge (Mm^3)			Use by (Mm^3)		Deficit
No.	Name	Streams	Direct	Total	Pumping	to Sea	
1	Pafos	20	46	66	18	47	0
2	Tylliria	7	23	30	11	20	0
3	Morfou	42	30	72	89	11	29
4	Kyrenia	9	19	28	11	17	0
5	Karpasia	3	26	29	2	27	0
6	Mesaoria	41	47	88	28	60	0
7	S.E. Mesaoria	0	11	11	35	1	25
8	Larnaka	10	34	44	14	31	0
9	Limassol	9	37	47	35	15	3
Total		141	273	415	243	229	57

Of the annual total Ground Water replenishment of 415 Mm3 some 66 % are due to direct recharge from rainfall and 34 % from the surface runoff. Of the total annual replenishment, some

58 % is pumped and used for irrigation and domestic water supply and some 55 % finds its way to the sea through the subsurface. This creates a deficit in certain aquifers where pumping exceeds the replenishment of a total of 13 %.

Trans-boundary Water There is no trans-boundary water flow in the island except along the artificial boundary created between the “occupied” and the government controlled part of the island. This does not involve more than 10% of the total water resources.

Water quality

Quality of surface water Water quality is generally good for domestic and irrigation uses. However, insecticide residues and high nitrate concentrations have recently been observed in dams, especially where there is intensive agriculture in the upstream parts of the watersheds.

Quality of groundwater Groundwater quality is generally good for domestic and irrigation uses. However, a rising trend of insecticide residues and high nitrate concentrations has been observed in the last few years in groundwater, especially where there is intensive agriculture and where the natural replenishment from surface streams has been cut off by surface reservoirs. In the same areas increased irrigation with available surface water has increased fertilizer leaching and insecticide input to the groundwater.

Quality of coastal water Water salinity is also increasing in coastal areas due to sea intrusion in aquifers caused by over-pumping. All the major aquifers in the island exhibit seawater intrusion of various extents. In at least three of them the inland propagation is of the order of 2 km rendering the most productive part useless.

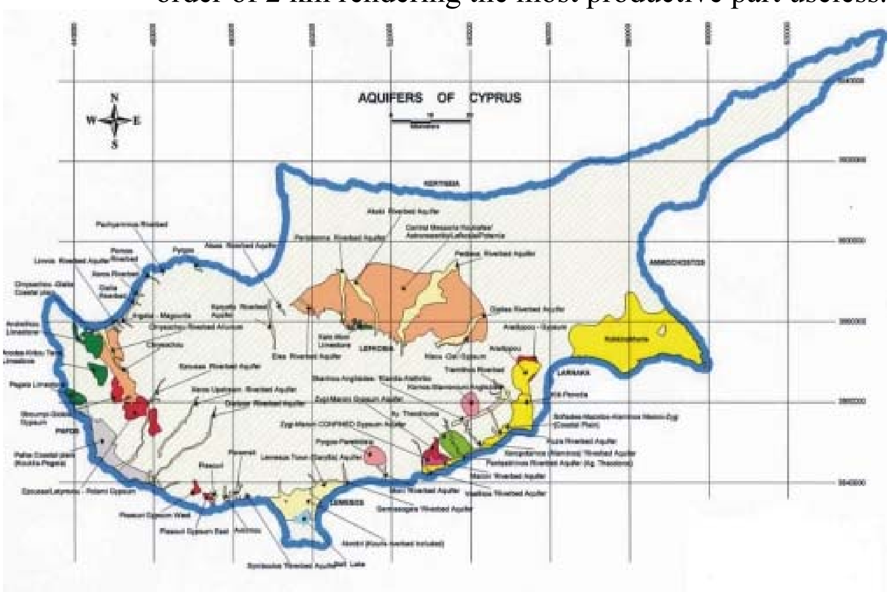


Fig 3. The aquifers of Cyprus (after A. Georgiou (WDD, 2001))

Water supply

The annual water demand for the government controlled part of the island is evaluated to be 266 million cubic meters of which 195 million cubic meters or 73% are for irrigation and 71 million cubic meters or 27% are for the domestic supply. Presently the contribution of the various water sources to the overall demand for all sectors is as follows:

- Groundwater 48%
- Surface water 38%
- Desalination 13%
- Springs 1%

The use of treated sewage effluent is limited at present, amounting to 1% of the agricultural demand.

Percentage of supply coming from:

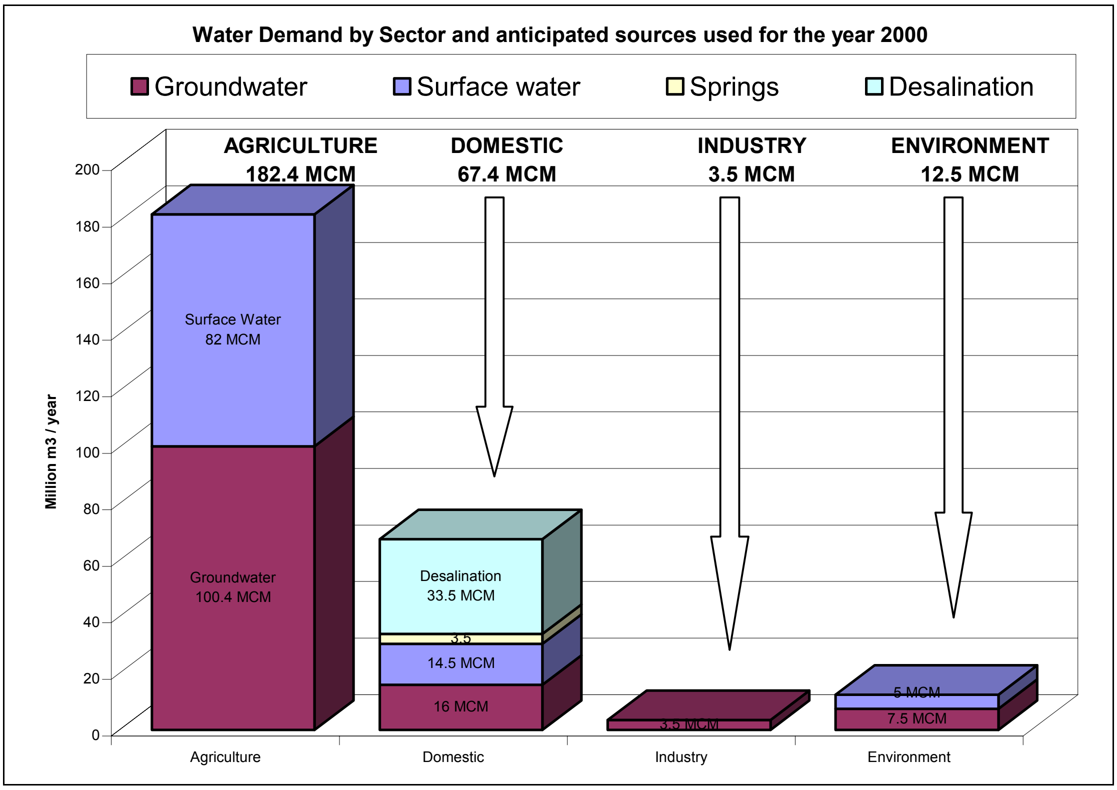
Groundwater: The annual groundwater extraction is estimated to be 127 million cubic meters or 48% of the total supply. Of this quantity about 100 million cubic meters are used for agriculture, 16 for domestic supply, 3.5 for industry and 7.5 million cubic meters for the environment. Water from springs mounting to 3.5 million cubic meters per year is used for the domestic water supply mainly of villages in the mountainous part of the island.
It should be noted that the quoted groundwater extraction is in most areas exceeding the safe yield of the aquifers. As a result of this the original yield of the wells in many areas has diminished whilst elsewhere sea intrusion has been observed extending occasionally up to 2 or more kilometers inland.

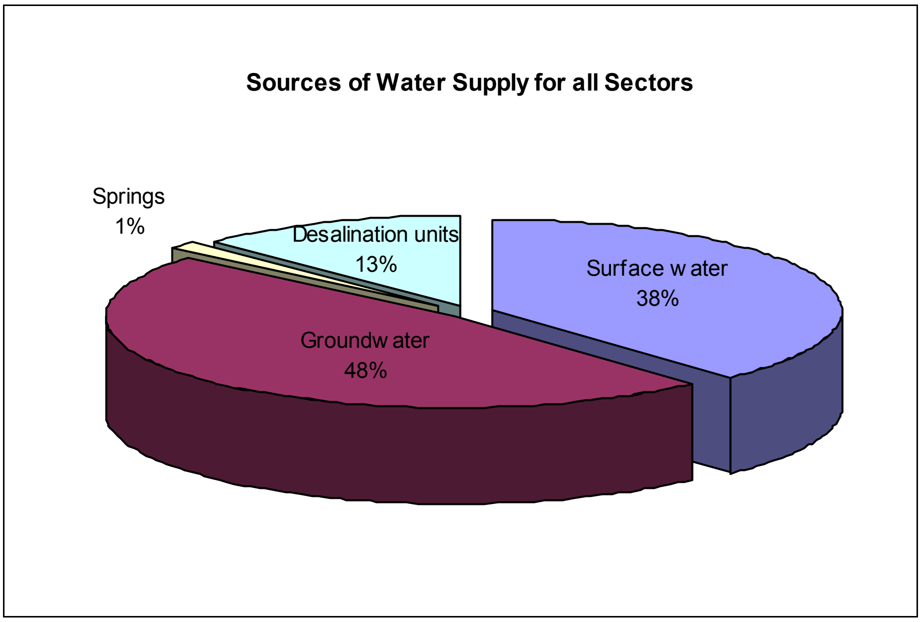
Surface water: The average annual yield of the 274 million cubic meter capacity main surface reservoirs is about 101 million cubic meters or 38% of the total supply. Of this yield some 82 million cubic meters are used for irrigation, 14.5 million cubic meters for domestic supply and 4.5 are used for ecological purposes.
This does not include use of surface water for the spate irrigation of cereals, olive and almond trees in early spring on the occasion of flow availability.

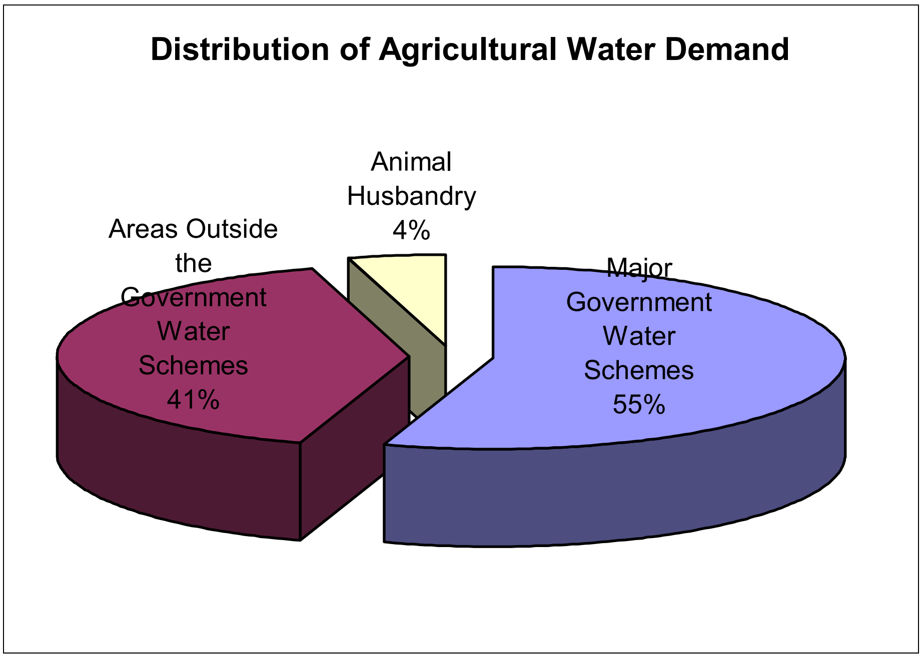
Desalination: Two Desalination Plants using seawater and the reverse osmosis method provide an annual supply of 30 million cubic meters for domestic purposes. The two plants with their nominal capacity are at Dhekelia (40000m^3/d) and at Larnaka airport (52000 m^3/d). Plans are under way for another plant at Limassol with a capacity of 20000 m^3/d to start operation by 2004 and with a possible extension of capacity to 40000 m^3/d.

Re-use of tertiary treated effluent: Two sewage schemes at Limassol (since 1995) and Larnaka (since 1997) provide annually, at present, some 4 million cubic meters of tertiary treated effluent for the irrigation of fodder, trees and parks. Sewage treatment plants are now under design or construction in all the major cities and sensitive mountain villages, especially those of equivalent population of 2000 or more, of Cyprus. All municipal sewage treatment plants have provisions for tertiary treatment in order to re-use the effluent. The schemes currently being implemented at Paphos, and at Paralimni- Agia Napa area together with the planned extension of the Greater Nicosia scheme and the built up of the existing schemes are expected to increase the reused quantity of treated effluent to 13 Mm^3 by the year 2005 rising to 25 Mm^3 by the year 2020.

The following figures and pie charts (Savvides, FAO Project 2002) illustrate the allocation of demand and source of supply, by sector.







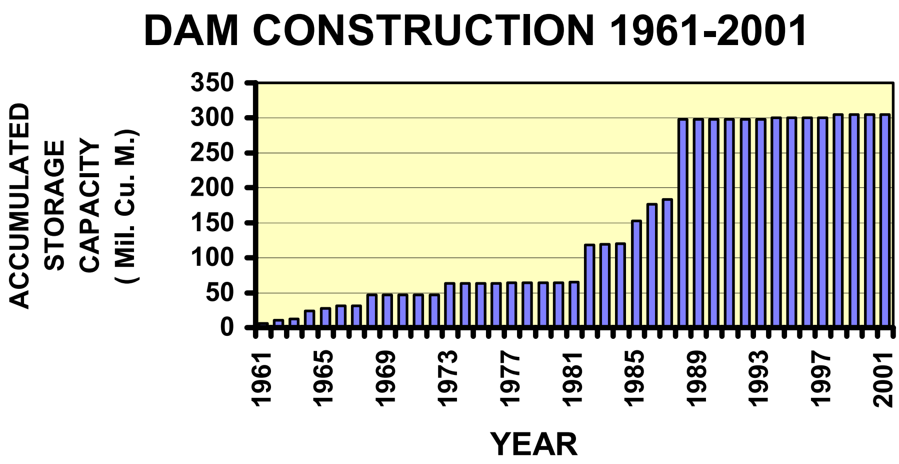
The permanent crops consume 59% of the total agricultural irrigation water demand, whereas vegetables consume 41%.
In years of low rainfall and limited water supply the vegetable area is reduced and priority of water demand satisfaction is given to the permanent crops.
The 67.5 Million m^3 of Domestic Water Demand (inhabitants and tourism) is distributed as follows:

- Main cities and suburbs: 78%
- Villages and British Bases 22%

The contribution of each source to the total domestic demand is as follows:

- 75% of the total domestic water demand is covered by the Treatment Plants and Desalination Units
- 20% is covered from groundwater through boreholes
- 5% is covered by springs

Water Storage features Since 1960, attention was turned to the systematic study and construction of water development works, both for storage and recharge purposes. After a comprehensive survey of the island's water resources a long-term plan for the construction of major development projects was followed, which involved the construction of a large number of dams. The current total storage capacity of surface reservoirs has reached 307,5 Mm^3 of water from a mere 6 Mm^3 in 1960, and will reach 325.5 by 2004 with the completion of the Kannaviou dam, a truly impressive achievement when compared to other countries of the same size and level of development as Cyprus. In Cyprus there are today 106 dams and ponds: 35 large dams with a capacity of 286,1 Mm^3 of water of which 4 are recharging-flood protection dams, 42 small dams with a capacity of 16,1 Mm^3 of which 32 are recharging-flood protection dams, and 26 ponds with a capacity of 2,5 Mm^3. Eighty-one (81%) of the dams, i.e., 85 in number are earth fill or rock fill dams and the remaining 19% i.e., 20 in number are concrete dams.



Problems:

Water Shortage

During the dry years 1997 – 2000 there was a severe shortage in the supply of water to all sectors, due to consecutive low rainfall. The available water in the major dams had reached critical low levels and priority was given for the domestic needs. In all sectors the water was rationalized and the shortage was (Savvides, FAO, 2002):

- 23.4% in the domestic sector
- 37.6% in the agricultural sector (average)

- 45.6% within the Government projects
- 20% for Agriculture outside Government Irrigation Schemes (assumed)

Due to the limited availability of water resources, priority was given to cover the domestic needs and in agriculture priority to permanent crops, covering only portion of their water demand.
The water allocated to farmers was in the range of 30% to 70% of the normal demand, depending on the type of crop and the availability of water in each project. In some projects the vegetable area was significantly reduced, in order to save water and cover part of the needs of the permanent crops.

1.2 Environmental issues

Water protection is highly ranked in Cyprus' environmental policy, since water is a particularly precious resource in the island.

National water policy focuses on the provision of adequate supplies of water for drinking and residential use, including the tourism and the industry sectors, as well as for the development of agriculture. In drought seasons, priority is given to the supply of drinking water, with restrictions in the supply of water for irrigation purposes.
The protection of waters from pollution is based on the legislation (Law for Water Pollution Control), which was introduced in 1991 as part of the broader environmental legislation of the island.
The recently introduced legislation for the protection of water, in line with the European Legislation, introduces for all water resources the general requirement for ecological protection aiming at "good ecological status".

Urban waste water

An adequate number of central sewage systems exist covering the urban areas of the island. Nicosia has a fully operating central sewage system, whilst the design of the Greater Nicosia central sewage system is under development. The coastal towns of Limassol and Larnaca have their own central sewage systems and tertiary level treatment plants for some years now. Similar systems are under construction for the rest coastal urban areas of Pafos, Ayia Napa and Paralimni. In addition there exist a big number, of the order of 400, of private biological treatment plants installed in hotels and other tourist facilities.
Moreover a number of central sewerage systems have been constructed covering some of the rural areas, whilst there is under implementation a big program for the collection and treatment of rural wastewaters covering the whole island.
The high quality treated effluents of the central treatment plants are utilized for irrigation and for aquifer recharging, under the provisions of a Code of Contact for Good Agricultural Practices and of Quality Standards for the re-use of treated effluent.

Groundwater

The Water Pollution Control Law (and a Decree issued under this law) regulates the quality of groundwater. A list of substances has been legislated whose direct and indirect discharge into groundwater is prohibited. Groundwater quality is monitored on a regular basis including the preparation of hydrochemical charts.

Groundwater quality is generally good for domestic and irrigation uses. However, insecticide residues and high nitrate concentrations have recently been observed in groundwater, especially where there is intensive agriculture and where the natural replenishment from surface streams has been cut off by surface reservoirs. In the same areas increased irrigation with available surface water has increased fertilizer leaching and insecticide input to the groundwater. On-going farmer training programmes, phytosanitary controls, and chemical analysis programmes for pesticides residues, etc. are the actions adopted to control the use of fertilizers and plant protection products.

Surface waters

Two are the problems of concern related to the surface waters environmental conditions: the discharges of dangerous substances, and nitrate pollution from agricultural sources.

Discharges of dangerous substances

The discharges of dangerous substances into surface waters are regulated by a Decree issued in 1993, which prohibits the direct discharges, and makes indirect discharges subject to a permit based on criteria such as effluent characteristics (quality standards, quantity), disposal characteristics (place and method of disposal), monitoring specifications, etc.

Two central industrial effluent and domestic septage treatment plants are in operation, one in Nicosia and the other in Limassol.

Nitrate pollution from agricultural sources

Water quality is generally good for domestic and irrigation uses. However, insecticide residues and high nitrate concentrations have recently been observed in dams, especially where there is intensive agriculture in the upstream parts of the watersheds.

A monitoring programme of the quality of waters in reservoirs (covering 226 chemical, microbiological and toxicological parameters) was completed in 2000. There is also in place a monitoring programme for surface waters (and groundwater) near the industrial areas of the island.

The provisions of the Code of Good Agricultural Practice are applied through the island, i.e. control of fertilizer use, use of improved irrigation systems and preparation of irrigation schedules, relocation (wherever is possible) of animal husbandry units, slurry collection, mechanical separation and land application of piggery waste, on-going farmer training programmes, etc.

1.3 Water laws and Regulations

There is currently no umbrella law covering water, however, all surface water, groundwater and wastewater belongs to the government, which has the power to construct waterworks and undertake their management. Legislation on water has evolved on an ad hoc basis. The result is that present statutory water laws are numerous, complex, duplicatory, with divided authority and recognition of private rights. Primary responsibility for enforcing these laws is divided between the two Ministries of Agriculture and the Interior. There are seven important water laws in force as well as another 15 that include provisions related to water.

These laws form the basis of resource development, interaction between the government and users, and establishment of local water bodies. The legislation covering groundwater abstraction is particularly deficient in light of significant degradation of several aquifers. Private individuals have the right to apply for permits to sink boreholes or dig wells. Several surface and groundwater sources may constitute private property in the form of registered water rights. Still the government has the power to declare some groundwater aquifers to be under “Special Measures” and impose restrictions on borehole drilling and water abstraction.

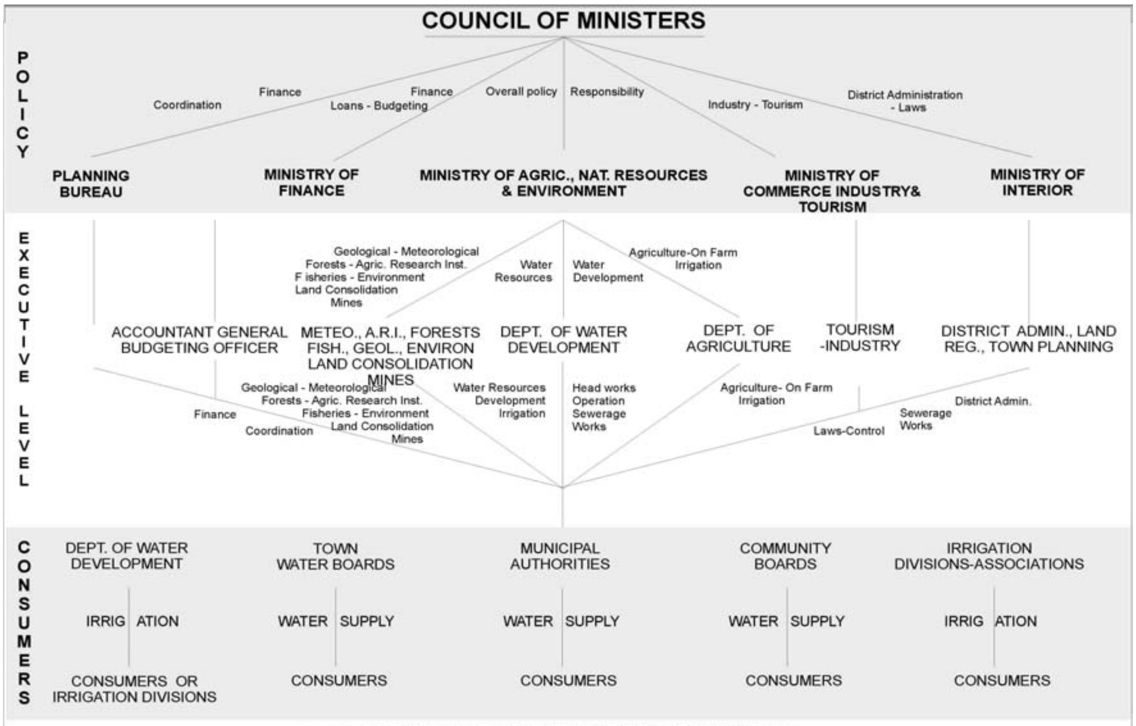
Illegal drilling of wells has been quite common and in one particular area up to 47 percent of the wells was drilled without a permit. The responsibility for monitoring compliance and dealing with illegal well drilling lies with the District Officer of the Ministry of Interior. In practice, monitoring of compliance is also executed by the WDD who must refer such cases to the DO to take action and bring to court such illegal actions.

Illegal drilling occurs mainly because farmers need to improve their economic situation. Illegal drilling not only continued but increased because of the limited supervision and control, the light penalties imposed, the possibility of each case being reconsidered, the issuing of a covering permit after discovery and interference in the process by non-technical lobbies. Added to this, the leniency in the case of farmers based on their social and economic situation plays an important role.

The protection of the environment and of the water quality has been encoded in the Control of Water Pollution Law 69 of 1991. This law provides for the elimination or reduction and control of water pollution, for the improved protection of water resources, the health of the population and the protection and improvement of the environment and water’s flora and fauna.

1.4 Institutional framework and constraints

The Chart below shows the structure of the water management institutions. The Council of Ministers is responsible for water policy and which is formed jointly by four ministries - Agriculture, Finance, Interior and Commerce. Executive power is divided between the Ministry of Agriculture, Natural resources and Environment (MANR&E) and the Ministry of Interior. MANR&E has technical responsibility for water resources policy, assessment and monitoring, but also for development and bulk selling water to end-users. The Ministry of Interior is responsible for enforcing water-related laws that include issuing groundwater permits. Its representatives act as the chairmen of municipal water boards, village water commissions and local irrigation associations, known as Irrigation Divisions (ID).



THE WATER RESOURCES ORGANIZATION CHART
AS IN 2000

The Water Development Department (WDD) is responsible for implementing MANR&E's water policy to have rational development and management of water. The WDD collects, processes, classifies and archives data. The information includes hydrological, hydrogeological, geotechnical and other data necessary for the study, maintenance and safety of water development works. The WDD plans, designs, constructs, operates and maintains water works. It also monitors and protects water resources from pollution. Major studies and construction works are often subcontracted to private firms.

At the regional level, the District Administration (DA) under the Ministry of Interior plays a key role. The DA. is responsible for implementing and enforcing water-related laws including the issue of groundwater permits. The District Officers (DO) are chairmen of District Water Boards, Irrigation Divisions, Municipal Water Boards and Village Water Commissions. Thus, all municipal water supplies and non-government irrigation schemes are in principle under the jurisdiction of the Ministry of Interior.

Other government departments as shown on the Chart, are also involved at various aspects of the water industry of the island.

At the end-user level, a number of local institutions are responsible for water administration at the local level. The Municipal Water Boards and Village Commissions deal with domestic supply; the Irrigation Divisions, Irrigation Associations, Waterworks Committees and WDD deal with irrigation, and the Sewage Boards deal with wastewater collection and treatment. All these organizations, except the WDD come under the Ministry of Interior's jurisdiction. At the user level, farmers have the right to form Irrigation Divisions and Associations to construct and manage irrigation schemes. An Irrigation Division is formed by landowners for sharing water whilst water-right owners form an Irrigation Association. Villages also have the right to establish their own commissions to develop domestic supplies from local resources.

Any group of 10 or more landowners can form themselves into an Irrigation Division, (under the Irrigation Divisions (Villages Law, Cap 342), in order to share amongst themselves in an agreed fashion the resources and costs of a supply of water (well, borehole, surface reservoir, major government reservoir etc.). The District Officer chairs the committee and the Village Chairman is an ex officio member. There can be several Irrigation Divisions in a village area. The committee balances its own finances and recovers its costs from the Division members. New Irrigation Divisions are set up as the Water Development Department implements new water schemes.

The Town Water Boards distribute water to the domestic and industrial consumers within a town. These are set up under the Water Supply (Municipal and Other Areas) Law, Cap 350, 1951. These derive their bulk supplies partly from boreholes and partly from bulk supplies of treated water delivered to storage reservoirs by the Water Development Department's trunk main system. Their governing Boards consist of three members nominated by the Government (the District Officer as chairman, the Accountant General and the Director of WDD) and up to three members from each of the municipal areas supplied by the Board. Many Municipalities (Paphos for example) operate their own water undertaking on the basis of own sources or from bulk supplies from the WDD, through a committee made up from the council.

Under the Water (Domestic Purposes) Villages Supplies Law, Cap 349, each village or part or a group of villages establish a Village Water Committee chaired by the village chairman. This Committee manages its own water undertaking on the basis of a spring(s), borehole(s) and some by direct supply with bulk supplies from WDD. Individuals may drill a borehole or well on his or someone else's land (with their consent) and use such water for irrigation, domestic, industrial and housing development supplies under the Wells Law, Cap 351. A permit for the drilling as well as a license for the use of the water are required.

Problems of present water management set up and plans for change

Inter-agency co-operation in managing water is as good as can be expected given the various approaches and goals set by each participating agency. Fragmentation of responsibility has caused many problems in all sectors. Since the WDD is responsible at the executive level for water management, the technical situation is very good. However, effective decision-making, implementation of works and enforcement is made difficult because legal and management responsibilities rest with the District Officers. These difficulties lead to considerable delays in project authorization, implementation and overall water management.

Through various laws the District Officer is the controlling authority at the user level. The WDD and the Department of Agriculture assist the District Officer in an advisory capacity on technical matters. This is not a satisfactory arrangement because there is no single agency responsible. When there is a conflict of interest and purpose, the technical departments are unable to implement agricultural policy even though it should be a major criterion in irrigation works and domestic water supply allocation

The District Officer for example is the authority by Law issuing drilling and water use permits. Usually but not always, the advice of the Water Development Department is requested. This has repercussions both on the management of the aquifers but also on the agricultural activity. The District Officer (Ministry of Interior) is the chairman of the Irrigation Divisions and the Town Water Boards whilst the Water Development Department representative participates in an advisory role. Although, there is generally good cooperation amongst the District Officer and the technical Departments of the Ministry of Agriculture, Natural Resources and Environment, on many occasions conflict of interest does not allow clear policies to be followed which, in turn, may not lead to sustainable management of scarce water resources.

It is broadly recognized that this dual responsibility, especially at user level where the WDD is only an advisor, has many disadvantages. Currently there is a decision by Government to bring this responsibility for water under a single ministry. The Government, in 1997, appointed the WDD as the single Water Entity responsible for water while continuing to operate as a government department. The Water Entity is responsible for the following activities: issuing drilling permits; groundwater use and abstraction from all sources by any organized entities; monitoring, control, collection and treatment of wastewater from rural, industrial and livestock areas. The legal, financial, technical and administrative details to implement this decision have been completed. The draft law and regulations that modernizes the water management in full harmony with the European Union Water Framework Directive has been submitted to the House of Representatives and discussions are expected to be initiated on May 2002.

1.5 Management, Institutional and policy options

The initial water policy

Water resource development in Cyprus initially focused on groundwater, because of the high cost of surface water development. However, depletion of key aquifers, together with rising overall demand necessitated a revision of this strategy. With independence in 1960, the slogan, “not a drop of water to the sea”, determined the water policy of the Government of the new Republic of Cyprus and all subsequent governments. Though this policy is still prevalent, water management approaches now are only storing amounts of water that do not affect the recharge of aquifers downstream of the dams, and that prevent saline intrusion in the coastal aquifers.

In the 1960s the island’s water resources were comprehensively surveyed under the “Cyprus Water Planning Project” with the FAO’s assistance. This survey paved the way for implementation of five major development projects based on the conjunctive use of surface and groundwater). These projects, comprising ten dams and using a number of local aquifers, provided 170 Mm^3 of water. The water would be used to irrigate 21 000 ha and provide domestic water to the major cities and surrounding towns and villages. To date, only 70 Mm^3 have been taken up by the farmers. Present storage capacity in Cyprus is 300 Mm^3 having increased from 5 Mm^3 in 1960. The Government also worked on schemes toward the replenishment and protection of groundwater resources and to provide piped water to all towns and villages for domestic and industrial uses.

The present water policy

The basic objectives of Cyprus's present water policy are:

- To secure a sustainable balance between supply and demand at the least possible cost.
- To keep in check increasing demands for water by appropriate pricing mechanisms and information being passed onto the end users.
- To apply irrigation water in line with the actual crops water requirements.
- To modify, as much as possible, cropping patterns in favour of crops with lower water requirements or annual winter grown crops.
- To reduce losses from the urban water distribution systems and to increase the efficiency of domestic water use.
- To emphasize high value crops.

The current Development Plan of the Island for 1999 to 2003 has on the water policy the following basic objectives:

- To complete the construction of major and secondary water works as per the development program. In particular, the works for the combined domestic water supply delivery to the Nicosia area and irrigation on the Tylliria rivers in the northern part of the Troodos mountains yielding a total yield of 18 Mm^3 The remaining water development projects are limited and therefore are not expected to augment the water supply substantially;
- To improve the operation, maintenance and control of the water works to ensure optimal exploitation of existing works;
- To monitor international technological developments regarding desalinating brackish and seawater. With specific regard to how to apply such methods, reuse treated effluent sewage and suppress evaporation from reservoirs;
- To improve the domestic supply of urban and rural areas with a view to securing at least 180 litres per capita per day and 135 litres per capita per day respectively. In particular to use non-conventional sources to ensure a permanent supply of water and remove the dependency on the weather conditions;
- To promote demand management through technical and pricing mechanisms.
- To promote an institutional reorganization to allow effective management of water resources, through the establishment of a single Water Entity;
- To protect water resources (surface and groundwater) from pollution, irrational use and sea intrusion;
- To harmonize as much as possible Cyprus's water policy with the European Union's policy.

1.6 Conclusions

In summary the following may be concluded in regard to the range of circumstances, the regional analysis and the main issues, problems and constraints that are pertinent to water resources and their management in the island.

- Cyprus is an arid to semi arid island state and its renewable freshwater resources are highly constrained. Although a large number of various water supply investments and interventions have been made, Cyprus is still a long way from reconciling the demand to the availability of water.
- The uneven spatial and temporal distribution of rainfall and thus water resources cause the need for the implementation of expensive water development works and inter-basin transfers of water.
- Some 60 per cent of the Island is arable of which 85 per cent is cultivated. Agriculture is by far the main user of water, some 70% of the total water demand, and this will remain so.
- There is a pronounced seasonality of demand peaking in the summer period due to increased irrigation requirements and influx of tourists. Certain choice tourist destination areas experience considerable stress in meeting the water demand. Tourism affects the demand for water and sewerage infrastructure. Ninety-three percent of beds are concentrated along the coast. Tourist water demand accounts for 21% of total domestic, municipal and industrial water demand.
- No significant expansion of irrigation water demand is envisaged in the private or communal sector. Changes however, are expected in all areas with the reduction of low or non-profitable lemon, citrus plantations and table-grapes and their substitution by others. It should be noted that, currently, in Cyprus, the limitation for expanding irrigation is not only water, but also the limited manpower which turns to the expanding tourism industry, services, industries and trade which attract a great number of farmers and villagers to the towns and tourist areas where conditions of life and remuneration are much better.
- The water development in the island is approaching limiting situations since most of the economic sites for surface water dams have been used up and additional reservoirs have prohibitively high costs to develop.
- Only improved water management and redistribution to water conserving uses could provide additional water resources. In addition to this, already Cyprus has turned to non-conventional water such as desalination and reuse of tertiary treated effluent to augment its available supplies.
- The current water policy focuses on water resource management rather than on further water infrastructure development.
- As a result of a prolonged dry period (1990 to present) but also because of insufficient control and effective economic incentives, all the aquifers of the island have been overexploited with the result of serious drop of water levels, sea intrusion to various extent, diminishing of reserves and reduction of the yield of wells. The large surface reservoir construction program has added to the problem since the natural recharge to the coastal aquifers has been reduced without an equal reduction of pumping.
- Environmental concerns are increasing because of the intensity of water utilization coupled with the scarcity of water resources in the recent years. These are further escalating due to the influx of tourism in choice areas and the general growth of economic activities. Water quality though, of both surface and groundwater, is generally good for domestic and irrigation uses. However, insecticide residues and high nitrate

concentrations have recently been observed in dams and aquifers, especially where there is intensive agriculture.

- The Institutional set up as now existing is a rather complex and bureaucratic system made up of at least four involved Ministries on the policy level, 15 Government Departments on the executive level, and a great number of Organisations on the Water Users level either for domestic water supplies or irrigation. New legislation for the protection of water and a new proposed law for water resources management under one Entity together with the implementation of the EU Water Framework directive give a new impetus to the local efforts for water management.
- Water laws are many and complex, including duplications. These have been enacted from time to time in the past as needs demanded, so as to cover the requirements of various water-related interests and authorities, without ever making an effort to group them together in an organized form or code. The recent law on the protection of water from pollution and the bill for the establishment of a water entity will modernize the approach to water resources management.
- The water policy is being conformed gradually to as much as possible, with that of the European Union, taking into account the conditions prevailing in the island. A great effort is currently being made to respond to the demanding provisions of the Water Framework Directive and other EU legislation and operational guidelines.

WaterStrategyMan

EVK1-CT-2001-00098

Report on Greece:

Range of circumstances and region analysis

09/06/2002

Preface

This is the report for the deliverable D1 of Work Package 1 of the WaterStrategyMan project. It has been compiled through the collaboration of:

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The Report contains:

1. An overview of the entire country comprised of analyses of the current situation regarding demand and supply, and the legal, institutional and administrative framework of water management in the country.

2. The selection of three regions for study, Attica, Thessaly and the Cyclades Islands, as candidates for the selection of Paradigms.

3. An analysis of the extended range of circumstances of each selected representative region.

Contents

Abstract

Greece, despite being one of the hydrologically richest (per capita) countries in the Mediterranean, faces severe water shortages in certain regions. Such shortages occur mostly due to the unequal distribution of water resources in both space and time, but also because of human pressures. Increased needs for irrigation in the summer, the tourist pressure in the coastal areas of the country and particularly in the islands, the sometimes lack of necessary infrastructure and of an appropriate administrative framework that can manage the available water resources, exacerbate the problem in the water deficient areas of the country. Through analysis of all Water regions, and specific indices, three regions were selected as representative concerning water deficits, namely, Attica, Thessaly and the Cyclades islands. The range of circumstances in these three regions is analyzed, and presented in table form.

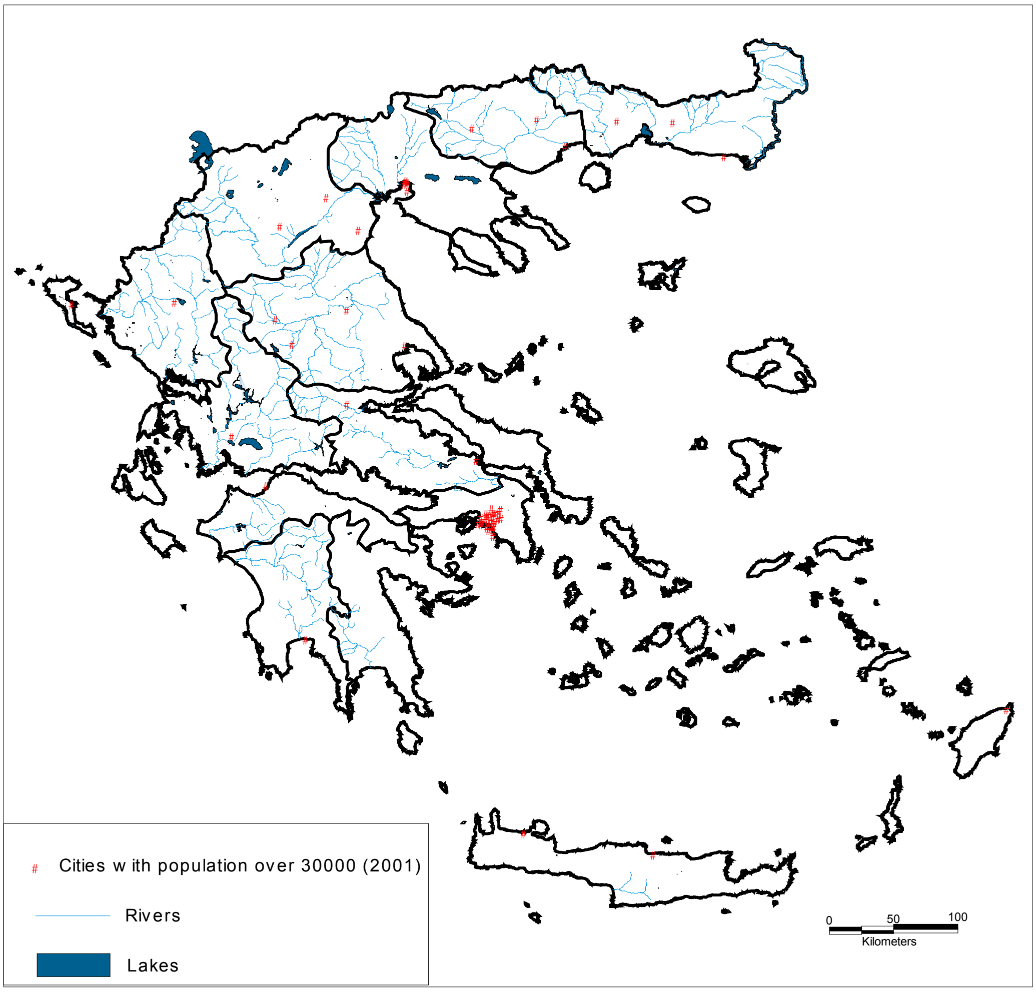
Introduction

The majority of the countries of the Mediterranean region are characterized by a strong seasonal distribution of precipitation, which may be one of the main reasons for the water scarcity problems that they are facing.

Map 1. Greece in the Mediterranean

Although Greece has one of the greatest water resources potential per capita in the Mediterranean area, and should theoretically have ample water for its population and traditional water uses, water is not evenly distributed in space and time. The maximum precipitation is recorded in the western parts, where the available water resources are consequently plentiful, while in other regions of the country precipitation is much lower and available water resources are insufficient to meet the demand. Due to this inequality in water distribution, both in space and time, some areas of Greece, such as Attica and the Aegean Islands are facing long-term water shortage problems. In this report, the status of water resources as well as the framework of water management in Greece are presented and analyzed in two sections; the first section gives an overview of water resources and analyses the management framework in the country, and the second part is comprised of short descriptions of the Greek water sections.

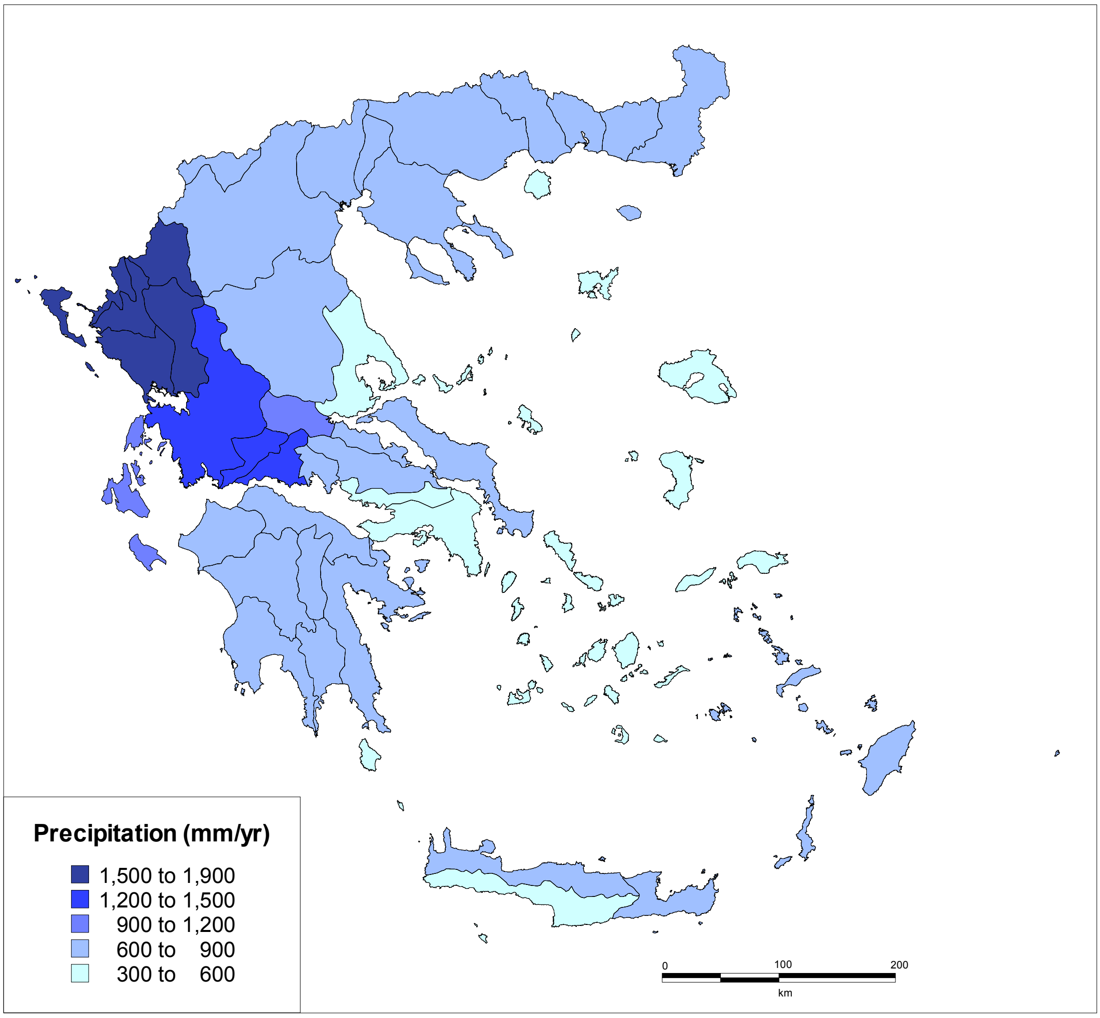
The permanent population of Greece according to the 2001 census was 10,964,080 inhabitants. The recorded tourist arrivals for 1998 were 11,363,822.



Map 2. Surface waters in Greece

Table 1. Summary of Greece's physical characteristics

Background	***Description***
Climate	*In general, the climate is Mediterranean, but varies significantly throughout the country due to different factors, such as the fact that the country is almost surrounded by sea, the geomorphology, and the north – south direction of the main mountainous chain. Thus, in the N – NW tends to be cold with severe winters, whereas in the S – SE and on the islands is temperate. In the winter the air masses that affect the climate are cold and dry N - NE because of the Siberian anticyclone and warm and wet S – SW because of the Azores anticyclone. On the contrary, in the summer the prevailing system is of northern, dry, continental winds.* *The annual precipitation varies from 200 mm at the plain and insular regions to 2150 mm on the mountainous regions.*
Geomorphology	*Greece is mostly a mountainous country. Its main mountainous chains is that of the Pindos Mountains' which run in the N, NW – S, SE direction and covers part of West Macedonia, Epirus, Peloponnesus and Crete forming a continuation of the Alpine folds and upraises. Another significant mountain chain is Rhodope which runs along the northern borders of the country.* *In Greece there are no plains in the geographical sense but only basins formed among the mountain chains which have been broadened due to the corrosive action of rivers.* *One of the main characteristics of the country is the extended coastline and the significant number of islands.*
Geology	*Formations are mainly composed of limestone (with many karstic horizons) and sedimentary rocks (flysch, schistones, etc). There are also metamorphic, igneous and volcanic rocks, as well as tertiary and quaternary deposits.*
Ground Water	*Many aquifers have been formed primarily in the sedimentary materials and the estimated amount of stored ground water is about 10,300* hm^3*/year.*
Surface Water	*There are 765 recorded streams, but only 45 are classified as perennial. Four rivers flow from the northern countries into Greece and only one crosses the border into Albania. There are also many seasonal springs that feed into various smaller streams.* *Greece has almost 60 lakes, three of them trans-boundary.*
Water storage features	*Dams of various capacities have been constructed for domestic and irrigation purposes and the production of hydroelectric power.* *There are also several small water reservoirs that are used mainly for irrigation.*



Map 3. Precipitation in Greece

1. Overview of the country

1.1. Water Demand and Supply Status

Almost 100% of the Greek population is connected to water supply and power utilities, while 76% of the population is connected to sewerage and wastewater treatment networks. Generally, water demand in Greece peaks in the hot and dry summer months, when water availability is at its lowest, due to the decrease in precipitation. The summer peak is due to the heat that encourages increased water usage, to the influx of visitors to the country during the summer tourist season and to the current irrigation practices and cultivated crop types.

There is a lot of data regarding the natural environment for the majority of Greece. However, they are not usually stored in relevant databases, and considerable amount of effort and research are required to retrieve them. In addition, not all the available data are valid, some are outdated or unreliable. There have been considerable efforts lately to collect, categorize and verify the available data, particularly in the HydroloGIS system. Overall however, it may be said that data availability regarding the natural environment is good. It is not so regarding water demand and supply, especially on what refers to the agricultural use of the water.

- Regarding domestic and industrial water use, there are data on urban areas and the biggest settlements, which may be made available by the water companies and utilities. In smaller communities, the data are scarce and non-dependable. Overall, data are mostly available where organized water utilities operate.

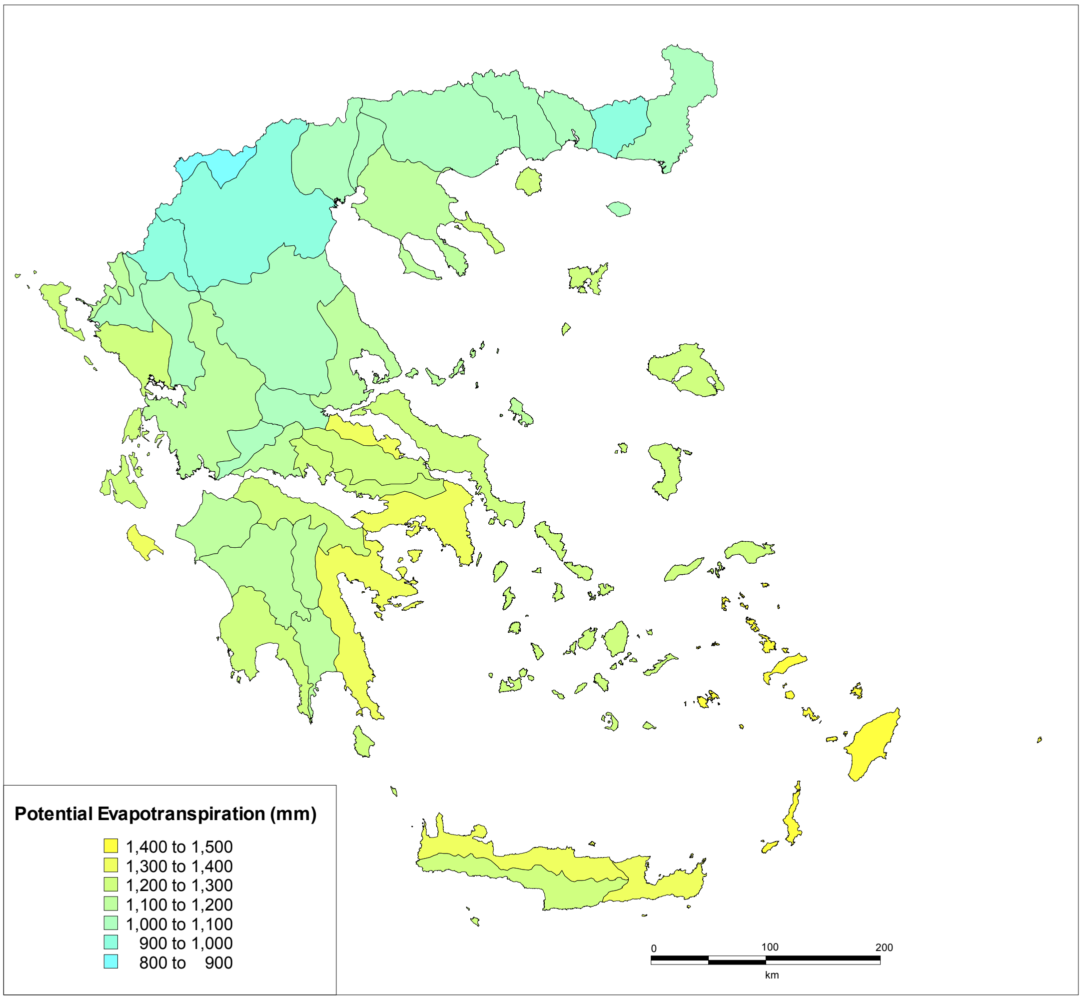
- Regarding agricultural water use, the volumes are usually estimated on the basis of the area of irrigated land (according to the Greek statistics services) multiplied by an index of irrigation requirement according to cultivation type. Since a large part of the water used for irrigation is obtained through private drills, often without a license, there are no exact measurements of the full volume of water used for irrigation, but only of the volumes provided by the local public irrigation networks.

Table 2. Annual water balance

	Flows (hm^3/y)
Precipitation	*113,402*
Surface water evapotranspiration losses (assumed to be 50% of precipitation)	*-56,701*
Surface water flows	*58,700*
Groundwater flow	*10,300*
Net potential surface and groundwater available	*69,000*
Net exploitable surface and groundwater	*5,480 – 7,940*

In some parts of the country, in addition to the limited water resources, water pressure may also be attributed to the large influx of visitors from other parts of the country or from abroad. Figures for tourist numbers vary from year to year and between measurements. The Aegean Islands have the highest visitor/tourist number compared to the permanent population. In August the peak number of visitors to the Aegean Islands is on the average ten times greater than the local population, and in certain islands it is even thirty times the local one.

About 14 km^3/y of water entering Greece (about 30% of total average annual water resources) originates in neighboring nations, where the water is both abstracted and used for effluent disposal. Thus, conflict arises in cases that the rivers are over-abstracted upstream, and where the quality of the waters deteriorates to the point that it cannot be used for its intended use downstream. Since international agreements are still pending and as the exploitation rate increases in the upstream countries, quantity conflicts are also due to happen.



Map 4. Potential Evapotranspiration in Greek hydrological basins

Given the water scarcity observed in parts of the country, conflicts are unavoidable to happen:

- **In urban centers,** where the main area for conflict is the transfer of water from other, richer in water resources regions or the exploitation of water resources that would be used for irrigation. Cases of water deficient urban centers are the Metropolitan Athens area and Thessaloniki.

- **In agricultural areas,** where conflict arises due to the excessive usage of water for irrigation purposes, which may be used for domestic supply and tourist activities, as well as for maintaining the ecological characteristics of the surface and ground water of the area. The agricultural activities and practices in Greece have neither been "modernized" nor adapted to current requirements and standards. One consequence is the vast amounts of water used for irrigation (irrigation uses almost 85%, while domestic uses are 13% and industrial uses are 2%), amounts that could be drastically reduced through the introduction of more efficient irrigation networks and a more organized selection of crops.

- **In areas dependent on tourism,** and particularly in the Aegean islands, conflicts are very intense. During the summer months, water demand reaches its peak both for irrigation, and for domestic supply; in some islands the summer peak can reach up to thirty times the domestic needs of the permanent population. As the domestic supply takes priority over the use for irrigation, conflicts invariably arise between the municipal water supply and the local farmers. Water resources in the Greek islands are very limited, and with few exceptions consist of groundwater contained in the local aquifers. The amount of water that can be abstracted is limited, as over-abstraction of those aquifers leads to salinization of the water rendering it mostly unusable. The soils in the islands are extremely vulnerable to erosion with resulting problems in developing the water resources (reservoir sedimentation, stream bed stability etc.).In this regard, the future of the islands may be threatened by increasing coastal areas stress, by expanding differences between tourist areas and the rural hinterlands, serious water resources interdependencies, high susceptibility to pollution, and by the sensitivity between the water and soil equilibrium.

Table 3. Available water resources in the 14 Water regions[1]

Water Availability (hm^3)	KEPE (1972)			AGELAKIS (1989)			*MINISTRY OF DEVELOPMENT (1996)*		
	Estimated Surface Water	Exploitable Groundwater	Total	Surface Water	Ground Water	Total	Surface Water	Ground Water	*Total*
01 Western Peloponnesus	2720	150	2870	3050 2750[2] 3462 (2273)[4]	700 (80)[2] 1882[3] 400 (80)[4]	3750 2830[2] 5344[3,4] 3862[4]	3534 (runoff) 46 (regulative)	423 (potential)	*4400 (potential)*
02 North Peloponnesus	3200	100	3300	2650 3201[2] 3190(831)[4]	900 (3500)[2] 1800[3] 700 (100)[4]	3550 6701[2] 4990[3,4] 3890[4]	2280 (runoff)[5] 160 (regulative)	400 (exploitable) 480 (degraded) 1660 (potential)	*3940 (potential)*
03 Eastern Peloponnesus	1243	108	1351	1000 1316 (63)[4]	950 (80)[2] 1774[3] 800 (116)[4]	1950 1973[2] 3090[3,4] 2116[4]	-	-	-
04 Western Sterea Ellada	11649	100	11749	9750 12816(7342)[4]	850 2200[3]	10600	5296 (potential) (3926)[6] 4523 (stored capacity)	3384 (potential)	*8680*
05 Epirus	8591	56	8647	8500 8591[2]	250 (59)[2]	8750 8650[2] 10900[3,4]	5938 (runoff) 1007 (regulative)	4412 (potential)	*10350 (potential)*

[1] Amount in brackets ( ) is amount measured

[2] Ministry of Agriculture

[3] IGME

[4] Land-planning research team - Doksiadis

[5] Koutsogiannis, 1996

[6] 600 hm^3 to Thessaly, 480 hm^3 to the city of Athens

Water Availability (hm^3)	KEPE (1972)			AGELAKIS (1989)			*MINISTRY OF DEVELOPMENT (1996)*		
	Estimated Surface Water	**Exploitable Groundwater**	**Total**	**Surface Water**	**Ground Water**	**Total**	**Surface Water**	**Ground Water**	***Total***
				8895(6817)[4]	259 (59)[4]	9154[4]			
06 Attica	219	20	239	200 219(16)[4]	200 (2)[2] 189[3] 443 (68)[4]	400 221[2] 400[3] 662[4]	259(potential) 41 (regulative)	190 (potential)	*449 (potential)*
07 Eastern Sterea Ellada	1815	280	2095	1900 1816[2] 1981(807)[4]	750 (89)[2] 910[3] 481 (201)[4]	2950 3051[3,4] 2462[4]	2874 (potential) 1400 (lakes)	1673 (potential) 1126 (regulative)	
08 Thessaly	3424	655	4079	3250 3253[2] 3356(3052)[4]	1350 (590)[2] 2140[3] 1090 (590)[4]	4600 3843[2] 5496[3,4] 4446[4]	2558 (potential) 2054 (storage capacity)	506	*3064*
09 Western Macedonia	4388	300	4688	4100 4320[2] 4356(2669)[4]	850 (417)[2] 1095[3]-1100[7] 717 (417)[4]	4950 4737[2] 5451[3,4] 5073[4]	-	-	-
10 Central Macedonia	6299	256	6555	6900[8] 7186[2] 7120(1152)[4]	624 (344)[4] (344)[2]	7744[4] 7530[2]	-	-	-
11 Eastern Macedonia	4600[9]	200	4800	4200[10] 4419 (2760)[4]	550 650[3] 552 (402)[4]	5069[3,4] 4971[4]	-	-	-

[7] Annual Replenishment

[8] 4219 hm^3 from former Yugoslavia

[9] 2300 hm^3 from former Yugoslavia

[10] 2300 hm^3 from Bulgaria

Water Availability (hm³)	KEPE (1972)			AGELAKIS (1989)			*MINISTRY OF DEVELOPMENT (1996)*		
	Estimated Surface Water	**Exploitable Groundwater**	**Total**	**Surface Water**	**Ground Water**	**Total**	**Surface Water**	**Ground Water**	***Total***
12 Thrace	10991[11]	180	11171	10900[12] 10991[2] 10983(1260)[4]	400 (180)[2] 730 (180)[4]	11300 11171[2] 11393[3,4] 11713[4]	10277[13]	485	*10762*
13 Crete	1564	105	1669	1300 300[2] 1355(300)[4]	1300 1300 (890)[2] 454 (304)[4]	2600 1659[2] 1809[4]	1558	1300[14]	*2858*
14 Aegean Islands	*856*	*49*	*905*	*1000* *1080[2]*	*250* *(61)[2]* *61[4]*	*1250* *1141[2]* *1141[4]*	*1561 (potential)* *74.3 (future storage capacity)*	*527 (potential)*	*2088*

Table 4. Water consumption in the 14 Water regions

11 2986 hm^3 from Bulgaria

12 7480 hm^3 from Bulgaria

13 7500 hm^3 from other countries

14 330 hm^3 brackish water

Water Consumption (hm^3)	KEPE (1972)							AGELAKIS (1989)				*MINISTRY OF DEVELOPMENT (1996)*[15]			
	Domestic Use		Irrigation		Industry		Total	Domestic Use	Irrigation	Industry – Energy	Total	Domestic Use	Irrigation–Animal Husbandry	Industry – Energy	*Total*
	Surface Water	Ground Water	Surface Water	Ground Water	Surface Water	Ground Water									
01 Western Peloponnesus	5	3.2	72	18	1	0.8	107	22	200	12	234 103[16] 607[17]	23	206	23	*252*
02 North Peloponnesus	9	7	118	32	3	3	174	37	400	3	440 328[2] 563[3]	41.7	408.1	3	*452.8*
03 Eastern Peloponnesus	7	3	70	75	1	2	158	17	200	3.5	220.5 190[2] 828[3]	-	-	-	-
04 Western Sterea Ellada	5.9	1.8	174	20	0.1	0.2	202	15	260	0.5	275.5	22,4	376.9		*398.3*
05 Epirus	8.2	2	120	18	0.8	1	150	28	230	4	262	42.64	385.4	1	*429.05*

[15] Demand

[16] Ministry of Agriculture

[17] IGME

Water Consumption (hm^3)	KEPE (1972)							AGELAKIS (1989)				*MINISTRY OF DEVELOPMENT (1996)*[15]			
	Domestic Use		Irrigation		Industry		Total	Domestic Use	Irrigation	Industry – Energy	Total	Domestic Use	Irrigation–Animal Husbandry	Industry – Energy	*Total*
	Surface Water	Ground Water	Surface Water	Ground Water	Surface Water	Ground Water									
06 Attica	124.4[18]	11.7[19]	3	10	7.6	1.3	158	255 203[3]	70 49[3]	17 65[3]	342 48[2] 317[2]	289	101.5	17.5	*408*
07 Eastern Sterea Ellada	9	5	99	26	3	2	144	36	380	5.5	421.5	165.9[16]	783.6	12.6	*962.1*
08 Thessaly	12	13.1	127.5	297,5	2.5	5.4	458	58 47.3[2]	720 934.2[2]	7 3.9[2]	785 985.4[2] 1146[3]	53.7	1580.5 (1297.2)		*1634.2* *(1350.9)*
09 Western Macedonia	14	4	285	24	-	-	338	40 48[10]	370 582[2]	30	440 652[2]	-	-	-	-
10 Central Macedonia	1.7	27.6	229	81	14.3	6.4	360	72 75[20]	280 477[2]	20	372 569[2]	-	-	-	-
11 Eastern Macedonia	2	10	187	25	-	7	231	23 28[6]	390 439[2]	9.5	422.5 426[2]	-	-	-	-
12 Thrace	2.9	6.9	125	25	0.1	0.1	160	27	420	6	453 536[2]	248.1[21]	2.5[7]	2.5[7]	*253.1*[7]

[18] 116 hm^3 from 07 (East Sterea Ellada)

[19] 4 hm^3 from 07 (East Sterea Ellada)

[20] Ministry of Internal Affairs

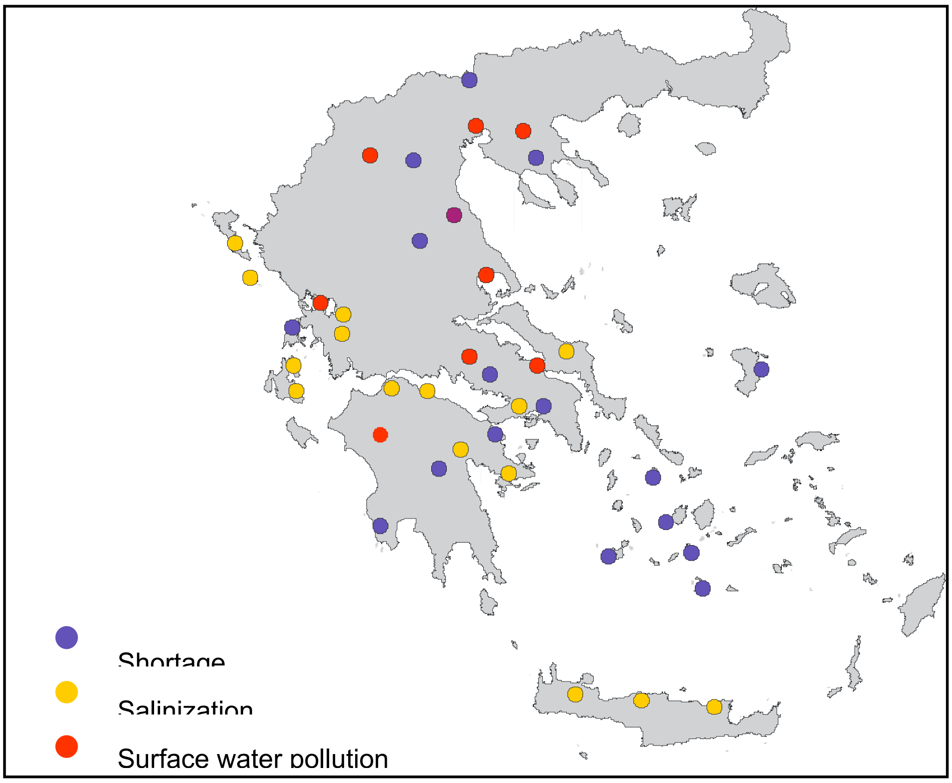
[21] Only for July

Water Consumption (hm^3)	KEPE (1972)							AGELAKIS (1989)				*MINISTRY OF DEVELOPMENT (1996)*[15]			
	Domestic Use		Irrigation		Industry		Total	Domestic Use	Irrigation	Industry – Energy	Total	Domestic Use	Irrigation– Animal Husbandry	Industry – Energy	*Total*
	Surface Water	Ground Water	Surface Water	Ground Water	Surface Water	Ground Water									
13 Crete	9.8	3.0	67	45,7	0.2	0.3	126	33	220	2	255 192[2]	42.33	330.2		*372.53*
14 Aegean Islands	*8*	*4.0*	*21.9*	*27,6*	*0.1*	*0.4*	*62*	*33*	*80*	*1*	*114* *89*[2]	*37.19*	*87*		*124.19*

1.2. Environment and protection

Overall, the coastal waters of Greece are of good quality, with the exception of the areas where effluents from the larger cities (Athens, Thessaloniki, Volos) are discharged. The same cannot however be said for the surface and ground waters. Until now, water pollution has been one of the main issues in trans-boundary water resources, as the disposal of raw domestic and industrial effluents has had profound effects on rivers like the Axios and their estuaries. However, despite the high levels of industrial pollutants in Greek rivers that pass through the upstream Balkan nations, the major sources of water pollution within Greece are agricultural runoff and untreated domestic effluents. No effluent charging systems exist and the sewage is discharged into the wastewater system for a nominal charge.

Domestic effluents and agrochemicals are a major source of surface and groundwater pollution in many parts of the country. Despite the existing EU legislation for all communities with a population above 2000 inhabitants to be connected to wastewater treatment plants by the year 2000, such progress could not be documented. Besides effluents and other pollutants entering the waterways, the quality of Greek river systems is dependent on the time of the year. Water levels decrease significantly in the summer, thus allowing higher concentrations of pollutants. Furthermore, overabstraction and saline intrusion in the underground aquifers exacerbates the problem of groundwater deterioration and increases the water shortage problems.



Map 5. Quality and quantity problem areas

Another issue that should be mentioned here is the occurrence of periodic droughts and floods, occurring in increasing frequency in the recent years. In the last decade, there were two serious droughts that affected the country, and particularly the capital city which depends on water transfers. The combination of prolonged drought periods with intermittent floods after torrential rainfall also worsens the pollution problems of urban and agricultural runoff, particularly in large urban centers like Athens, and agricultural plains like Thessaly.

1.3. Water laws and regulations

In the Greek legal system there are several laws and regulations for the allocation of water resources, the management of water resources and services, and the quality and quantity aspects of water regarding each use. According to Article 24 of the Greek Constitution, the protection of the natural environment is not only a responsibility of the state, but also of the citizens. The state is under obligation to take preventive and corrective measures for the protection of the natural environment in the framework of sustainability. These measures should be taken both on the legislative and the administrative level.

The protection of water resources is also regulated by a number of international agreements and legislation, such as the Ramsar international agreement about the protection of internationally important wetlands. Several EU directives on the protection of waters and public health have been adapted by the Greek legislation (98/83/EC, 91/767/ EC, 87/217/ EC, 86/280/ EC, 84/491/ EC, 83/513/ EC, 82/176/ EC, 80/68/ EC).

Law 1650/1986 regulates the sampling and ascertaining the quality of water, depending on the type of the receiving waters that require protection and the sensitivity of the local ecosystems. It also proposes a group of measures and limits for the protection of waters from building projects and activities, effluent and usable water standards, sampling and measuring equipment etc (Article 10).

Map 6. Districts and Prefectures of Greece

Of the Greek legislation, the most important ones regarding the administrative aspect of the resource are laws 1739/1987 and 1069/1980, which formulate the general framework of water management and the framework of municipal water supply respectively.

Law 1069/1980 regulates the foundation and operation of municipal water supply utilities. According to the law, any municipality with a population over 10,000 people can proceed to create a public water utility. The municipality’s responsibilities for water supply, sewerage services, and refuse collection are transferred to the utility, which also assumes the ownership of all networks and infrastructure related to those duties, as well as the responsibility for the provision, financing and monitoring the quality of services. It should be stressed that free flowing waters are characterized by the Article 967 of the Civil Law as communal resources that cannot be traded. Therefore, they are not part of the holdings of the municipal utilities or authorities, but rather resources that can be exploited for public, municipal or religious uses.

Law 1739/1987 regulates all procedures and administrative instruments that will allow the management and protection of water resources on the national and regional level. The law defines water resources to include all surface and groundwaters, regardless of quality, origin or potential use, the waters of natural springs, inland or marine, and the waters of thermal and gaseous springs. This law functions as a framework for the administration, rather than actual management, of water resources. It defines the responsible authorities and instruments, and elaborates on the responsibilities of existing structures (e.g. the ministries, the Power utility etc). It also legislated the creation of new instruments for effective water management in Greece.

The Department of Water and Natural Resources is based in the Ministry of Development, which supervises also the Interministerial Water Commission. The Interministerial Water Commission, created with law 1739 acts as a consulting body for the formulation of the national water policy. At the same time, the country was divided into fourteen water regions, and Regional Water Commissions and Regional services of Water Resources Management were introduced as branches of the Ministry of Development.

So far, law 1739/1987 has yet to be fully implemented as most of these agencies are not fully functional. One of the major disadvantages of the current institutional framework for the management of water resources is the fragmentation and scattering of responsibility among different agencies, which leads to overlaps in responsibility and difficulty in coordinating the actions of the different authorities. Table 5 in the following section summarizes the authorities responsible for the different aspects of water management according to law 1739/1987.

1.4. Institutional framework and constraints

Responsibility on water allocation and management is distributed in the national, regional and local levels of administration. The initial allocation of water is done by the Ministry of Development, which is responsible for water allocation to individual uses, as well as for the management of water designated for industrial use. Once the initial allocation is effected, the water for each use falls under the responsibility of the respective ministry. The most important ones are the Ministry of Agriculture, responsible for the use of water in irrigation, the Ministry of the Interior, responsible for the use of water for municipal water supply, with the exception of the cities of Athens and Thessaloniki, and the Ministry of the Environment, Urban Planning and Public Works (MEUPPW), responsible for the use of water for the water supply of Athens and Thessaloniki and the conservation of the quality of the environment (See Figure 1).

The most pressing issue is the fact that there are many government departments dealing with water problems, but their activities are compartmentalized and not well-coordinated. Added to this is a water law system which is not responsive to modern issues of an industrial society and widely scattered, thus permitting overlapping functions, multiple advisory bodies and insufficiently decentralized management responsibilities through regional organizations. A Master Plan has yet to be formulated along with the corresponding management principles for the 14 water regions. Legislation tends to be also deficient in the case of pollution issues, where quality standards for water bodies and/or effluent disposal have not been clearly established. Furthermore, the sporadic consideration of water quality issues in a coherent water policy and the absence of systematic, uniform and enforceable pollution charges have compounded problems and have handicapped water resources management efforts.

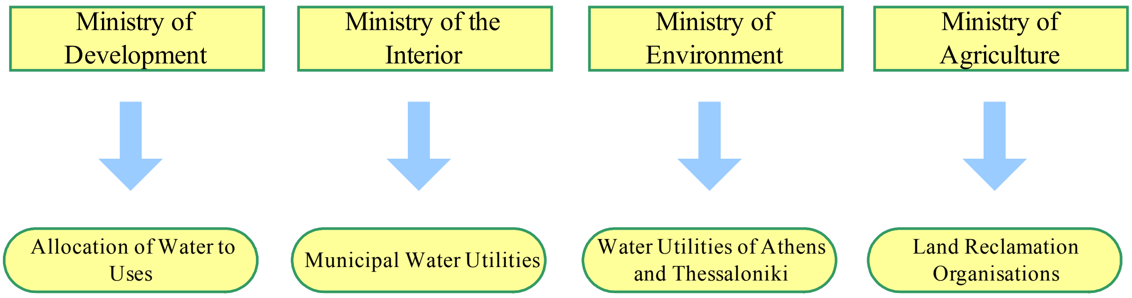
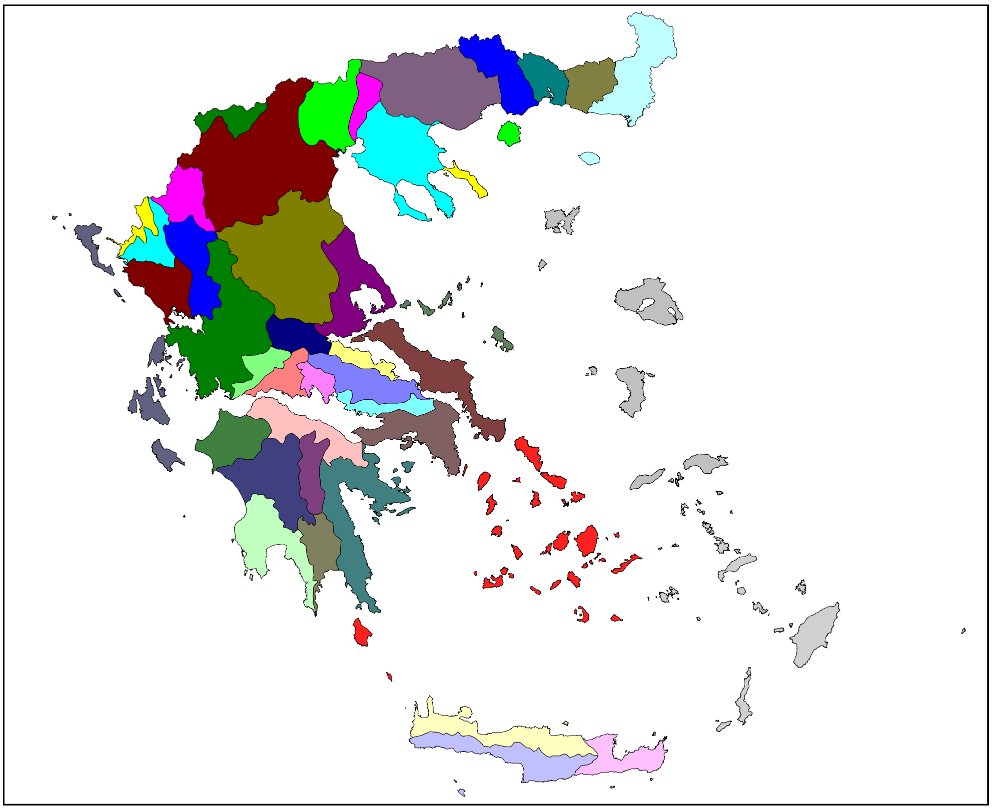


Figure 1. Water Governance in the National Level

On the regional level, the regional authorities are responsible for the approval of planning and financing for projects involving water supply and irrigation. Prefecture authorities are responsible for the issuing of permits for abstraction and for the allocation of water within each region/use. On the local/municipal level, the municipality is responsible for the supply water and services to the people, or, for the creation of public companies responsible for the provision of water and sanitary services, (see table 5).

Table 5. Responsible Authorities in the Water Sector

Agency/Authority	***Responsibilities***
Ministry of Agriculture	*Use in irrigation and animal husbandry* *Undertaking and participation in water resources management research programmes*
Ministry of the Interior	*Supervising Municipal water supply, except for Athens and Thessaloniki* *Provision of water services in cases where municipalities are unable* *Undertaking and participation in water resources management research programmes*
Ministry of the Environment	*Protection of water quality and quantity* *Supervising water supply to Athens and Thessaloniki* *Providing water services in cases where municipalities are unable to* *Undertaking and participation in water resources management research programmes*
Ministry of Development	*Responsibility for the allocation of water to use categories* *Use of water in industry and energy production* *Coordination and follow-up on research, exploitation and protection activities* *Provision of any uses and services not included in the responsibilities of other agencies* *Undertaking and participation in water resources management research programmes*
Ministry of Transportation	*Use of water in transportation*
Ministry of Culture	*Use of water in sports*
Ministry of Foreign Affairs	*International water issues*
Ministry of Health and Welfare	*Undertaking and participation in water resources management research programmes*
Regional Authorities	*Approval of municipal decisions for the creation of Water Utilities, the extension of the duties of Water Utilities, or the participation of other municipalities in Water Utilities*
Prefecture Authorities	*Issuing of water use licenses* *Provision of water services in cases where municipalities are unable to*
Municipal Authorities	*Provision of water services* *Creation of Municipal Water Utilities*
National Tourism Organization	*Use of water in recreation and therapeutic spas*
Public Power Corporation, *National Institute of Geological Research,* *National Meteorological Services,* *National Center for Marine Research*	*Undertaking and participation in water resources management research programmes*



Map 7. The 44 hydrological basins of Greece

1.5. Management, Institutional and policy options

As has been mentioned above, currently the focus in Greece is on developmental policies (see table 6) rather than on water resources management and policies. Law 1739/1987 provides the basic framework for water management, which is however not currently fully applied. The management of resources is essentially effected on a regional level, after the initial allocation to uses.

Table 6. The development priorities

Area type	***Development Priorities***
Urban	*Meeting the needs of maintaining the water infrastructure (transport, water supply and sewerage, refuse disposal areas)*
Agricultural	*Promoting less intensive agriculture practices. Reuse and conservation.*
Tourist destinations	*Improving the tourist quality to higher income groups* *Supporting the workforce*

As the local authorities are responsible for water use, with the exception of protected water bodies and areas, the management of water resources is poor and disorganized. Maintenance of infrastructure in the more remote areas tends to be poor, while long term contingency planning is almost non-existent. Financial constraints are the main reason behind the poor management and lack of planning (see table 7). Responses to water shortages vary depending on the area and the conditions.

Overall they tend to be short-term responses, driven by crises that require the confrontation of the acute shortages. In cases of water shortage, supply augmentation management options are used most often. Demand reduction management principles have been used in the past, particularly in the Athens Metropolitan Area in the early 1990's, where increased water prices were successfully used to compensate for the prolonged drought that led to severe water shortages. Even the limited demand reduction management responses applied may not be widely used as the price of water tends to play a pivotal role in political processes. Overall, the growth of the greater capital area has been supported by a series of reservoirs and abstractions from the western parts of the country.

Generally, the means used to confront water shortages have depended mainly on the cost of the method. Hence, the first response to water shortages invariably involves new drilling of the aquifers. Groundwater is extensively used both for domestic and irrigation water supply throughout the country, and particularly in the Aegean Islands.

In cases where the quality or quantity of groundwater does not meet the required standards, an alternative way of ensuring water supply is importing water from neighbouring, richer water areas (water hauling by ships, underwater pipes etc). For permanent water shortage other structural solutions are preferred. Dams and reservoirs are used where there are funds available, and locations suitable, for their construction; alternatively, desalination plants are also used in cases of more limited funds or lack of suitable locations.

Table 7. Constraints facing the water sector

Category	***Constraints***
Natural	*Uneven water resource distribution* *Uneven precipitation distribution, spatially and temporally* *Dependence on transboundary waters*
Human	*Uneven population distribution* *Tourist influx is uneven in space and time* *Excessive water consumption for irrigation* *Demand peaks in the dry season* *Groundwater is contaminated by pollutants* *Overexploitation of underground aquifers causes salinization and irreversible damage* *Lack of environmental awareness*
Technical	*Local authorities lack the technology, know how and specialised personnel needed for long term management and for the construction and particularly maintenance of water infrastructure* *Old distribution networks with high losses* *Some areas very deficient in resources require new technologies (e.g. the islands) or the transfer of water from remote areas (e.g. Athens)* *Lack of proper irrigation techniques that would save water* *Illegal connections to the networks*
Financial	*Deficient allocation of funds to the remote regions, exacerbated by the multitude of responsible authorities* *Water pricing is politically influenced and not based on water cost, leading to inadequate finances for the funding of further infrastructure*
Administrative and institutional	*Lack of well defined, long-term water policy* *Focus on short – term development policies* *Lack of coordination among responsible authorities* *Inadequate setup of water authorities with overlapping responsibilities* *Distribution of responsibility to local authorities with limited resources* *Management units are defined politically rather than basin-wide* *Lack of reliable data on supply and demand, particularly for irrigation* *Lack of public awareness on water issues, and of public participation in decision making*

There is great need for new approaches to water management that will serve to mitigate at least some of the above problem issues and constraints, and promote sustainable use of the available resources while aiding to achieve the aims of development policies. It may also be pointed out that the traditional spatial environmental view has been imploded and project boundaries - and their impacts and consequences - are becoming much more diffuse. Hence, a strategic approach is needed that should include drastic measures of ecological rehabilitation, innovative institutional mechanisms, and a balance between autonomy and cooperation. Such integrated approaches should incorporate environmental monitoring and information by expanding the factual basis of holistic urban/industrial water management models. In addition, they should also be accompanied by a framework for negotiations that stresses the importance of comprehensive institutional formats and the clarity in local and national decision making processes.

Table 8. Water Resources Planning Matrix

Activity	**Municipal Authority/ Water Utility**	**Regional Authorities**	**Prefecture Authorities**	**Ministry of Development**	**Ministry of Environment**	**Ministry of Agriculture**	***Ministry of Finance***
Surface water							
Use	X			X			
Storage	X				X	X	*X*
Recharge					X		
Diversion				X	X	X	
Quality monitoring					X		
Assessment					X		
Ground water							
Use	X			X			
Storage	X				X	X	
Recharge					X		
Quality monitoring					X		
Assessment					X		
Well/drill permits			X				
Irrigation network							
Rehabilitation	X		X			X	
Modernization	X		X			X	
Reuse							
Drainage water					X	X	
Wastewater					X	X	
Desalination	X			X	X		*X*
Introduction of technology	X			X			
Efficient water utilization							
Domestic	X						
Industrial				X			
Irrigation						X	
Legislation							
Regulation and codes				X	X	X	
Standards					X		
Policy setting				X			
Water allocation				X			
Project financing	X	X	X				*X*
Project design	X	X	X	X			
Project Implementation	X			X			
Operation and maintenance	X						
Pricing	X						
Enforcement	X						
Water Data records				*X*	*X*	*X*	

1.6. Conclusions

The main constraints and problem issues are the following:

- Dependence on transboundary waters flowing from non-EU regions. Waters flowing from non-EU regions are very difficult to regulate, particularly in matters of quality; the lack of infrastructure in the neighboring countries results in pollution downstream into Greek waters.
- Strong dependence on irrigation. Even with the best management techniques and strategies, agriculture will remain the major user of water in the country, due to the hot and dry climate.
- Pronounced seasonality of demand, which makes the provision of water services harder, as it is not always possible to ensure adequate supply.
  - The demand that is due to tourism peaks in the summer when a major influx of tourists is observed.
  - The demand for agriculture peaks in the dry hot season, the same time as the domestic demand peaks due to tourism.
- Uneven distribution of resources. Both precipitation and surface water resources are concentrated in the western and northern parts of the country which are self-sufficient, while the eastern and southern parts of the country face water shortages.
- Uneven distribution of population. Overall, the population is concentrated in the eastern coastal areas which tend to be under stress. Furthermore, the concentration of almost half the Greek population in Athens, in the poorest water region of the country, and the seasonal influx of visitors to the Greek islands, exacerbates the water shortage problems.
- Overexploitation and salinization of aquifers, which is a common problem in the areas dependent on groundwater, and particularly in coastal areas.
- Water quality deterioration due to human activities.
- Focus on short – term developmental policies rather on the actual water resource management.
- Lack of inter-ministerial coordination and overlaps in areas of authority.Instead of an organized, coordinated approach to water resources management, measures taken are only partial and generally ineffective.
- Absence of master plans or national guidelines for comprehensive planning and management in the past, despite recent efforts for responding to that problem.
- Lack of organized, collective efforts, which are required to respond to the demanding provisions of the Water Framework Directive and other EU legislation and operational guidelines.

WaterStrategyMan

EVK1-CT-2001-00098

Report on Italy:
Range of circumstances and region analysis

July 2002

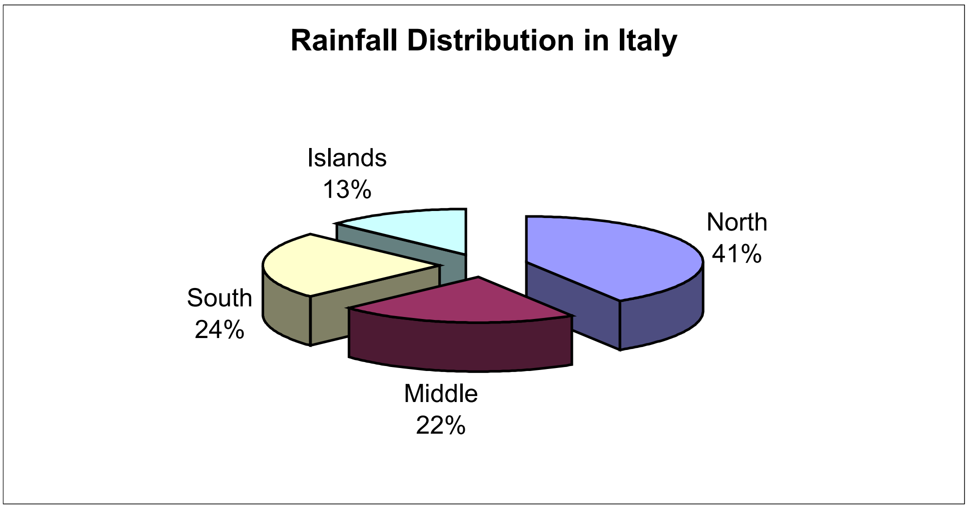
Contents

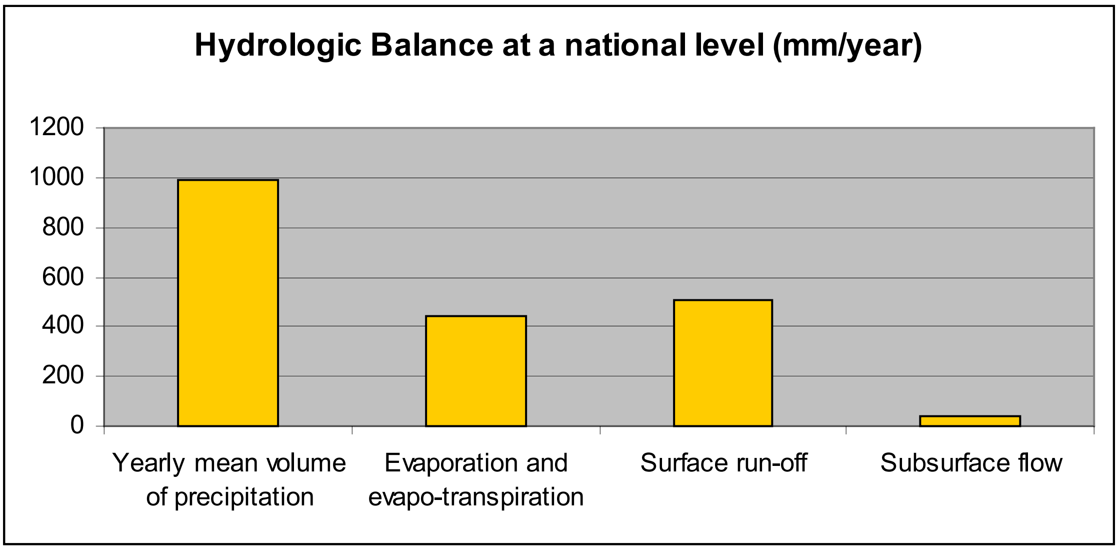
Abstract

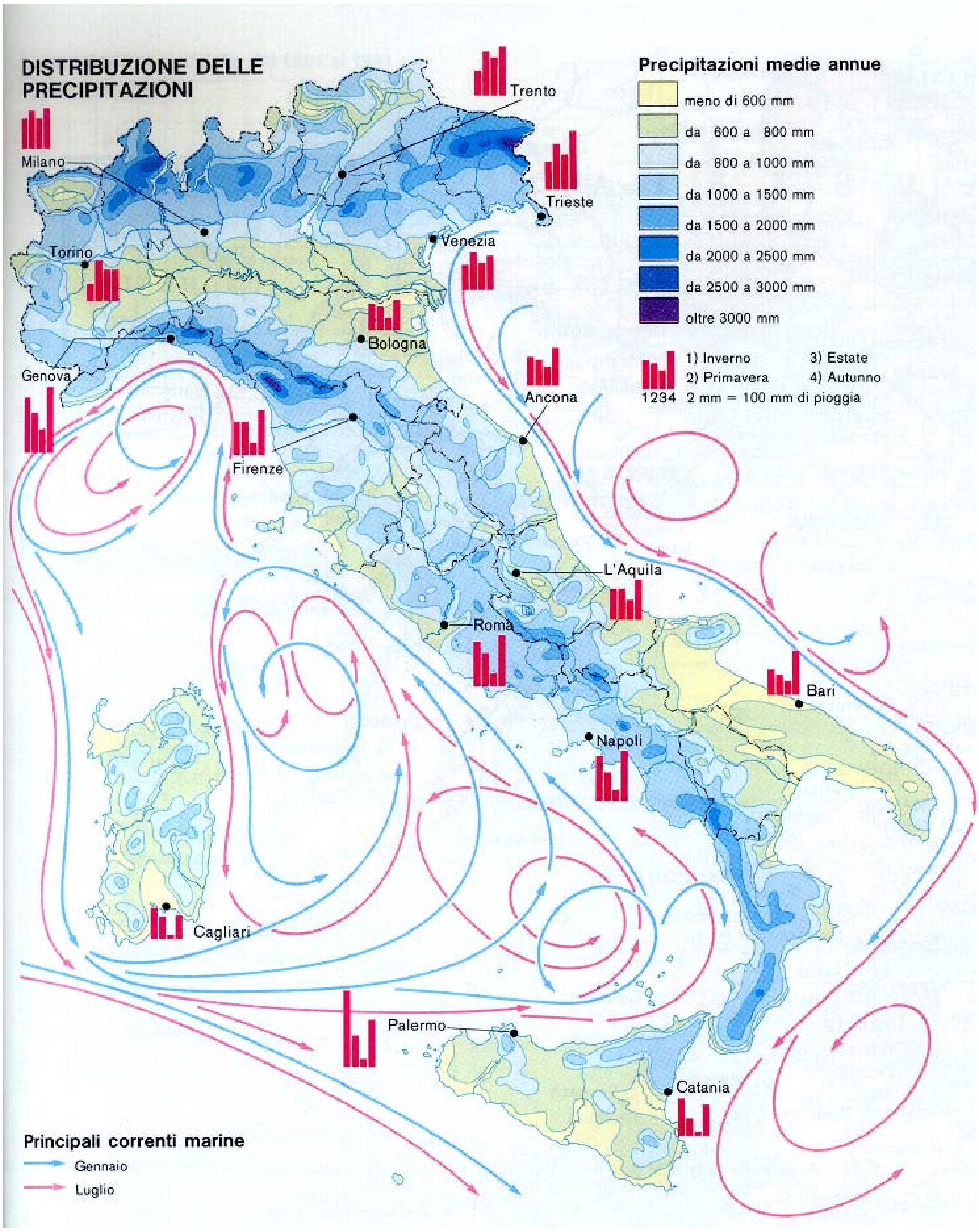
Availability of water in Italy is conditioned by the peculiar climatic characteristics and extremely variable from point to point. At the country level, with the help of several reservoirs, the total usable surface water can be estimated around 39.7 km^3; groundwater is about 12 km^3. In respect to the actual population, the annual available resource varies from 388 m^3/hab (Sicily) to 1,975 m^3/hab (North East zones). Conspicuous withdrawals provide the supply for domestic, agricultural and industrial utilisation with a complex convey and delivery network. Drainage systems, not always equipped with efficient treatment plants, discharge wastewater in rivers, lakes and coastal waters, polluting surface and groundwater bodies. At the same time, the characteristic hydrologic conditions are responsible of frequent heavy rainfall, causing floods and landslides. Utilisation, protection and control of water resources are therefore a complex problem, further aggravated by the lack of appropriate governing systems.

Introduction - Physical and Hydrological Situation

Considering the hydrologic status of Italy, the country shows extremely variable situations. In the North of Italy there are great basins supplied by the Alps and characterised by high water flow; on the contrary, along the Apennine range, water courses have a narrower basin and a more irregular course.
The mean yearly precipitation in Italy is estimated in 300 billion m^3 that is 990 mm, greater than the European mean value of 646 mm.
Distribution of rainfall along the Italian territory is described by the following graph:




Hydrologic Balance at a national level (mm/year)
1200
1000
800
600
400
200
0
Yearly mean volume of precipitation
Evaporation and evapo-transpiration
Surface run-off
Subsurface flow



Rainfall Distribution and Sea currents in Italy

Main Rivers in Italy

RIVER	LENGTH (Km)	BASIN (Km^2)	DISCHARGE (m^3/sec)		
			Average	Minimum	Maximum
Po	652	74970	1680	220	8000
Adda	313	7979	250	20	800
Oglio	276	8324	130	5	700
Tanaro	276	8324	130	5	700
Ticino	248	7228	410	100	5400
Mincio-Sarca	194	2859	80	30	150
Secchia	172	2292	42	4	788
Dora baltea	160	4322	215	25	2000
Adige	410	12200	400	100	4000
Tevere	405	17169	230	90	3400
Arno	241	8247	140	7	2000
Piave	220	4100	130	50	2400
Reno	211	4626	95	1	1160
Volturno	175	5455	40	8	2000
Tagliamento	170	2700	100	40	5000
Ombrone	161	3480	90	-	1980
Brenta	160	2300	139	25	1036
Liri-Garigliano	158	5020	90	25	1350
Tirso	150	3100	20	-	-

Main Lakes in Italy

LAKE	AREA (km^2)	DEPTH (m)		VOLUME (Km^3)
		maximum	average	
Garda	370	346	136.1	50
Maggiore	212	372	175.4	37
Como	146	410	154.5	27
Trasimeno	128	6.6	6	0.77
Bolsena	114	146	77.9	9
Iseo	65	251	123	8
Bracciano	57	160	86.1	5

Main Hydrographic Basins in Italy

On the four largest Italian Rivers Po, Adige, Arno, and of Upper Adriatic

The River Po watershed is by far the largest and the most complex of the watersheds of national significance identified by the law on soil conservation. The main stretch of the river is 652 long, of which 510 are embanked, and it is fed by 141 tributaries. The watershed extends for 71,057 square kilometres (23.6% of the total area of Italy) into six regions (Piedmont, Valle d'Aosta, Lombardy, Veneto, Liguria, Emilia Romagna), the autonomous province of Trento, twenty-six provinces and 3,188 municipalities. The watershed's economic, productive and environmental importance is second to none, in that it contributes as much as 40% to the formation of Gross Domestic Product. As regards residential and productive settlements in the watershed, there are approximately 15,764,600 inhabitants, 3,171,000 employed by industries and 2,791,000 by services; there are 4,188,000 heads of cattle, 5,232,000 swine. Livestock farming, which in the case of swine is concentrated in the provinces of Parma, Reggio-Emilia, Modena, Cremona and Mantova, accounts for 55% of the national total and, in the case of cattle, for 48%. The highest density of settlements is found in the Lambro-Seveso-Olona catchment basin, with 1,478 inhabitants/square kilometre, while the minimum levels are in the upper part of the Trebbia and Parma sub-watersheds with 26 and 24 inhabitants/square kilometres. The two main agglomerations are the municipalities of Milan and Turin. Some 37% of Italy's industry is located in the watershed, employing 47% of the workforce and accounting for 48% of the total national electric consumption. There are 280 power plants (269 hydroelectric, 11 thermal power) with a total power rating in the region of 17,000 MW.

The River Adige watershed covers about 12,000 square kilometres in the autonomous provinces of and Trento and the Veneto region. The main river course is 409 km in length. The watershed supports a population of 1.5 million; the water resources are used for many purposes and are subjected to increasing pollution particularly in he areas where the density of urban and industrial settlements is higher, such the Bolzano and Vicenza valley floors. The orographic profile of the watershed is characterised by ample ridges. The River Adige and its main tributaries, which stem from Alpine saddles and rims, are characterised by slight gradients; the secondary courses, on the other hand, begin at higher altitudes and flow down into the recipient courses after a short stretch.

185 glaciers are situated in the watershed, covering an overall surface area of 212 square kilometres, the main ones in the Venosta mountains, the Pusteresi Alps and the Ortles Cavedale. The northernmost part of the Adige watershed is formed of crystalline and metamorphic rocks, the low permeability of which is reflected in the limited underground circulation. Snow persists until late spring and represent a steady source of water supply. The higher part of the Adige valley interrupts the continuity of the belt of blowouts which runs along the foot of the Alps from Piemonte to Friuli. The lower course of the Adige assumes the characteristic common to watercourses flowing into the upper Adriatic, which cross the plains with aquifers very near to the surface and terminate in marshy deltas. Substantial withdrawals for potable supply are made from the lower Adige by the provinces of Rovigo, Padua and Venice (total population about 500,000). Completion of the sewer networks and the construction of industrial and municipal waste water treatment facilities is becoming increasingly urgent. The smaller valleys are crossed by rapid torrential streams carrying large amounts of solid which exceed the receptive and disposal capacity of the watercourses and result in the formation of voluminous and ample alluvial fans: Substantial masses of debris thus block the channel of the Adige, cause the river bed to rise progressively and raise the flood stage. Rainwater and the melting snow cover and glaciers in spring and summer, together with the heavier and sudden autumn precipitation, give rise to violent and extensive flooding which has been amply documented in the last two centuries. This situation makes it necessary to continually extract material from the channel to prevent its bed from rising, since much of the river is forced to run between artificial embankments.

The watersheds of the Rivers Isonzo, Tagliamento, Livenza, Piave, Brenta-Bacchiglione, together known as the Upper Adriatic Basin, cover a total of 17,000 km^2 in the Regions of Trentino-Alto Adige, Veneto and Friuli Venezia Giulia, with a resident population of about 2,3 million. The extension of the individual watersheds is as follows: the Isonzo extends for about 1,100 square kilometres beyond the boundaries, the Tagliamento extends for 2,700 km^2 in Friuli Venezia Giulia, the Livenza for about 2,600 square kilometres in Friuli Venezia Giulia and Veneto, the Piave for 4,000 in the provinces of Veneto, Belluno, Treviso, and Venice; the Brenta-Bacchiglione for about 6,600 kilometres in the provinces of Vicenza, Padova, Verona and Treviso in Veneto, and in the province of Trento. Both the mountain and piedmont areas are characterised by numerous small inhabited centres; in the upper plain area there are a high number of large municipalities; the lower plain hosts the most important residential settlements: For the most part, the presence of industry is moderate, if we exclude Belluno valley in the Piave watershed, the location of Belluno and Feltre which are centres with significant industrial settlements. In the upper plains industry is widespread; in the lower plains there are important industrial settlements and agriculture is intensive. Altogether the area included in the watersheds can be regarded as consisting of three homogeneous zones from the hydrological point of view: - the mountain and mountain pediment area: formed by the reliefs of Bellunese, Carnia and the Alpine and hill zones which border the northern and north-eastern parts of Veneto and Friuli. With the exception of the northernmost part of Carnia and upper part of the Brenta river, occupied by metamorphic rocks with limited groundwater circulation, the extensive calcareous and dolomitic formations are the site of considerable groundwater which provides a substantial input to the watercourses. In this area the drainage pattern has been subjected to numerous defence works, in the forms of channels, dams, and canals for hydroelectric purposes, the regime of watercourses is conditioned by these works. In terms of both water capacity and transport of solid materials; - the upper plain consisting of extensive alluvial fans deposited by the watercourses flowing from the mountain watersheds; this area is characterised by watercourses extending over wide, virtually dry gravel beds, particularly during the summer months. Aquifer recharge also takes place at the surface of these fans as a result of both the direct input of precipitation and the input of water from the Alps and Pre-Alps. The large volumes of water from the mountain pediment deposits feed major blowouts along the edges of the fans; - the lower plain formed of the land which, from the belt of blowouts emerging at the end of the fans along the mountain pediment, declines towards the coast line; the water in this area is collected by a dense network of mostly artificial reclamation ditches and drain which partly converge into marshy and lake areas.

The River Arno watershed covers about 8,000 square kilometres in Tuscany and Umbria and is divided into six sub-watersheds: Casentino, Val di Chiana, Sieve and Upper, Middle and Lower Valdarno. The main watercourse is the River Arno, which is about 241 km in length, follows a rectilinear route in the upper parts of the watershed and has numerous meandering between the Era and Pesa tributaries, particularly in its end stretch. Some 2 million inhabitants live in a polycentric type of settlement formed of 142 municipalities, in which there site of major historical importance together with small and medium centres and more recent settlements deriving from intensive industrial development. The upper part of the Arno watershed is formed by the Apennine mountains and the middle-lower part and by the pre-Apennine relieves. Only 17% of the total area is flat land. The Apennine range is mainly sandstone which develops into marl and clay. Permeability is generally low and mainly due to fissures. Ground water circulation, which is widespread but limited, feeds small springs and results in seasonally varied river regime. The secondary watersheds of the pre-Apennine range are formed of sandy and conglomerate rocks; the latter two are characterised by discontinuous groundwater circulation. The permeability of the rocks is very low and the streams are fed almost exclusively during the rain season. The lowlands in the Arno watershed are the site of vast marshy areas, now almost entirely reclaimed, in which the groundwater lies at surface level.

Summary of Italy's physical characteristics

Background	Description
Climate	The climate is in prevalence Mediterranean but it varies along the Italian Peninsula in according with its geomorphology. Six large climatic regions can be distinguished: 1) An Alpine region with long cold winters and short cool summers having an elevated daytime temperature range; 2) A Po region, with continental conditions, consisting of cold and often snowy winters and warm summers; 3) An Adriatic region with continental character, with its winters being dominated by cold north-east winds 4) An Apennine region, also with continental tendencies and cold snowy winters. 5) A Ligurian-Tyrrhenian region, with frequent precipitation and cool winters 6) A Mediterranean region, also with a limited annual temperature range; precipitation is frequent, especially in winter, and the summers are hot and dry. Rainfall distribution varies from the highest quantities of 3,000 mm on the Alps and the Apennines to 600 mm in the southern regions.
Geomorphology	the 23% of Italy is covered by plains, while the 35% by the mountainous areas of Alps and Apennines the rest (42%) consists of hill zones.
Geology	The Alps are largely formed from crystalline rocks (granites, gneisses, mica-schists, porphyries, etc.) but there are also sedimentary rocks (limestone, dolomites and sandstone) that are widespread in the eastern sector and the pre-Alpine belt. Sedimentary rocks are also prevalent throughout the Apennines (limestone, dolomites, sandstone, clays etc The flat areas are basically formed of mixed deposits that are mainly fluvial in origin (conglomerates, sands, clays).
Surface Water & Water storage features	There are only a few tens of watercourses longer than 100 km among which The Po River is the longest with 652 km and has a basin almost equal to a fourth of the national territory (74,970 km^2). Italy is fairly well supplied with lakes, having several thousand natural and artificial basins of different sizes and origins

1. Overview of the country

1.1. Water Demand and Supply Status

The information available on a national basis about quantity and distribution of water resources in Italy is mostly still that elaborated during the National Conference on Water Resources of 1971 (CNA), and later updated in 1989, above all in inductive way. More recent estimates have been made in relation to each region and to each basin, but their availability is occasional and their methodology does not make it easy to compare data with each other.
Table no.1 summarises the main available overall data. According to standard parameters (for instance, the annual average flow rate), Italy should be placed among the countries rich in water resources, the theoretical annual available resource being of 155 km³, that is 2700 m³/hab. Nevertheless, considering the potentially usable resources, the irregularity of flows and the practical difficulties of using many "theoretically" available resources, such availability lowers considerably to 110 km³ (2000 m³/hab.). If we consider, instead, only the actual usable resources, the availability datum drops to 42 km³, that is 928 m³/hab, also because of the existing network of water infrastructures.

Table 1: Water Resources available in Italy (km³/year)

Resources	Estimate 1970	Estimate 1989
Rainfall (A)	296	296
Evaporation (B)	132	132
Losses (C)	9	9
Total surface runoff (A-(B+C))	155	155
Potentially Usable Surface Water (D)	110	110
Groundwater Resources (E)	13	12
Existing reservoirs capacity	7.7	8.4
Capacity of reservoirs under construction	2	2
Other potential reservoirs	6.5	6.5
Usable Surface water (F)	42	40
Total available resources (E+F)	55	52

The availability of surface water must be summed up to groundwater resources. The distribution of subterranean basins in Italy is not yet well known. In general, in the North of Italy groundwater resources are abundant, and they are supplied by the main water courses. As a consequence, above all in piedmont areas, that are characterised by permeable ground, groundwater represents a very important resource. Also Central Italy is quite rich in groundwater, thanks to the abundance of springs and of mineral and hot spring waters, coming from the big carbonate massifs forming the Apennine range. On the contrary, in the South of Italy the usable aquifers are mainly limited to the few coastal plain areas and to inland zones. Totally, the annual available groundwater supply is about 12-13 km^3, that is about $200m^3$/hab.

As far as the *surface water availability* is concerned (Table no. 1), it has been calculated by considering a representative water course for each hydrographic area. According to the existing artificial regulation of each representative river, some "curves of supply capacity" have been established. From 1970 to 1989, water availability has slightly increased thanks to the activation of a certain number of reservoirs; in some cases it has, instead, decreased, because the quantity of water that could be stored in reservoirs has been reduced owing to static safety reasons. Groundwater resources are distributed in a very irregular way, as well. It is estimated that about 70% of about 13 km^3 annually available is located in the alluvial plains of the Northern regions, particularly in the Po River Basin.. The quantity of groundwater in the Southern regions of Italy is much poorer and quite exhausted.

In many parts of the country - for example, in the coastal areas of the South, such as the Salento area, but also in many areas of the North, above all those around the industrial areas that have a high water consumption - over-exploitation of deep aquifers has been since long recorded (with the subsequent phenomena of subsidence and salt intrusion). It is then to consider that the use of water aquifers, in particular for drinking water supply, depends upon its quality.

The regions of the North rely on the abundance of resources, that are available on a regular basis; moreover, the morphology of these regions has permitted the considerable increase of water availability thanks to the storage of water in reservoirs. Unfortunately, this relatively easy way to get to water resources in the North of Italy has caused a very intensive exploitation of water resources, above all for energy and agricultural purposes. As a consequence, the flow of most rivers has been artificially controlled, and during low water seasons, many of these rivers have problems of flow.

On the contrary, the availability of water resources in the South of Italy is much more reduced. This is due both to the scarcity of precipitation (in such regions like Puglia, Sicily and Sardinia, atmospheric precipitation is 40-50% less than in the most rainy regions of Italy), and above all to the scarcity of usable water resources.

In fact, in the basins of the North about 50% of available resources are usable; in the Southern regions, this percentage drops remarkably, the lowest ones being 15-20% in Sicily and Sardinia, and even 10% in Puglia.
According to Table no. 2, without any artificial control of flow, only 18 millions m³ per year could be entirely used. Moreover, such resources are mostly concentrated in the North (90%), thanks to the natural storing capabilities of lakes and glaciers. Owing to the existing reservoirs, controlled flows guarantee an average availability two times and a half higher than that.

Table 2: Water Resources available in Italy per each Hydrographical Area in 1989(hm^3/year)

Hydrographical Area	Rainfall	Potentially Usable Surface Water		Existing reservoirs capacity	Groundwater Resources (B)	Total Available Resources (A+B)
		Without Reg.	With Reg. (A)			
Po basin	71800	11374	16118	2194	4468	20586
North east	42800	4425	10939	1069	1721	12660
Liguria	6400	235	372	29	307	679
Romagna-Marche	20700	299	995	212	620	1615
Toscana	20900	199	543	141	440	983
Lazio-Umbria	24100	321	1399	452	1126	2525
Abruzzo-Molise	11900	621	2454	603	248	2702
Puglia	13200	13	523	397	325	848
Campania	23200	152	1237	77	929	2166
Calabria-Lucania	24000	650	2514	1131	595	3109
Sicilia	18800	29	738	718	1151	1889
Sardegna	18300	29	1841	1403	217	2058
Italy	296000	18347	39673	8426	12146	51820

As far as the single regions are concerned, reservoirs allow Puglia, Sicily and Sardinia to increase considerably their own usable resources. Therefore, reservoirs in the Southern regions of Italy are crucial. In Table no. 3 the availability per habitant is calculated, so showing, one more time, some remarkable differences. By analysing the differences, one can understand the flow direction of inter-regional water transfers. The region of Liguria, in the North, and above all Puglia, in the South, have rather

poor natural water resources in comparison to their population, but they balance such deficit by receiving water supply from neighbouring regions, respectively from the Po Valley and from the region of Campania-Lucania. Other important water supplies occur among provinces, for instance in the regions of Romagna, Lazio and Campania and in the smallest islands.
The irregularity of flows makes practically unusable most water resources that are theoretically available; on the other side, it provokes strong floods during the most intensive precipitation. Particularly serious precipitation - the peaks being even higher than 100 mm/h - are frequent phenomena in all areas of the country and in all seasons of the year. Due to the morphology of the Italian territory, mainly characterised by mountains and hills, such phenomena not only usually cause a sudden increase of water flow towards the water courses, but they also cause intensive erosive phenomena and landslides.

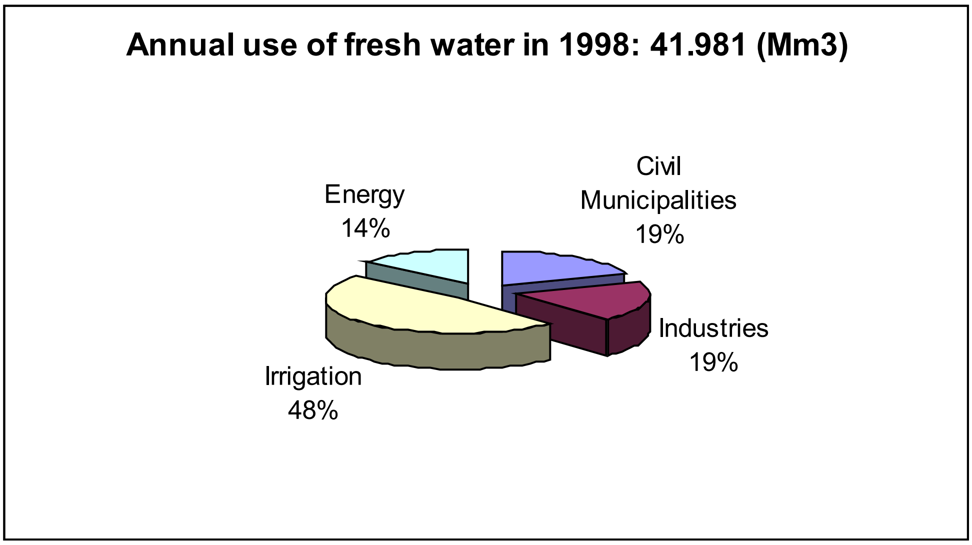
Table 3: Per-Capita Water Resources available in Italy per each Hydrographical Area in 1989 (hm^3/year)

Hydrological Area	Rainfall	Available Surface Water (A)	Existing reservoirs capacity	Groundwater Resources (B)	Total Available Resources (A+B)
Po basin	4654	1045	142	290	1334
North east	6693	1707	167	268	1975
Liguria	3557	207	16	171	377
Romagna-Marche	6126	294	63	183	478
Toscana	5853	152	39	123	275
Lazio-Umbria	4173	242	78	195	437
Abruzzo-Molise	7728	1594	392	161	1755
Puglia	3429	136	103	84	220
Campania	4290	229	14	172	400
Calabria-Lucania	9110	954	429	226	1180
Sicilia	3865	152	148	237	388
Sardegna	11854	1161	885	137	1298
Italy	5273	705	150	216	921

The gross amount of waterworks requirements is about 8 km^3 (table 4): a little more than 70% of such amount is in fact supplied to consumers, while the difference is made up of losses and lack of invoicing. Between 1975 and 1987 a considerable increase of withdrawals (+35%) has been recorded. In the following decade, instead, the trend seemed to have stopped. The data (source: Federgasacqua), referred to more than a half of the total population, show that water consumption has been generally stable during the past decade.

Water Use Distribution In Italy (hm^3)

	CIVIL MUN.	INDUSTRIES	IRRIGATION	ENERGY	TOTAL
North West	2268	3520	8193	3502	17483
North East	1453	1648	5277	1800	10687
Centre	1618	1482	970	581	4142
South	1803	879	3506	36	6224
Islands	798	457	2191	0	3446
Italy	7940	7986	20136	5919	41982



It is difficult to estimate the exact quantity of water used by Italian industries every year, however it has been calculated around 8 km³. Then,

if we also consider about 23 km^3 of water used to cool thermoelectric plants, the total amount exceeds 30 km^3.
To perform such operations, only a small amount of fresh water is used, sea water being the most used, above all for cooling operations. In the case of thermoelectric power stations, the figures are rather precise (17 km^3 of sea water used, that is about 75%), while it is problematic to make estimates for the industrial sector. In such regions like Sicily and Puglia, sea water allows to meet most of such needs.
With regards to energy uses, only such inland thermoelectric power stations are analysed, which use fresh water for cooling operations. Moreover, the calculation is made referring only to ENEL plants, without considering autonomous power stations. On the whole, the amount of fresh water used by cooling plants for cooling operations is around 250 m^3/sec. If we consider the hypothesis formulated by CNA (5,000 hours functioning), the total amount is about 6 km^3, to be summed to the lower amount needed by closed circuit cooling plants.
In this esteem, uses of hydroelectric energy have not been considered, because they do not make represent a real "consumption". Anyway, it is evident that an estimate of water consumption at local level and in a certain season of the year must take into consideration also such uses, because they cause considerable variations in the seasonal flow rate.
Therefore, the total amount of yearly withdrawals of fresh water for industrial and energy purposes is about 12-13 km^3.

It can be assumed that underground resources represent the main supplying source for civil uses, above all in the North of Italy, where 90 % of water supply comes from deep aquifers and springs. In the South and in the islands, surface reservoirs represent a very important factor, in that they provide about 15-25% of the total supply: some provinces rely completely on surface resources.
Deep aquifers provide also the greatest supply of water for industrial uses, particularly in the North. Surface water withdrawals are almost exclusively carried out for energy consumption, while a certain amount, rather difficult to estimate, is provided to industries by the network ,of land-reclamation syndicates; quantity is calculated together with the amount of water used for irrigation.
Also in this case, the most important resource in the South is surface water ; sometimes it is obtained through non-conventional operations (for instance: by desalinisation), while for cooling operations, sea water is in fact the only resource exploited.
Most times, surface water is used for irrigation. A small fraction of private consumers - about 10-25% of the total amount - draws water from

their own wells, brooks (especially in the mountain), rainwater abstractions and small hill lakes.

1.2 Environment and protection

Italy shows a rather variable situation according to the problem of water availability, as well as to that of water quality, because of its peculiar position and its hydrologic characteristics.
In the North, where there are bigger and more regular water courses, bacteriological and organic problems play a relatively secondary role. If we do not consider the connections between rivers and their tributaries - the so called "black spot areas" - this kind of problem mainly involves minor water courses that are placed in the nearby of urban areas, and occasionally main water courses during periods of minimum flow; seen under this point of view, the status of some big rivers in the Northeast area, such as Piave and Tagliamento, but even Po, is particularly critical.
Surface runoff of the basins situated in the North of Italy flows into the Northern area of the Adriatic Sea, which is an inland, not very deep sea, with little water exchange and mostly characterised by many lagoons in the very northern area, where therefore the dilution of river inflows is not sufficient.
Furthermore, most of the big rivers in the North have built up a system of big and little lakes. So, controlling the flow of nutritious substances is an important question, particularly if referred to those substances contained in urban waste water as well as in agricultural and zootechnical wastes; even if organic, chemical and bacteriological quality of lakes has improved significantly almost everywhere, their trophic status still causes many concerns.
Nowadays, coast pollution seems to be under control (as far as sewer wastes are concerned). Eutrophication in the Northern Adriatic area seems to have decreased, since in the last years alga and mucilage proliferation has no more occurred, while this problem had hardly affected the ecosystem of that area since the half of the seventies up to the beginning of the nineties.
In the nearby of transition ecosystems (Venice and Marano lagoons, Po delta, damp inland areas), the status of the area is still critical.

A third aspect of great importance, especially for Northern Italy, is the *pollution of aquifers*, because most part of the drinking water supply system in the North of Italy depends on underground water. In the last decades a worrying deterioration of the aquifers has occurred, above all owing to the presence of organochlorinated compounds and heavy metals in the metropolitan area of Turin, in the neighbouring area of Milan, and in the piedmont area of Veneto region. Nitrates are found in particular in northern flat areas especially in Lombardia region and along the Via Emilia. Plant protection products are spread in the whole Po Valley, even if concentrated in certain areas. On the whole, the contamination of the aquifers involves those aquifers that provide drinking water supply for at least 5 millions people.

In some areas, and in particular in proximity of the industrial sites of Emilia and Veneto and in the southern plains of Veneto and Friuli, a lowering of aquifers levels is occurring, along with occasional phenomena of subsidence. These latter may have been caused by the intense withdrawals.

In Central Italy, the conditions of the main rivers, like Tevere and Arno, is strongly affected by the seasonal variability of flow rate, while the pollution due to bacteriological and organic agents is still widespread. Because of the mountainous and hilly territory, most urban areas and industrial sites are concentrated in the narrow plain areas along the course of these rivers.

Arno, one of the biggest rivers of Central Italy, shows the worst conditions, because of the massive pressure of urban areas and because of the industrial sites around Florence and Prato. The quality degree of the last reach of the river in this region always turns out to be very poor.

Tevere shows acute pollution only in certain rather localised reaches. Upstream, where the flow rate is low, non-purified discharges from the neighbouring cities cause such pollution. Downstream, the degree of pollution decreases, but it worsens again and significantly in the final reach, after the river has gone through the metropolitan area of Rome. On the contrary, in the middle reach, polluters from agricultural activities are more frequently found.

In both cases, water quality is expected to improve considerably, after that the existing medium and big purifier plants have adapted their technologies to the current needs .

On the contrary, with regards to the issue of quality, a different approach must be adopted in the South of Italy, first of all because water courses are mainly torrent-like, and therefore dry for most part of the year; secondly, because the population rate is very high along the coastal areas, thus making the problem of coastal pollution more urgent.

Among the different kinds of pollution, the bacteriological one is particularly important, because it causes many repercussions to the seaside resorts, where bathing is prohibited.

Nevertheless, also the few perennial water streams sometimes suffer from high pollution. To give only one meaningful example, the Sarno river, in whose basin the canning and tanning industries are concentrated.

Moreover, the problem of quality assurance, above all trophic quality, is crucial, in that it involves the reservoirs used to store drinking water. Many of them have suffered problems of eutrophication, mainly caused by farm pollution, as well as by non-purified discharge drains.
Deep aquifers, in particular along the coastal plain areas, have been widely exploited and it shows the effects of excessive withdrawals. Unusually excessive salt deposit is a phenomenon systematically detected in the areas of Salento and Metaponto, in the gulf of Naples, and in the regions of Calabria, Sicily and Sardinia.
The main source of pollution for surface water is Agriculture. First of all, fertilisers and pesticides have a strong environmental impact on deep aquifers. But also an excessive or wrong amount of these substances, in particular if used shortly before precipitation in a period of frequent precipitation, may cause the erosion of a big quantity of pollutants that flow directly into surface water courses.
More generally, another important source of widespread pollution is the runoff of rainfall waters. These waters come more and more often into contact with the polluted ground, thus carrying with them big amounts of pollutants that spoil water courses. In this case, pollution is not so much caused by organic or bacteric polluting agents - also because this phenomenon increases with the increase of water courses flow rate - but mainly by toxic substances such as heavy metals.
The runoff of rainwater in urban streets, for instance, has been indicated as one of the main causes of pollution from lead and other metals.
The main source of widespread pollution of deep aquifers may be considered the following:

- Agriculture, in particular for the use of fertilisers (of animal as well as synthetic origin) and plants protection products;
- Rubbish tips, in particular if lacking in specific technical equipment that can prevent infiltration. We are referring to tips built before the end of the 1970s, that have been used even after that date and are sometimes still functioning today. These tips have been generally built in vacant areas previously occupied by quarries, even in proximity of water courses or gorges.
- Vacant industrial sites, in particular where dangerous operations have been performed, that might have produced toxic substances causing the contamination of the ground.
- The shedding of waste water on the ground, containing toxic substances such as: heavy metals, solvents, chlorides and phenols.

The industrial pollutants are certainly far more dangerous than the agricultural ones, but against the formers there exist treatment methods that are quite effective in limiting the pollution of drinking water. On the contrary, in the case of farm pollution, such methods do not exist.
Nowadays the pollution of deep aquifers represents, above all in the North of Italy, the most pressing problem of the future and, most probably, can turn to be the greatest water emergency of Italy.

1.3 Water laws and Regulations

Law no. 319 of 10 May 1976 (protecting water from pollution)
The law governs:

- General criteria and methods for establishing quality and quantity properties of bodies of water in order to formulate a discharge registry;
- General criteria regarding correct and rational water use;
- General technical rules regulating the installation and functioning of aqueduct plants;
- General technical rules regulating the installation and functioning of sewage systems and refinement plants;
- General technical rules regulating sewage disposal at soil and subsurface level, regulating sediment disposal resulting from processing and refinement;

Presidential Decree no. 515 of 3 July 1982 (quality of surface water intended for drinking water production)
The EEC Directive no. 75/440 classes surface water quality, and specifically as:

- Category A1: water requiring physical treatment and simple disinfection
- Category A2: water requiring physical and standard chemical treatment and disinfection
- Category A3: water requiring physical and more stringent chemical treatment, refining and disinfection

If properties and quality are inferior to the maximum limits imposed for class A3, surface water may not be intended for drinking water production. Furthermore, regional councils are responsible for classifying water, also in relation to upgrading processes in progress.

Presidential Decree no. 236 of 24 May 1988 (quality of water intended for human consumption)
The EEC Directive no. 80/778 sets the maximum limits to be respected for the quality of water supplied by the drinking water network. This water is to respect 62 physical-chemical and bacteriological parameters. The law also requires the introduction of 'total conservation' and 'respect' areas in order to safe-guard water surrounding drawing points and of 'protection' areas to safe-guard catchment basins in groundwater

replenishment areas. For the said areas, incompatible uses or activities (such as organic waste accumulation, fertiliser or pesticide spreading, waste disposal, etc.) have been gradually reduced.

Law no. 135 of 30 May 1991 (urban waste water treatment)

Law no. 135 of 1991 implements EEC Directive no. 91/271 of 21 May 1991 (Urban waste waters) which harmonised regulation of sewage release into natural bodies of water within the European Union, modifying the legal system and the technical-environmental objectives and thus becoming the basis for programmes regarding collection and treatment of waste waters from civil settlements. In particular, many obligations regarding sewage collection and different levels of treatment (in terms of space and/or time) are provided in relation to settlements, 'sensitivity' of the receiving body and the sewage network length.

Law no.183 of 18 May 1989 (regulations for soil defence)

The whole issue of water and soil pollution has undergone significant changes under Law 183/89, which established that the water basin administration authorities are also to supervise waters flowing into the basin area under their responsibility. The law is an important attempt to rationalise works in a hydrographical basin by overcoming, at least at planning level, the fragmentation between national government, Regional and Provincial councils, and the different Ministries.
This is a fundamental law in terms of water resources planning as it aims not only to guarantee soil defence but also to implement water quality improvement as well as to utilise and manage water resources for the purposes of achieving rational economic and social development.
The features of law 183/89 are the following:

- The sub-division of hydrographic basins into ones of national interest (Po, Adige, Veneto rivers, Arno, Tevere, Liri-Garigliano-Volturno), inter-regional basins and regional basins;
- An administration authority directly linked to the Ministry for Public Works and the Ministry of the Environment is proposed for basins of national interest;
- Two boards (institutional and technical) formed in accordance with the regional councils involved are proposed for inter-regional basins;

- A vital tool for pursuing the aims of the law is the 'Basin Plan', which is adopted by basin administration authorities for national-interest basins and by regional councils for the other basins.

The organisation and reaffirmation of the unitarity of the hydrographic basin as a physical system and the explicit indication of economic and social restrictions in water resources management are to be considered as positive features of the law. The Basin Plan is defined by law as a 'fact-finding, regulatory and technical-operational instrument through which interventions and utilisation regulations are formulated and planned for the purposes of water conservation, defence and enhancement based on the physical and environmental characteristics of the territory concerned'.

Parliamentary Decrees nos. 132 and 133 of 27 January 1992
These decrees took into account various other European directives, and exactly:

- No.132: the EEC Directive 80/68 for the protection of underground waters against pollution provoked by several dangerous substances.
- No.133: various EEC Directives regarding industrial disposal of dangerous substances into waters.

Law no. 61 of 21 January 1994 (environmental monitoring)
The law refers to environmental inspection organisation and to the setting up of the national agency for environmental protection (water protection comes under the chapter heading 'environment').

Law no. 36 of 5 January 1994: 'Directive regarding the issue of water resources'
The water sector reform set in motion with the general policy law regarding soil protection was completed in 1994 – four years after law 183 of 1989 and after more than a decade of parliamentary activity – with the enactment of the water services reorganisation law.
The pivot point of the reform introduced is the concept of water balance, interpreted as a correspondence between available resources and requirements for the various uses. Here *Principles to safe-guard the environment and economic efficiency* are united within a single regulatory text and within a unitary territory rule project of for the first time.
The law, created to resolve the excessive fragmentation within Italian water services and to rationalise the confusing legislative framework,

includes some general principles regarding resources conservation and utilisation:

- Under art.1, all waters, both surface and underground, and also if not extracted from the ground, are public and constitute a resource to be used according to *criteria of solidarity*; any water use is to be carried out safe-guarding future generations' expectations and rights to utilise unharmed environmental assets, and water use must be orientated towards saving and replenishing resources in order to not compromise water assets, the liveableness of the environment, agriculture, water fauna and flora, geomorphologic processes and hydrological balance;
- art. 2 sets out that *water use for human consumption is given priority importance* in comparison with other uses; resource use priority must, however, be assessed during planning, within the context of the water basin, and verified during implementation of these plans; a more rational use of resources is also referred to in art. 3, which establishes the principle of balancing the water budget, on the basis of which the basin administration authorities guarantee the supply of available or feasible resources for the various uses in the area concerned;
- Art. 5, instead, indicates methods for obtaining *water savings*: by gradually extending the policy of upgrading existing networks presenting sizeable leakages, by installing dual networks in new residential commercial and industrial settlements of a significant dimension, by installation of meters in individual housing units and installation of differentiated meters in factories and tertiary properties within the urban context, and by disseminating water saving methods and appliances in the domestic, industrial, tertiary and agricultural sectors.

A significant innovation introduced by the Galli law is the *separation of proprietorship from management* of water services;
Under law 36/94, the Provincial or Local council keeps proprietorship and assigns management through public competitions, having the power to choose from its own specialist companies, private concessionary firms or mixed public-private companies.
One of the main reforms introduced by the law is the *attempt to overcome management fragmentation* typical of the water services sector in Italy and to *promote entrepreneurial growth* of the water system. The identification of *optimal territorial environments* (ATO), where *unitary and complete management* of the water cycle may be sought, is required

for this purpose; a cycle in the sense of a group of services regarding water collection, feeding and supply for civil use, along with sewage networks and waste water processing.
A third fundamental point identified by the Galli law for sector reorganisation is the new tariffs policy: based on the *principle of covering costs*, the reform requires tariffs to be calculated on the basis of the quality of water resources and services provided, management costs, works and relative modernisation, return on capital invested, etc.

1.4. Institutional framework and constraints

In Italy the administration and management of water resources is divided into three principle levels: state, regional and local. Within each level the responsibilities are further broken down into management groups which often carry out similar duties: For example the monitoring, gathering and processing of data is carried out by the national technical services as well as regional organisations. During the past 15-20 years Italian legislation has been redirected with a decentralisation of rights and authority of the state towards regional and local management, resulting in the re-organisation of roles and duties in an attempt to overcome the breakdown of management and to encourage the co-ordination of various projects, as seen amongst the bills 183/89 and 36/94. These objectives could not be realised, however, without taking into account the territorial and hydrographic diversity in Italy: as seen through the classification of Italian water catchment-basins on a national, regional and inter-regional level and the institution of the Basin Authority (acting from bill 183/89) and the fundamental definition of the Ambiti Territoriali Ottimali (Optimal Territorial Environments) as part of the water catchment-basin objective of integrated management of water resources on behalf of towns and cities.

The three administrative levels listed above can be defined as follows:

- The State is responsible for the formulation and regulation of laws, establishing technical standards, co-ordinating research and monitoring/observation.
- The regions are concerned with the planning and administration of resources through the councils, technical services and regional syndicates and the eventual co-ordination with the Basin Authority.
- On a local level, between the towns and cities, exist various associations for re-adaptation, treatment and provisions of water. They are responsible for the organisation of water services directed at the final users.

Regarding state administration the bill 300/99 established the *Ministry of Environment and of Territorial Protection* and appointed it with the concerns and responsibilities of the waters from the *Ministry of Environment and the Ministry of Public Works***.** This organisation operates through the *Department of Water Sources* which ensures: 1) The

management and protection of water resources. 2) The prevention of and protection against water pollution. 3) Coastal and sea defence.
Focussing on detail, this department is divided into two sections, which carry out specific assignments.
The *Office for Protection of Inland Water* is responsible for:

- The programming, co-ordination and control of rational usage of water resources and the multiple uses of water resources.
- The protection/guardianship of the internal surface and underground waters against pollution.
- The protection of the water resources in terms of quality and quantity.
- The protection of the bodies of water, rivers, lakes and lagoons.
- The promotion of vigilance and control of discharge pollution in the internal bodies of water.
- Creating awareness of and the implementation of directives and regulation within the European Union in terms of internal, surface and underground waters.
- National census of bodies of water.
- Formation of the national water balance on the grounds of the water-catchment basins.
- Directive and parameter formulations in order to identify the areas in risk of a water crisis, as prevention to hydro emergencies.
- Criteria for the management of water services integrated by the Optimal Territorial Environments.
- Criteria for the management of provisional services, of retrieving and accumulating potable water.
- Criteria for the programming of the transfer of water for human consumption and for the general utilisation of waters destined for hydro-electricity.
- Vigilance and control of the use of hydro-resources.

The *Office for Sea Conservation* has projects more closely linked with monitoring and guardianship of the Italian seas and also carries out activities on the proceedings of ICRAM, the *Central Institute for Sea Research.*

The same bill, 300/99, has established the *Agency For Environmental Protection And Technical Services*, to which has been assigned projects that will combine the technical-scientific activities in the interests of the nation. It works towards the protection of the environment, guardianship of water resources and in defence of soil, identifying and broadening national and inter-regional water-catchments. The functions of ANPA, the *National Agency For Environmental Protection* and those of the *National Technical Services* controlled from the *Prime Minister's Office*, have been nominally transferred. The transfer is to be instigated in the year 2002, in the meantime ANPA, initiated in 1994, will continue to carry out the technical-scientific activities aimed at the protection of the environment, for example:

- Collect, elaborate, verify provide information and public data relative to the monitoring networks of the environment, to spread criteria, methods and guide lines for the control and protection of the environment.
- Promote programming and formation in terms of the environment based on available information.
- Exercise control over the physical, chemical and biological aspects of pollution, over environmental hygiene and over the peaceful use of nuclear energy;

The national technical services are committed to providing awareness for the protection of soil, the rehabilitation of waters and the enjoyment and management of the hydro-patrimony. The *Servizio Idrografico e Mareografico*, deals with the provision of systematic relief to water courses, the vastness of the surface 'down-flowing', the soil deposits, the underground 'down-flows' and springs.

The second administrative level, the regional level, carries out the planning and administration of water as a resource, in terms of responsibilities. It's particular points of interest being:

- Plan the use of water through the allocation of available resources to the various users, defining the hydro-balance, individualising the necessary hydro works and schemes.
- The affirmation of quality through guaranteeing diverse uses, planning the structure of drainage schemes and of the purification plants, in order to determine the measures needed to combat and prevent pollution.
- Plan the hydro-geological defence of the territory through the co-ordination of activities carried out by the offices of civil protection and the creation of information systems of control.

- Collaborate in the relief and development of the project for water catchment-basins on a national and inter-regional level.
- Provide the hydraulic police with an ever ready and complete intervention illustrating the management and maintenance of the works and plants and the conservation of goods;
- Assume the necessary initiatives and responsibilities as guardian over the use of waters in the catchment-basins.

The various functions carried out on a regional level are sub-divided between councils, technical services and regional offices, between which is the *Regional Agency For Environment Protection* (ARPA). The principle interests of these organisations include monitoring and controlling the territory and human activity, the valuation of the environmental impact of plans and works and the scientific-technical support in terms of the environment.

As already noted the local management includes towns, districts, their management and associations, the mountain communities, the re-adaptation syndicates, the mountainous water catchment-basins and other public associations and institutions of public rights with headquarters in the hydrographical basin. They are responsible for the organisation of public water services, collection, adduction and distribution of water to the civil users, of sewerage and purification of refuse. In agreement with the established bill 36/94, the action of local groups is required to be co-ordinated and finalised with an integrated management of water services, through the Ambito Territoriale Ottimale. Most of the Italian regions have already provided the grounds to institute the authority of the Ambito Territoriale Ottimale. This authority can have the nature of a union and receives the title of water services, -integration of aqueducts, sewerage and purification with a commitment to an external body which in practice will become the right and true manager of the service. Projects of *ATO Authority* deal with the preparation and control of services and their relative tariffs, applied through the managing sector.

The Basin Authorities, on a national, regional and inter-regional level, are responsible for:

- Defining the physical system on an informed, organised and up-to-date basis, the utilisation of the territories already noted as seen from the public and inter-city urban instruments, relative to the responsibilities of water-catchment basins.

- Identifying and measuring the actual and potential situations in terms of the degradation and causes of degradation to the physical systems.
- Preparing directives, in alignment with soil protection, for hydrogeology and hydraulics and for the utilisation of waters and soils.
- Planning and utilising water, agricultural, forestry and mining resources.
- Identifying the links and works between hydraulics, agricultural-hydraulics, forestry-hydraulics, forestation, hydraulic re-adaptation, stabilisation and consolidation of land appointed to the conservation of soil and guardianship of the environments.
- Carrying-out the known relief of the ongoing processes, specifically to do with energy, drinking water and irrigation.

1.5. Management, Institutional and policy options

Demand for urban uses

Insufficiency of civil water supply affects in particular Southern Italy (Calabria, Puglia and Sicilia regions) while Northern and Central Italy the water consumes are pretty constant or show a negative trend. Moreover water demand can increase locally due to tourist pressure, for example along Liguria and the Adriatic coasts.
At the local levels some critical factors can exacerbate the situation:

- Growth of urban population in areas interested by industrial development
- Insufficient management of the water distribution network
- Peaks in water demand due to scattered tourist presence
- Pollutant loads in shallow aquifers coming from substances used in agriculture (such as pesticides and fertilisers) and from substances originated by industrial processes (such as heavy metals and solvents).

The policy options are:

- Build new infrastructures
- Improve management of the water demand

The first option requires: 1) the development of new water sources, through the uptake from new springs and rivers, the drilling of wells and the construction of new reservoirs 2) to import water from near areas to completely satisfy the local requirement or just to cover the seasonal peaks 3) to build additional water supply systems to face emergencies 4) use of new technologies in treatment plants.
This first policy option has been applied for several years in the past. However it is subject to some technical constraints, pointed out in feasibility studies, and to the environmental impact analysis. These matters, together with its rising costs, are pointing to other alternatives.

The *demand management* option is based on the conviction that the requirements of the civil water supply system is not an exogenous variable: the water endowment that is currently around 200 l/hab*day could be increased through specific measures aiming at controlling the distribution losses and in general to reduce the demand. As regards the losses, it has been studied that a reduction of 10-15 % of the distribution network losses, could lead to an average potential increment of 20% of water available to civil supply systems at the national level and of 25-30% in the South and in the Islands. Other measures of the *demand management* option are: 1) re-use of treated waste water for “secondary” purposes such as street cleansing or maintenance of public green space and road-vegetation 2) incentives to domestic water savings, in particular as far as regards the toilet assemblies and the domestic electrical appliance 3) re-distribution of water consumes during the day.

Demand for Irrigation

The 40% of the agricultural production and the 60% of the agricultural export of Italy depend on irrigation. Irrigation also is of primary importance for the Italian agricultural landscape that would otherwise present some desert areas.

Although agriculture represents the greatest water consumer at the national level (50-60% of the total), the water requirements of areas that can be potentially irrigated are not completely covered. The repeated droughts of the last ten years have engraved on the estimated availability. For example, in the areas that have been heavily interested by the droughts of years 1988-1990, the percentage of area irrigated over the potential one was of 57 % in the first year and of 30 % in the following two.

The policy options are:

- Increase the available resources through additional systems of uptake, distribution and derivation.
- Gain water for irrigation by decreasing the amount allocated to the industrial user.
- Improve the efficiency of distribution networks and of treatment systems.
- Look for non-conventional sources
- Manage the water demand

As regards the structural solution, some projects of water systems mainly reserved to irrigation tasks have already been approved and some others are under construction both at the North and the South of Italy. It has been estimated that these interventions could increase the available water duty of an average increment of 100 % in Southern Italy and of 40 % in central and Northern Italy. However this kind of solution takes into account just the technical aspect and rarely results convenient from a

costs-benefits point of view. The costs could be reasonably recovered only in case the water systems used for irrigation could be adapted to serve multiple uses and this mainly depends on the water resource policy at the programming level.
The second policy option, based on subtraction of water from other uses, accomplish the Law 36 of 1994, that gives priority to agricultural uses in respect to the others in situation of reduced availability and droughts conditions.
In the policy of non-conventional water sources particular importance is given to the combined use of fresh and brackish water, usual practice in Puglia region, the re-use of civil waste water, its amount could cover the 29% of the water used in irrigation and the incentives to self-supply ways from small lakes and ponds.
The demand management option aims to a more efficient water allocation, giving preferences to high quality and productive cultivation. At the same time it is evident the need to increase the irrigation method and at least to move from a surface to a sprinkler irrigation method.

Industrial demand

The water consumes for industrial use in Northern Italy have been progressively diminishing in the recent years, first of all due to application of technologies requiring ever less water. There are not deficit conditions but at a local level the pressure on resources due to over-exploitation is getting almost unsustainable. In Southern Italy the past years were characterised by a policy of industrial development supported by construction of the necessary supply systems, while currently the expansion of industrial sectors keeps the focus on valorisation of existing resources.
Generally, while there is no deficit of cooling water due to the possibility of using salt water, the availability of process water is limited and will get more and more reduced with the future re-allocation of water towards civil uses.

In this case the policy options are:

- Conjunctive use of distribution systems for irrigation and industrial supply
- A more efficient allocation of available resources.

The conjunctive use policy has been applied by local irrigation consortiums in the plans of Veneto and Friuli regions, where the location of distribution networks coincide with the factory sites: this is indeed the greater constraint affecting this kind of water management.

WaterStrategyMan

EVK1-CT-2001-00098

Report on Spain:

Range of circumstances and region analysis

09/06/2002

Preface

This is the report for the deliverable D1 of Work Package 1 of the WaterStrategyMan project.

It has been compiled through the collaboration of:
Mr. Cipriano Marin, Mathematician. Expert in planning.
Mr. Giuseppe Orlando, Geographer.
Mr Luis Gortázar, Environmental Consultant.
Mr. José María Romero. Jurist.
Ms. Felisa Hodgson, Biologist.
Mr. Germán Hernández Durán. Civil Engineer.

The Report contains:

1. An overview of the entire country comprised of analyses of the current situation regarding demand and supply, and the legal, institutional and administrative framework of water management in the country.

1. Contents

Abstract

Although Spain's water resources related to population, in global terms, are actually above the Mediterranean, water in Spain can be considered a scarce resource and extremely vulnerable. This is caused by its unequal spatial distribution, with excedentary basins and extremely deficitary basins, and by factors such as population growth and displacement, tourist growth in coastal areas or continuous increase of irrigation in arid and semiarid areas, which are clearly deficitary. Competency and management overlapping regarding resource use and re-use, seriously threaten the policies on water sustainable use that try to start both at the national and Autonomous Region level. The great biodiversity and water environment richness is also threatened due to the big local and regional disarrangement as regards the assignment of water resources.

Among the different hydrographic regions and deficitary basins, the two cases of the Canary Islands and of Doñana and its surroundings have been selected. The Canary Islands show a complete range of risks and conflict situations within a deficitary territory with a spectacular tourist growth. Doñana represents the paradigm of conservation and development, an environment where population pressure and water table exploitation for new crops has to conciliate with the conservation of one of the most important wetlands in the world. The range of circumstances in these two regions is analysed, and presented in table form.

Introduction

Spain is a country characterised by big geographical and climatic contrasts that determine availability and distribution of natural water resources. From the water point of view, this diversity of environments determines the existence of very different hydrologic areas, of high aridity gradients, of islands of humidity in dry contexts, of strong variability of the surface flow, of a hydrogeology with important regional differences and a very high heterogeneousity as regards water distribution, both in the Spanish mainland an d in the Canary and Balearic archipelagos.

We can say concisely that there is a strong difference between Northern and North-western areas with abundant water resources and the dry Southern and Eastern areas. Schematically, three large sectors can be differentiated, with regard to abundance and distribution of water resources:

Northern and North-western sector, including Galicia and Pyrenean-Cantabrian regions, is characterised by a great abundance and relative regularity of water resources, being therefore improbable that this factor would acquire a limitative nature from a socio-economic or environmental point of view.

The Central sector, constituted by the large inner river basins, shows the pluviometric shadow by the surrounding mountain systems, receiving little rainfall, with an rise in aridity in the most continental areas (middle Ebro river basin, low Duero river basin, etc.). Within this sector water availability is very conditioned by the contributions produced in the mountain systems. Among them are of special importance those proceeding from the Cantabrian system (Duero river basin) and Pyrenees (Ebro river basin), which are the main water resource producers in the Iberian area. Within this sector. Water resources from the detritic water tables localised in the middle of the big depression are also important.

The Mediterranean sector is constituted by small river basins and average slopes towards the sea. Pluviometry is generally quit low, due to its localisation in a sector of shadow with regard to the humid North-western winds. To be emphasised the marked irregularity of precipitations with long drought periods and catastrophic episodes of convective rainfalls. Scarcity and irregularity is not compensated by rivers' contribution, as river basins are quite small in this sector and with a torrent regime, lacking big water-producers orographic centres. Natural scarcity of water increases going southwards, reaching its maximum levels in the coastal areas of Murcia and Almeria. Within this area, subterranean water resources acquire great importance, and are mostly constituted by carbonated water tables.

The permanent population of Spain according to the 1999 census was 39,238,000 inhabitants. The recorded tourist international arrivals for 2000 were 48,5 M.

Map 1. Spain in the Mediterranean

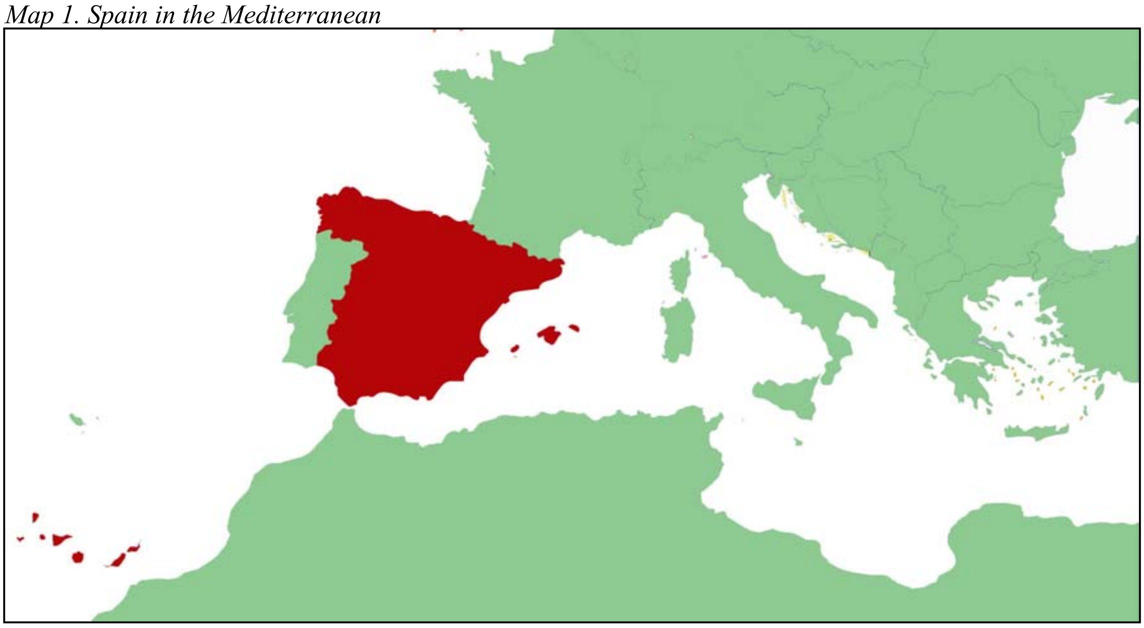
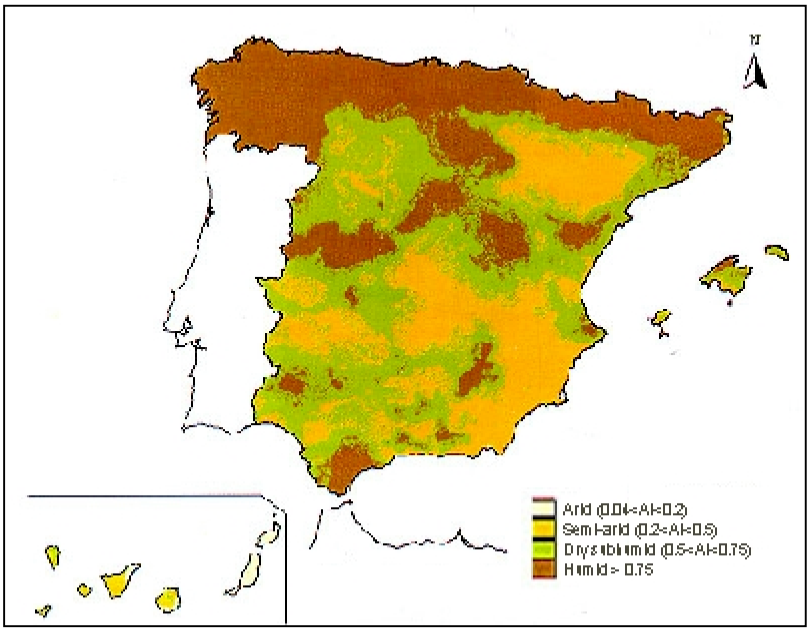


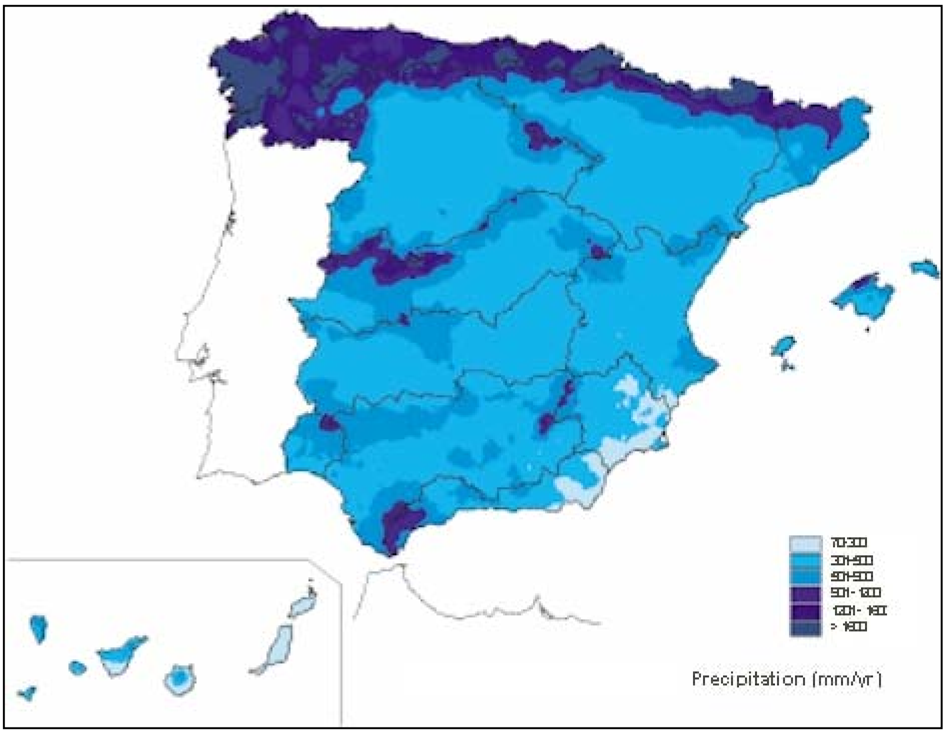
Table 1. Summary of Spain's physical features

Background	Description
Climate	The main characteristic of Spain's climate is its diversity, due to its geographical situation: it is in fact localised between two big sea-masses (Atlantic Ocean and Mediterranean sea) and two continents (Europe and Africa). The Northern part is characterised by a mild climate, with storms of Atlantic origin that are practically present all the year round, giving rise to a high relative humidity and mild temperatures, temperate in winter and cool in summer. In the Mediterranean coast and part of inner Andalusia (basically the Guadalquivir river basin), Climate is characterised by dry summer and mild winters. The predominant climate of the rest of the country is typically continental, with dry hot summers and cold winters. Winter anticyclones are usual for this area, and this situation gives rise to thermal inversions. Climate is generally dry in the Canary Islands (especially in the eastern islands, as the western ones are influenced by Atlantic air masses charged with humidity) and in the coastal area of Murcia and Almeria, where only scarce precipitations occur. In accordance with the humidity UNESCO's Global Humidity Index, based on a ratio of annual precipitation and potential evapo-transpiration (P/PET) index, Spain can be divided into de following zones: • Arid areas: Eastern mainland sector, eastern-southern areas of the Canary Islands and Tabernas desert, near Almeria. • Semi-arid areas: Ebro Depression, Almeria, Murcia, southern Jucar river basin, Guadiana headwaters area. • Sub-humid: Duero river basin, southern inner basins of Catalonia, Balearic Islands and Guadalquivir river basin. • Humid: Galicia and Cantabrian area.
Geology	One of the most relevant features of Spanish mainland is its central plateau, flat lands with average altitude of 600 m above the sea level that occupy nearly half of the Spanish area. It is vertebrated by the Central Cordillera, characterised by granitic and shale formations. The origin of the plateau lies in the existence of two depressions of the basement that were filled by hundreds of metres of clay-loamy and gypsiferous sediments coming from the adjacent mountain chains. There are other two outstanding deep depressions (Ebro and Guadalquivir) filled by tertiary materials that offer low resistance to erosion. Limestone is the main constituent of the existing alpine-type mountain chains.
Geomorphology	Spain is the second highest country in Europe. The 24% of its total area is found above 1000 m a.s.l. and a 76% between 500 and 1000 m. The four structural elements that characterise the Spanish relief (plateau, mountain ledges, large depressions and peripheral mountain chains) are permeable and drained by a large number of springs that provide the main flow of the biggest rivers. Oppositely, the siliceous basement that form the Central Mountain System, The Galician Massif, Sierra Morena and Extremadura, are low permeability materials, characterised by very quick surface runoff and moderate basal flows.
Soils	According with the *Soil Taxonomy* classification, in Spain we find ten of the eleven orders of soil established. For this reason the Spanish territory is called "the miniature continent" by a number of geographers. The most represented orders are: Inceptisols (little more than 60% of the total territory), Entisols (15%), Aridisols (10%) and Alfisols (5%).

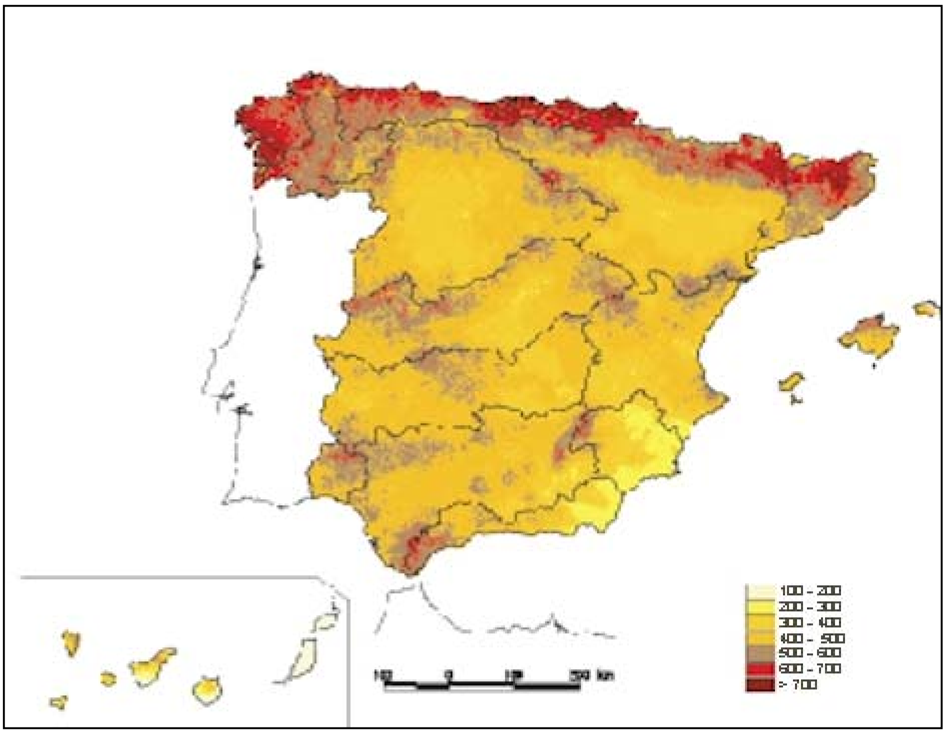
Surface water	The little river flow reveals the scarce pluviometry within the hydrographical network. Big collectors are divided in those coming from the central plateau (Duero, Tajo and Guadiana rivers), and those flowing from the depressions (Ebro and Guadalquivir) with water volumes that can go beyond 5,000 hm^3. The other rivers, of minor importance, correspond to the maritime slopes of the peripheral mountain chains and have small length and small river basins. Among these, the Mediterranean ones are characterised by very little and irregular flow, while the Atlantic ones have bigger, regular flow. The total volume of waters collected by Spanish rivers is about 106 000 hm^3. In Spain there are a total of 2474 lakes and lagoons, mostly small-sized but with a great diversity with regard to their genesis.
Water storage features	Dam capacity is at present of 53,191 hm^3 (INE 2001). This quantity is one of the highest dam index ratio in Europe. The only problem is that they are unequally distributed. A good percentage of these is constituted by dams with hydroelectric capacity: Maximum capacity of hydroelectric dams is 18,047 million kWh (UNESA, 1997).

Map 2
Climatic classification according with the UNESCO's humidity index





Map 3. Precipitations in Spain



Map 4. Actual yearly average evapo-transpiration

1. Overview of the country

1.1 Water Demand and Supply Status

Urban water supply

This demand encloses the one originated in population centres, both to satisfy domestic consumption and linked to other activities, can be industrial or service-related. It sums up to some 4,700 hm^3 /year.

Coastal concentration of population specially affect the Mediterranean area, with in a process tending to coastal conurbation. The important tourist development of these regions, which in many cases is the main economic activity, sums to this demographic distribution feature and water spatial demand. Tourist activities produce an approximate yearly increase of 10% in the population demand, although the increase is higher due to the high consumption of several recreational activities. This increase is very concentrated in time, more precisely in the summer period, which have bigger supply problems.

Forecasts made by the basin hydrological plans suggest increases of 15% and 36% on the present situation, in 10 and 20 years respectively. The draught periods of the last decade have shown the serious risks of lack of supply in large regions.

As regards sewerage, the percentage of purified urban waste water is around 60%, although only 45% meets the requirements of Directive 91/271.

Industry

Yearly water quantity dedicated to industry use in Spain are at present about 1,700 hm^3, approximately 5% of total consumption. This number do not include those industry use supplied by the urban distribution grid nor those aimed to power production (refrigeration and hydropower) whose specific consumption is quite low. Geographical distribution of the industrial activity shows similar trends to the population one, with a higher concentration in the eastern Mediterranean coast, especially in the regions of Catalonia, Valencia and Murcia.

Irrigation

Quantitatively speaking, irrigation is the main use of water in Spain, with a demand higher than 24,000 hm^3/year, that represents more than 80% of the total. These resource supply an area of 3.4 million ha, that are close to 18% of the total cultivated area. Irrigation demands, precisely in deficitary areas, are nowadays one of the main points of friction within the resource assignment policy, especially in the subject of inter-basin transfers.

Environmental requirements

Conservation of ecological and landscape resources linked with water requires maintaining minimum flows: water table discharges, river flow-level or quantity of water reaching the sea at the river mouth, without which these resources can suffer a strong degradation. In the Mediterranean area and in the south there is a clear concentration of the risk of scarcity, and this situation corresponds to the natural scarce availability of water resources and to the high concentration of demands that concern all water uses: agriculture, tourism, industry and population supply.

Scarcity in deficitary areas had as a first effect an accused tendency towards over-exploitation of ground water, above its natural renewal ratio. In the actual case of ground water, exploitation is at present around 5,500 hm^3 per year, that cover 30% of urban and industrial supply and 27% of the irrigated area. Excessive exploitation of surface water resources sums up to the impacts produced by ground water overexploitation. This policy brought to the present situation where Spain is, after Cyprus, Albania, Iceland and Norway, one of the countries with the highest number of dams per inhabitant (30 dams for every million of Spanish inhabitants).

Map 5. Density and distribution of the population. The effect on the deficit areas.

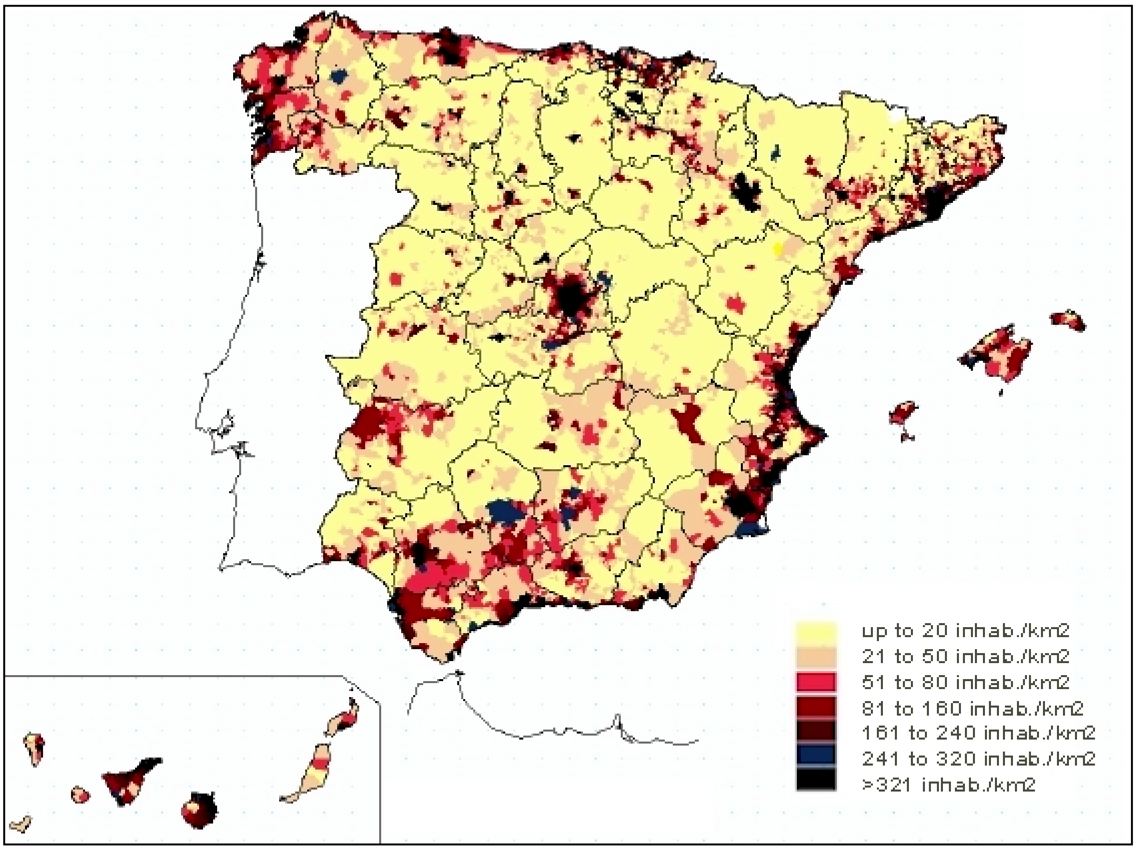


Table 2. Available Surface Water Resources in the 13 water regions.

Water Availability (hm^3)	A 1967	B 1980	C 1990	D 1991	E 1993	F 1998
Coastal Galicia	-	-	-	1302	1302	-
North	8525	7448	-	4967	8828	-
Duero	6405	9111	9465	9269	7797	10229
Tajo	4356	8343	6281	6233	6233	5063
Guadiana	2252	2462	3017	2385	2963	2963
Guadalquivir	3564	2810	4780	3255	3416	3451
South	538	785	533	861	1109	1007
Segura	665	1317	1742	700	1125	1500
Júcar	1850	3104	2003	2564	3052	3437
Ebro	8502	14133	9289	9337	10727	9898
C.I. Catalonia	697	1656	-	1358	1358	1587
Balearic Islands	-	313	-	312	312	300
Canary Islands	-	496	-	496	420	417

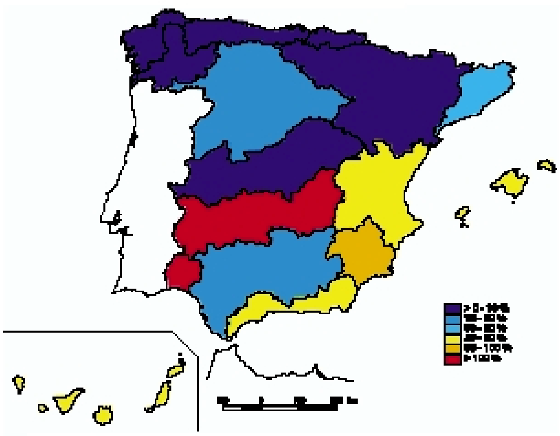
A) Water Resources. II Social and Economic Development Plan. Presidency of the Government, PG (1967).
B) National Hydrologic Planning. Inter-Ministry Commission of Hydrological Planning. MOPU-CIPH (1980).
C) Hydrologic Plan. MOPU-DGOH (1990).These data only refer to river basins involving more than one Autonomous Region.
D) Water in Spain. Engineering Institute of Spain. IIE-ITGE-UNESA. (1991).
E) PHN Report. MOPT (1993). It includes over-exploited water tables: Guadiana I (280 hm^3/year), Guadalquivir (25 hm^3/year), South (60 hm^3/year), Segura (325 hm^3/year), Júcar (125 hm^3/year), C.I. Catalonia (50 hm^3/year), Balearic Islands (30 hm^3/year) and Canary Islands (160 hm^3/year). Total 1055 hm^3/year. It does not include returns (8.000 hm^3/year), nor re-use or desalination (115 hm^3/year)
F) River Basin Hydrologic Plans (1998).

Table 3. Available Groundwater Resources in the 13 water regions. Deficits of water balance.

Water Availability (Hm^3)	Natural reloading	Pumping Hm^3/year	% Pumping/Reloading	% Pumping/total	Deficit ([1]) p/r > 1
Coastal Galicia	2234	-	-	-	-
North	8716	52	-	-	-
Duero	3000	371	12.4	6.7	-
Tajo	2393	164	6.9	3.0	-
Guadiana	750	814	110	14.7	240
Guadalquivir	2343	507	21.6	9.2	10
South	680	420	61.8	7.6	68
Segura	588	478	81.2	8.6	215
Júcar	2492	1425	57.2	25.8	54
Ebro	4614	198	4.3	3.6	-
C.I. Catalonia	909	424	46.6	7.7	10
Balearic Islands	508	284	55.9	5.1	14
Canary Islands	681	395	58.0	7.1	32

1. Deficit of exploitation units in relation with pumping/reloading > 1

Ratio pumping/reloading



Ratio pumping/total pumping in Spain

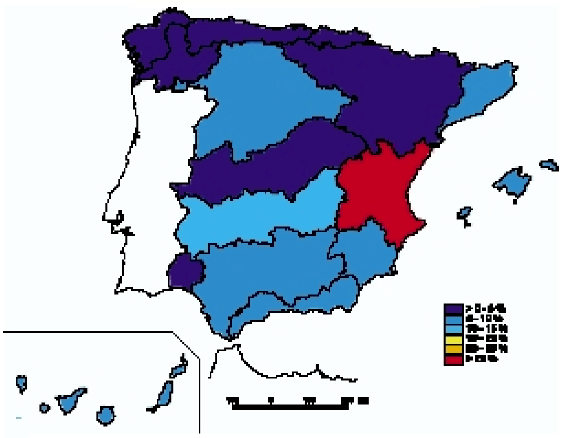
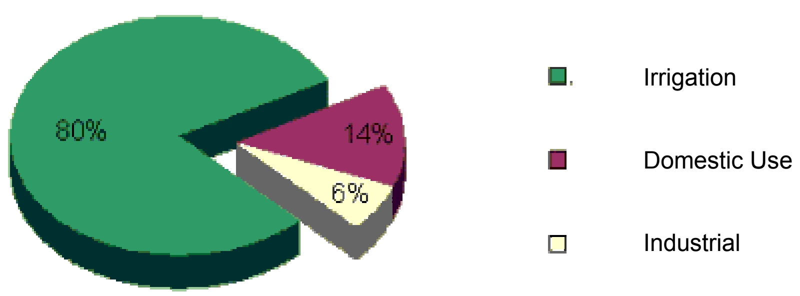
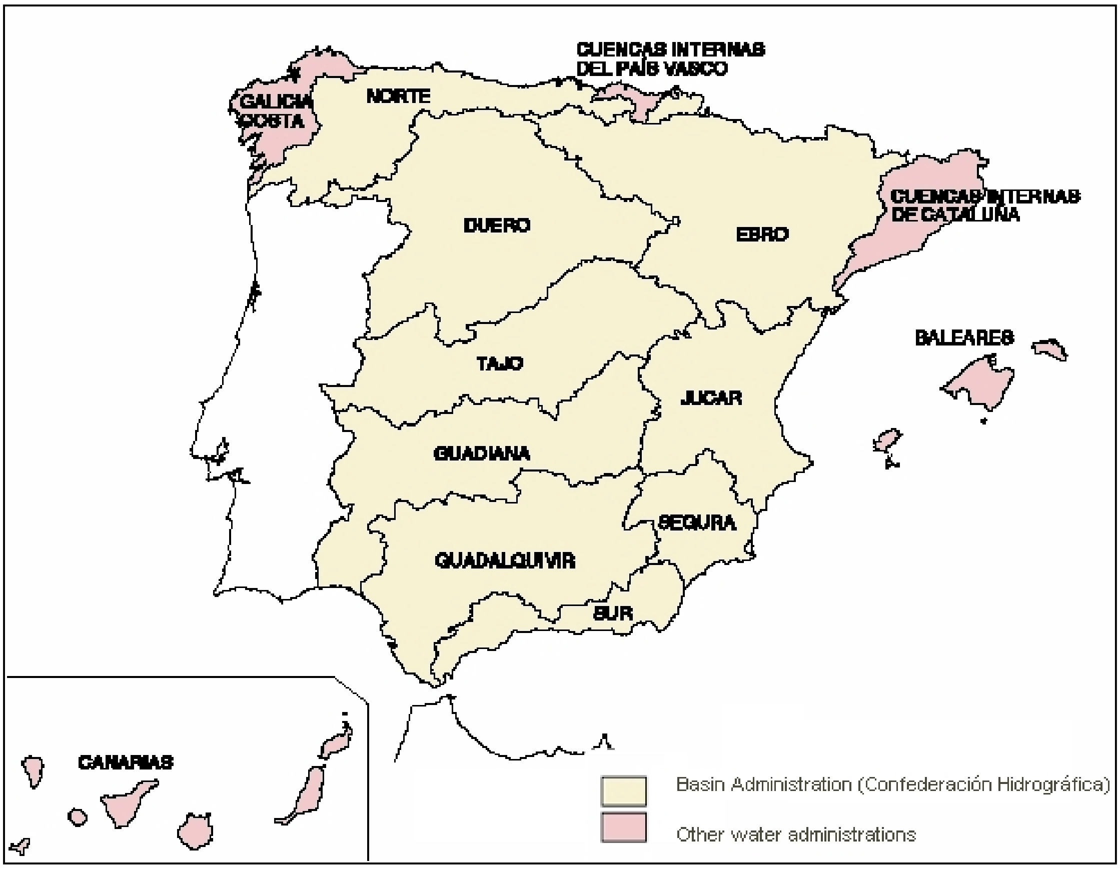


Table 4. Water consumption in the 13 Water regions.

Water Consumtion (hm^3)	Domestic Use	Industry	Irrigation	Refriger.	Total	Consumo	Retorno
Coastal Galicia	210	53	532	24	819	479	340
North	550	527	532	73	1692	646	1046
Duero	214	10	3603	33	3860	2929	931
Tajo	768	25	1875	1397	4065	1728	2337
Guadiana	157	84	2285	5	2531	2877	654
Guadalquivir	532	88	3140	0	3760	2636	1124
South	248	32	1070	0	1350	912	438
Segura	172	23	1639	0	1834	1350	484
Júcar	563	80	2284	35	2962	1958	1004
Ebro	313	415	6310	3340	10378	5361	5017
C.I. Catalonia	682	296	371	8	1357	493	864
Balearic Islands	95	4	189	0	288	171	117
Canary Islands	153	10	264	0	427	244	183

Figure 1. Distribution of consumptions





Map 6. The Hydrologic basins of Spain – Water Administrations.

1.2 Environment and Protection

Groundwater over-exploitation is among the most relevant environmental effects of water use in Spain. Convergence of intensive crops and displacement of population towards deficitary areas is contributing to a progressive degrading of water subterranean resources, with all the associated problems such as marine intrusion, salinisation of soils and degrading of riverine and coastal ecosystems.

Risks can be better appreciated in the Eastern Spanish regions, in the Mediterranean area and the islands (especially the Canary Islands). This situation responds to a natural limited water resource availability and to a high demand concentration, that affects all water uses: agriculture, tourism, industry and domestic supply. Over-exploitation of subterranean resources reaches very serious levels in the Segura basin and in the most populated islands with a high tourist development.

The situation of subterranean resources has an important repercussion on surface waters, as it brings to spring , lowering of basic levels of river flow, reduction of inland wetlands and coast salinisation. The exhaustive exploitation of surface water resources sums up to the impacts produced by over-exploitation of ground waters. We have in fact regulation percentages higher than 70 % for the Jucar and near to 90% for the Segura basin.

Spread contamination coming from agriculture, connected to the increasing use of fertilisers and other chemical like insecticides, is another worrying danger for Spain, as it can bring to serious eutrophication problems in dams and contamination of ground water.

As regards waste water and purification, in spite of the big effort in infrastructures, it has not been possible to stop degradation of water quality, that affects both human consumption and natural areas linked to water (wetlands, river borders, etc.). As a reference it is noteworthy that 60% of water from Spanish rivers is not apt for human consumption.

To control water quality, Spain relies on 1200 championing stations, 1000 of which make periodical championing while the resting 200 make it only occasionally. They all make up the water Quality Integral Network (*Red Integral de Calidad del Agua - ICA*) that allows to check water characteristics in the hydrographic basins. The vigilance on water quality is carried out by more than 200 Alarm Automatic Stations (EAA) that continuously measure a group of parameters that work as water quality indicators and other elements of alarm.

The most affected natural areas, landscapes and ecosystems of interest, especially those included in the Natura 2000 network, correspond to:

- Riverine ecosystems, especially those located in the Mediterranean areas, which are seriously threatened.
- Continental wetlands and lake systems, subjected to strong impacts caused by water-tables over-exploitation or surface water depletion.
- Small wetlands linked to ground water.

- Lands traditional submitted to irrigation, whose abandon involves the loss of an important landscape and cultural heritage of the Mediterranean region, which in several cases also host habitats or species of regional. national or communitarian importance.

The following table shows the main significant effects linked to water deficit caused by over-exploitation:

Table 5. Environmental effects associated with water deficit and water-table overexploitation

ECOLOGICAL AND PUBLIC-USE REPERCUSSIONS	HYDROLOGICAL EFFECTS				
	Water-table overexploitation	Marine Intrusion	Deterioration of water quality in water tables	Reduction of river contributions	Deterioration of surface water quality
Subsidence processes	Serious				
Soil salinisation		Critical	Critical		
Eutrophication of masses of water				Serious	Critical
Alteration of coastal ecosystems	Critical		Serious	Serious	Serious
Degradation of wetlands (e.g. Daimiel – Doñana)	Critical		Serious	Serious	Moderate
Degradation of riverine ecosystems	Critical		Moderate	Critical	Critical
Loss of biodiversity - water species of animal and plants			Serious	Critical	Critical
Alteration of riparian communities				Critical	Critical
Degradation of agricultural traditional landscapes	Critical	Critical	Serious	Serious	Serious
Health-Sanitary risks linked to public river-beds				Critical	Critical
Loss of recreational resources linked to water				Serious	Serious
Loss of landscapes	Serious			Serious	Serious

Critical effects (red)
Serious effects (yellow)
Moderate effects (blue)

1.3 Water laws and Regulations

With regard to competencies in the field of water, in the Spanish case we must take into account the complementary, and sometimes decisive role of the Autonomous regions. Article 149.1.22 of the Spanish Constitution attributes the State the exclusive competency in the subject of legislation, planning and concession of resources and water exploitation when they flow through more than one Autonomous Region. On the contrary, according with the article 148.1.10, Autonomous Communities can have competencies on water exploitation projects and construction, and irrigation channels of interest within their territory. Most Autonomous regions have been transferred these competencies, which also include subterranean waters.

The Water Law (Ley de Aguas - 29/1985), is the State's basic text that regulates this subject, and only regulates the State's competencies. Nevertheless, the exercise of these competencies has to be ruled by the delimitation criterion used by the Water Law, based on the "river basin" concept, being the interregional river basins of exclusive competency of the State, with few exceptions. Law 9/1992, December 23rd, regulates the transfer of competencies to Autonomous regions. The Water Law disposes that Basin Administration bodies have to be created for hydrographical basins exceeding the Autonomous Regions' territory. These Basin Administration bodies will be the State's bodies with competencies on this issue. In Spain exist nine Basin Administration bodies (Confederaciones Hidrográficas): Northern Spain, Duero, Tajo, Guadiana, Guadalquivir, Southern Spain, Segura, Júcar and Ebro.

Within this framework, one singularity is the "Canary Islands' Water Law" of 1990. Since the special hydrological characteristics and the islands' water rights historical context, this law give almost total competency to the Canary Islands' Government, including the possibility to develop Hydrologic Plans.

The hydrological planning has also the Law rank (Law 10/2001-Hydrological National Plan), and organises a large part of competencies and functions within the water management scope.

Beside the Water Law, and among a large variety of regulations related with the use of water, the following ones are worth emphasizing:

- Water resources for domestic use: Royal Decree 1138/1990: Health-Technical regulation for the supply and quality control of potable water for public consumption.
- Regulation of municipal competency with regard to potable water supply to population, including sewerage (beside the articles of the Water Law): Basis Laws of the Local Administration.
- Regulation of the Water Public Domain (R.D. 849/1986, April 11th).
- Standards to measure the quality of water, including water contamination by persistent organic pollutants are contained in the Royal Decree 927/1988.
- Royal Decree 261/1996, February 16th, on the protection of water against the contamination produced by effluents from agricultural sources.
- Energy aspects related to water are regulated by the R. D. 2818/1998, about electric power produced by plants powered by renewable energy sources, waste or cogeneration.

- Royal Decree (Ley 9/2000) on Envirronmental Impact Evaluation (including trasvases of but of 100 hm^3 /year).

As regards water resource protection, it is integrated by an extensive legislative repertory referring to the protection of the environment and of habitats declared protected areas or of community's interest. The several national laws (in particular Law 4/1989 about conservation of natural areas and of wild flora and fauna), are complemented by autonomous regions' laws, and in both cases specific regulations on water in protected areas are included. Special attention is given to forest areas that are providers of water resources, wetlands (especially SBPZ and RAMSAR sites) and to those sections of rivers that host a high biodiversity. The Legal Order attends to and is especially complemented by the Directive 92/43/EEC regarding conservation of natural habitats and wild flora and fauna, as well as the Directive 79/409/EEC, relative to wild bird conservation.

Most EC's directives have been transposed the related legal order, both with regard to water protection and public health. As an example, there are more than 20 EC Directives, incorporated to the Spanish legal order regarding quality requirements of water in function of its use.

Map 7. Autonomus Regions in Spain

1.4 Institucional framework and constraints

The institutional and competency framework of hydrological planning and water use is structured on the base of the two following instruments:
- The National Hydrological Plan.
- The Hydrological Plans of each basin.

The Canary Islands' Hydrological Plan should be added to the above instruments because of its singularity and its specific competencies.

The National Hydrological Plan, approved by law (Law 10/2001) defines the competency areas and the water management framework in Spain. This Plan was among the most polemic elements as regards water policy in this country, especially referring to the water transfers from "excedentary" basins such as the Ebro case. The development and trusteeship of the Hydrological Plan and of the water policy at the national level are exclusive duty of the Ministry of the Environment, where an outstanding role is played by the General Direction of Hydraulic works and Water Quality. The Water National Council, already included by the Law of 1985, is the higher advisory body, has functions of great importance as regards hydrological planning in Spain, in particular with its capacity to sanction the Basin Hydrological Plans.

The management at the level of each hydrographic basin is assigned to the already mentioned Basin Administrations, whose functions are collected within art. 21 of the Law, and are the following:
- The elaboration of the Basin Hydrological Plan, its following-up and revision.
- The administration and control of the public water domain.
- The administration and control of the exploitations of general interest or that affect more than one Autonomous Region.
- Planning, construction and exploitation of all works carried out with charge to the own funds of the Administration and those that have been assigned to them by the State.
- Those deriving from agreements made with the Autonomous Regions, Local Administrations and other public or private bodies, or those signed with privates.

The competency survey closes with the Users' Communities, registered at the Basin Administration, among which the irrigators' Communities stand out for their importance. On the other hand, the State Water Society have been created for the promotion of the hydraulic infrastructures included within the Basin Hydrological Plans. Their objective is to facilitate the joint intervention of private and public initiative for the execution and exploitation of the works carried out in each basin and, in definitive, to optimise the available economic resources.

One of the characteristics of the institutional conflicts is found in the disparity of criteria between the Ministry of Agriculture and the Ministry of the Environment when it is time to elaborate the Basin Plans. An almost permanent disagreement that rises from the contradiction that who decides water agricultural uses is not the final responsible for them. A significant example is given by the clear disconnection between the National Hydrological Plan and the National Irrigation Plan, presented by

the Ministry of Agriculture but not approved, that plans 250,000 ha of new irrigated lands, while the Basin Hydrological Plans forecast a total of 1,500,000 ha. On the other hand the viability of new irrigated lands is not so clear, and it should be questioned to consider them as the main, or only way of rural development.
Municipalities have competency for potable water supply to the population and for sewerage. To carry out these services, local bodies can use the type of management allowed by articles 57, 85 and 87 of the Law of Bases for the Local Regime. Therefore it can be chosen between a direct management (by the Local Administration itself, its Autonomous bodies or commercial societies with exclusive capital), or an indirect management (commercial societies with majoritarian capital, concessions and agreements).

It is within Municipal supply that the extreme overlapping and atomisation of competencies is shown in the clearest and most negative way. The Administration's uncontrol of the concessionaire companies' functioning is very high, in a framework where most supply services with a public management are being transferred to private companies (it does not exist a national regulation. It is worth reminding that he process of privatisation is not subjected to any control and in most occasion it is used to correct deficits, of various origin, of the municipal budgets. Competency and institutional overlapping is also shown in cases such as low efficiency of the purification plants given to municipalities, most of which are unoperational or abandoned after they have been entrusted to municipalities.

Low bill collecting efficiency sums up to the competency dispersion of the institutional framework. It is due not only to the same concept of the economic-financial regime, but also to the low efficiency of the system to collect exactions (collection is situated around 50% of total billing and in many cases considerable delays take place). Furthermore, 75% of the water consumed in Spain still does not pass through a meter (although water is constantly qualified as a "scarce resource"), and this favours a unmeasured and inappropriate use, that is added to the fact that pipelines suffer losses frequently higher than 40-50%.

Table 6. Responsible Authorities in the Water Sector

Responsibilities	Agency/Authority
Planning Regulations	Ministry of Environment Water National Council (Consultative) Basin Administrations (Conferederaciones Hidrográficas) Autonomous Regions (A.R.)
Administration and control of the hydraulic public dominion.	Basin Administrations (Confederaciones Hidrográficas) Autonomous Regions (internal river basins)
Domestic and urban	Ministry of Environment Ministry of Industry Ministry of Health and Consumption. Basin Administrations Civil Works Administration (A.R) Health Administration (A.R.) Industry Administration (A.R.) Environment Administration (A.R.) Diputaciones Provinciales. Minicipalities as final administration in charge
Irrigation	Ministry of Agriculture Ministry of Environment Autonomous Regions Comunidades de Regantes
Infrastructures	Ministry of Environment Basin Administrations (Confederaciones Hidrográficas) State Water Society Autonomous Regions
Purificatin and Re-use	Ministry of Environment Ministry of Development Ministry of Health and Consumption. Basin Administrations Civil Works Administration (A.R) Health Administration (A.R.) Environment Administration (A.R.) Diputaciones Provinciales. Minicipalities as final administration in charge
Hydroelectric uses	Ministry of Environment Ministry of Industry and Energy Basin Administrations Autonomous Regions

1.5 Management, Institutional and policy options

Spanish water policy is found in the National Hydrological Plan, in the Basin Hydrological Plans and, complemantarily, in the policies and decisions developed at the level of each Autonomous Region.

The strategic options set forth in the National Hydrological Plan can be summarised as follows:

Programmed reduction of demand.

- Maintenance of present-day water contribution by inter-basin transfers.
- Increase in available volumes through a major use of waste water and modernisation of irrigated lands.
- Adoption of measures of saving and modernisation of irrigated lands.
- Programmed withdrawal, by public initiative, of the irrigated lands supplied through overexploited water tables which are unsustainable on the medium-long term.
- Application of compensatory measures to the affected collectives.
- Priority maintenance of water domestic supply.
- Reduction of losses during water transportation (there are limit situations that at present are around 50% in large trasvases).

Large-scale desalination. Covering deficits through large-scale desalination of seawater complemented by saving and re-use measures:

- Applications of the measures considered in the previous option, except the reduction of irrigated lands, incorporating an additional water contribution from seawater desalination.
- Maintenance of consumption levels similar to the present ones, only increased by the new demands of supply.
- Effective control of the agricultural demand increase through legal and technical-administrative instruments.

Inter-river basin transfers. Covering deficits through water transfer from other basins, according with the existing possibilities, complemented by desalination, saving and re-use measures:

- Stabilisation of agricultural demand, maintaining irrigated land area at the same level corresponding to the present-day situation, through application of legal and technical-administrative instruments.
- Adoption of water saving and re-use complementary measures similar to those contemplated in the previous options.
- Local seawater desalination for local supply.
- Inter-basin transfer are planned following the criterion of minimising both water costs and environmental effects on the affected river sections and the territories that host the water-transportation infrastructures.

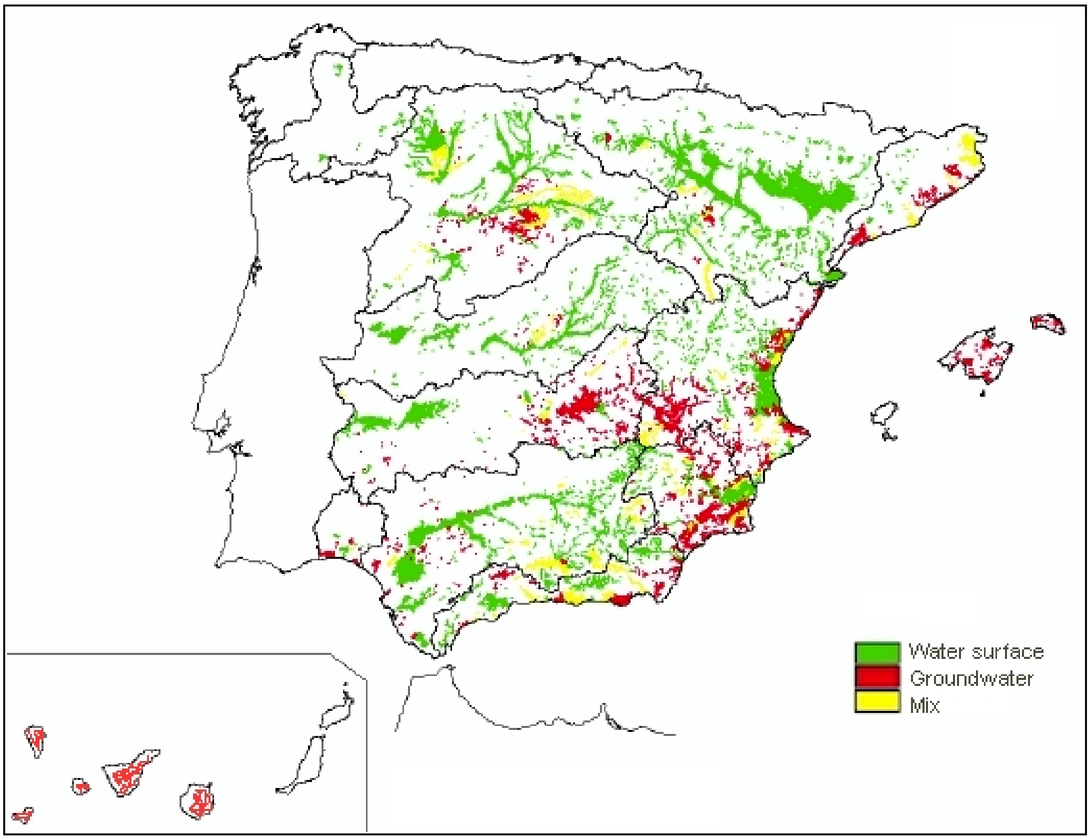
This last option has generated the strongest social tensions and environmental contestations between the different basins. It is worth reminding that the National

Hydrological Plan states in its prologue that “inter-basin transfers should constitute the last solution".

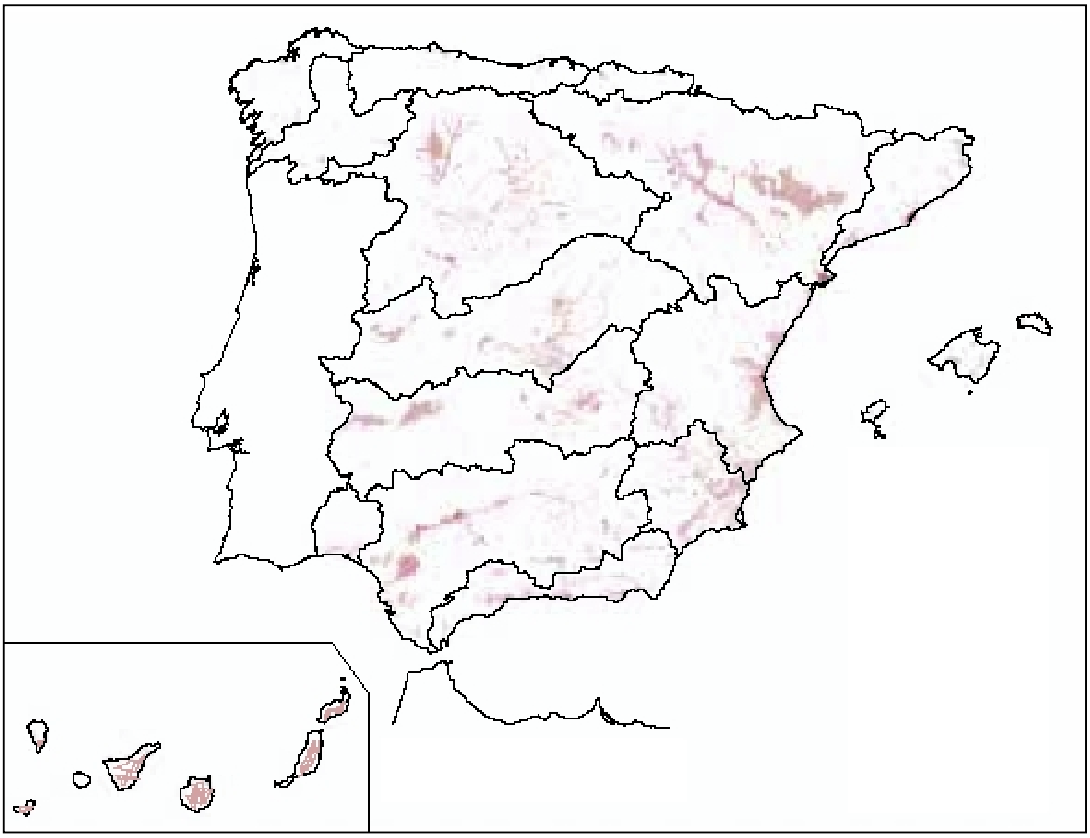
Beside the multiple initiatives at the Autonomous regions level, at the State level there is a group of Programmes and action lines that exemplify the options of future with regard to water policy and management. We have therefore:

- The Programme for the improvement and modernisation of traditionally irrigated lands, whose aim is irrigating water saving, improvement of water quality, re-use of waste waters and energy saving.
- As regards sewerage, there is a National Plan of Sewerage and Waste Water Purification, through which infrastructures for sewerage and waste water purification are planned, with the aim to achieve by 2005 that urban settlements of more than 2,000 inhabitants will rely on adequate purification systems. Nevertheless, municipal wastes sum up to 3.500 hm3/year approximately, of which more than 700 are directed to the sea. In these moment re-use of waste water is close to 100-150 hm3/year, and constitute one of the most delicate points to resolve as regards sustainable management of water resources, due to the high degree of competency disorder.

Furthermore a number of awareness promotion campaigns on sustainable use of water have been carried out, although their repercussion at a national level is of little significance. On this line it is necessary to include the impact of the new municipal, large-reaching initiatives such as the implementation of local Agendas 21, that include programmed improvements regarding water sustainable use and water quality.



Map 8. Distribution of the irrigated land. Water source.



Map 9. Distribution of the water deficit (all concepts).

Table 7. Constraints facing the water sector

Category	Constraints
Natural	Unequal water spatial distribution. Uneven precipitation distribution, spatially and temporally. Dependence on transboundary waters. High sensitivity and risk of loss of the aquatic ecosystems. Frequent droughts.
Human	Tendency - distribution of population towards deficit areas. Tourist influx is uneven in space and time. Excessive water consumption for irrigation. Demand peaks in the dry season. Groundwater and surface water is contaminated by pollutants. Spread contamination coming from agriculture. Overexploitation of underground aquifers. Irrigation of unsuitable or nonprofitable cultures. Lack of environmental awareness.
Technical	Technological incapacity of the local authorities and particularly maintenance of water infrastructure. Old distribution networks with high losses (average 50 years) Complexity of transvases. Lack of proper irrigation techniques that would save water. Low efficiency of the purification systems. Little technological diversification. Illegal connections to the networks. Absence of control (60% of water not entered). Use of conventional energy sources for the massive desalination. Lack of information on new technologies for water saving and management
Financial	Water pricing is politically influenced and not based on water cost, leading to inadequate finances for the funding of further infrastructure. Inadequate prices for final uses in sectors like the tourism and the new cultures - competition with other traditional sectors. Deficient allocation of funds to the remote regions. Serious difficulties for the application and collection of the “spill canon”. Noninclusion of environmental externalities. Destiny of the financial collection for aims different from the water.
Administrative and Institutional	Overlapping and atomisation of competencies (e.g. urban supply). Lack of coordination among responsible authorities. Lack of participation of key water actors in the Basin Administrations. Undefinition of the roll of the Users Communities. Lack of convergence of the sectorial policies. Absence of homogenous criteria in the privatization processes. Lack of citizen participation.

Table 8. Water Resources Planning Matrix

Activity	Municipal Authority/ Water Utility	Autonomous Regions	River basin authorities	Users Communitiess	Ministry of Environment	Ministry of Agriculture	Ministry of Industry
Surface water							
Use	X	X	X	X	X	X	X
Storage	X	X	X	X	X	X	X
Recharge		X	X		X	X	X
Diversion		X	X		X		
Quality monitoring		X	X		X		
Assessment	X	X	X				X
Ground water							
Use	X	X	X	X	X	X	X
Storage	X	X	X	X	X	X	
Recharge		X	X		X		
Quality monitoring		X			X	X	
Assessment	X	X	X		X		
Well/drill permits		X	X				
Irrigation network							
Rehabilitation		X	X	X	X	X	
Modernization		X	X	X	X	X	
Reuse							
Drainage water			X		X	X	
Wastewater	X	X	X		X		
Desalination	X	X		X	X		
Introduction of technology		X	X		X		X
Efficient water utilization							
Domestic	X	X	X		X		
Industrial		X			X		X
Irrigation		X		X	X	X	
Legislation							
Regulation and		X			X	X	X
codes	X	X			X	X	X
Standards							
Policy setting					X		
Water allocation	X	X	X		X		
Project financing		X	X	X	X	X	X
Project design		X	X		X		
Project Implementation		X	X	X		X	
Operation and maintenance	X	X	X	X			
Pricing	X	X	X		X		X
Enforcement							
Water Data records	X		X		X	X	

WaterStrategyMan

Report on the Israeli Water System:

General Description and Data

Prepared by:

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June 2002

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Abstract

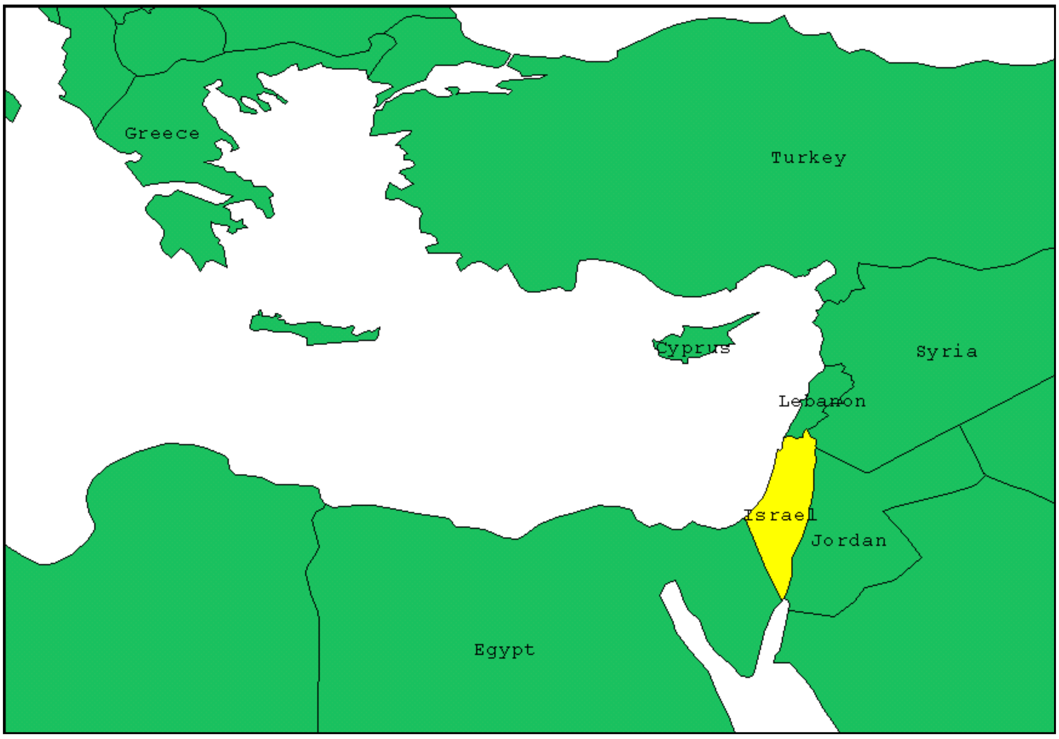
Chronic scarcity of water is a fact of life in Israel where aggregate demand exceed the supply of fresh water in a largely semi-arid environment. The Israeli water economy is in the midst of a severe crisis whose main features are large fresh water deficits, increased deterioration of water quality and ecological crisis (almost all rivers have been tapped to the point of non-existence). Factors contributing to the crisis include population growth and economic development, over-pumping of the aquifers and poor water institutions. In principal, Israel should be examined as a single "water region" because water can be easily transferred from one area to another via an efficient national water delivery system. The current report provides data on various aspects of the Israeli water economy and offers a few policy changes required to overcome the current crisis.

A. INTRODUCTION AND GENERAL BACKGROUND

A1. A Brief Description of Israel

A1.1 Physical Characteristics

Israel is located on the Eastern Shore of the Mediterranean Sea (Figure 1, Figure 2). Israel is bounded on the north by Lebanon, on the northeast by Syria, on the east by Jordan, and on the southwest by Egypt. Its southernmost tip extends to the Gulf of Aqaba, an arm of the Red Sea. Israel covers 21,946 sq. km (8473 sq. mi.).



Map No. 1. Geographic location of Israel

Israel occupied the Gaza Strip, the West Bank region, and the Golan Heights area of southwestern Syria. However, Palestinian self-rule took effect in the Gaza Strip and parts of the West Bank following a peace agreement between Israel and the Palestinian Authority.

Physical characteristics of Israel which are relevant to the current study are summarized in Table 1.

***Table 1*. Summary of Israel's Physical Characteristics**

Background	***Description***
Climate	*Israeli climate is characterized by a short, cool and rainy winter and a long, hot dry summer. Though a very small size (22,145 square km) the unique geographical disposition of Israel induces a rich climatic diversity. Gradually but steeply, rainfall decrease (from 700 to 30 mm) and potential evaporation increases (from 1200 to 2800 mm) from north to south as well as with reduced elevation. A west-east eco-climatic gradient is superimposed on an elevation gradient of 1200 m above see level to 400 m below sea level (the lowest point along the Jordan-Arava rift Valley). On top of this gradients in climatic means, a north-south and higher-lower elevation gradients exist in climatic variability around these means, namely- an increasing variability and uncertainty in precipitation with increased aridity. The long, hot and dry summer that extends all over Israel, and the spatially prevailing ranges of precipitation and potential evapotranspiration make Israel a dry-land country. Lands with aridity index ranges between 0.5 to 0.65 (Dry subhumid lands) include most of the coastal plain, the northern valleys and the Galilee. Mean annual precipitation in these areas is 500-700 mm and it is of a typical eastern-Mediterranean climate. Semi-arid drylands of Israel, with Aridity Index ranging between 0.20 to 0.50 are located south and east of the dry subhumid drylands. The northern Negev, the upper reaches of the Judean Desert, the northern Jordan Valley, the Kinnarot and Hulla Valleys are semiarid drylands. The mean annual precipitation is 300 – 500 mm. Arid drylands, with aridity index ranging between 0.05 to 0.20 are located south and east of the semi arid dryland. The western Negev and Be'er Sheva Valley, the central reches of the Judean Desert and the southern Jordan valley are arid dry lands with mean annual precipitation of 100-300 mm. Finally, Hyperarid dry lands with aridity index lower than 0.05 of Israel , with mean annual precipitation of 30-90 mm, are south and east of the arid drylands. They include the central and southern Negev from Mitzpe ramon to Eilat, the Dead sea Basin and the Arava Valley.*

Background	***Description***
Land	*Israel has an extreme length of about 420 km and a width that varies from about 16 to 115 km; it can be divided into five major topographical areas the highlands of Galilee, the Plain of Esdraelon (also called the Plain of Jezreel), the Judean and Samarian hills, the coastal plains, and the Negev.* *The hills of Galilee dominate the northern section of Israel, extending east about 40 km from a narrow coastal plain across to Lake Tiberias (also called Sea of Galilee or Lake Kinneret). Israel's highest point, Mount Meron (1208 m), is in this area. To the south of the highlands of Galilee lies the Plain of Esdraelon, about 55 km long and about 25 km wide, running across Israel from the vicinity of Haifa on the Mediterranean coast to the Jordan River. Formerly a malarial swampland, the valley has been drained and is now a densely populated and productive agricultural region.* *Extending about 195 km along the Mediterranean, the coastal plains range from a width of less than 1 km to a maximum of about 32-km. They consist of the Plain of Zevulun, extending about 16 km north of Haifa along the Bay of Haifa; the Plain of Sharon, extending south from the vicinity of Haifa to Tel Aviv; and the Plain of Judea, from Tel Aviv to the city of Gaza. The coastal plains contain most of Israel's large cities, industry, and commerce. The Judean Hills, and north of them the Samarian Hills, form a barrier running north and south throughout most of Israel.* *The Negev is a desert region to the south. The desert extends north from the Gulf of Aqaba to a line from the southern end of the Dead Sea to the Mediterranean, passing just south of Beersheba.* *The chief river of Israel is the Jordan. It descends from Mount Hermon on the Lebanon-Syrian border to Lake Kinneret, some 209 m below sea level and ultimately into the Dead Sea, approximately 395 m below sea level, the lowest point in Israel.* *The coastline of Israel has few indentations. The only natural harbor on the Mediterranean is Haifa*
Groundwater and Hydrogeology	*The base flow of the Jordan River, which feeds the sea of Galilee comes from limestone aquifers in the north of the country, that its recharge area is in Syria and Lebanon. Another aquifer of primary importance is The Mountain Aquifer which is built of permeable limestone. The third aquifer of importance is the Coastal Plain aquifer. It is built of permeable sandstone rocks. Layers of semi-permeable loam to impermeable clay are sandwiched in-between the sandstone layers, dividing them into sub-aquifers. Data on the annual water potential associated with these and other aquifers (of relatively minor importance) are presented in the section on water supply. In aggregate, ground water resources supply about 57% of the annual fresh water potential in Israel.*

A1.2 Population

Table2. Population Data

(Source: New Master Plan for the Water Economy of Israel, January 2002, hereinafter: (1))

Year	Population (millions)	Annual Rate of Increase
1998	6.041	
2000	6.200	1.3%
2010 Projected	7.295	1.6%
2020 Projected	8.600	1.6%

Table 3. Geographic distribution of population

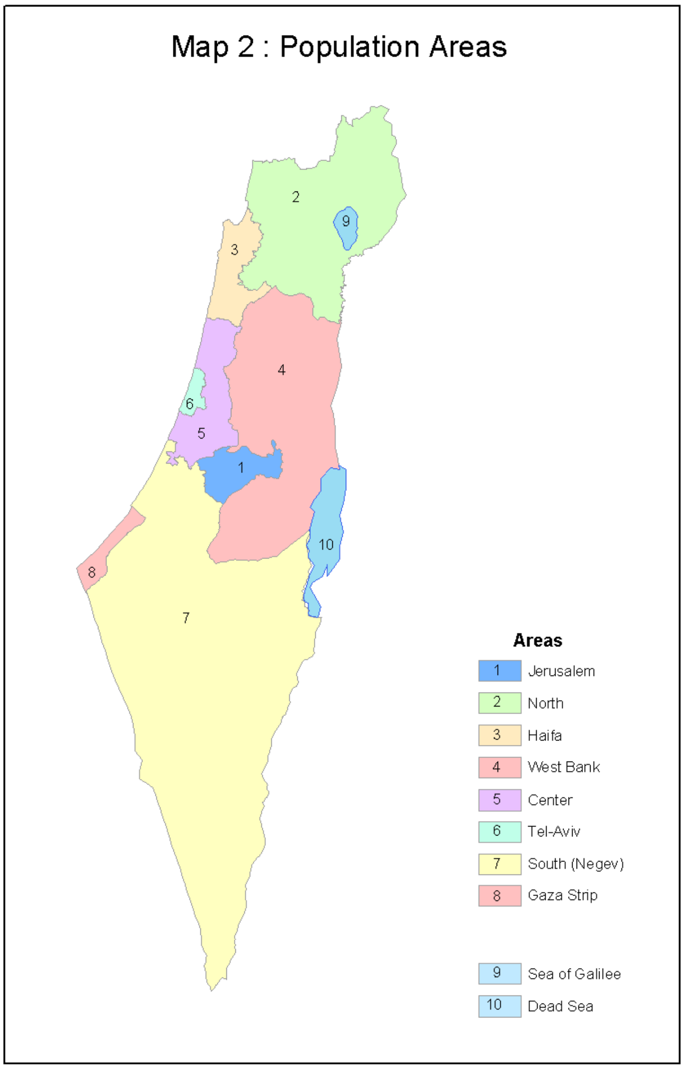
Source: Statistical Abstract of Israel, 2001.
Division based on Ministry of the Interior districts
See Map No. 2

District	Population		Area of District	
	(Thousands)	%	Sq. kilometers	%
1. Jerusalem	711	11	652	3
2. North	1042	16	4478	21
3. Haifa	840	13	863	4
4.Center	1530	24	1276	6
5. Tel Aviv	1301	20	171	1
6. South	841	13	14231	65
7. Judea & Samaria*	172	3		
TOTAL	6437	100%	21671	100%

* Jewish population only

Table 4. Distribution of population by type of settlement

Type of Settlement	Population (in millions)	
	Millions	%
3 metropolitan areas (Pop. exceeding 200,000)	1.5	23
9 big cities (Pop. 100,000-200,000)	1.4	21
Mid-sized cities (Pop. 20,000-100,000)	1.7	26
Small towns and cities (Pop. 2,000-20,000)	1.2	19
Villages and communities	0.7	11
TOTAL	6.4	100%


Map 2 : Population Areas
2
9
3
4
6
5
1
10
8
7
Areas
1 Jerusalem
2 North
3 Haifa
4 West Bank
5 Center
6 Tel-Aviv
7 South (Negev)
8 Gaza Strip
9 Sea of Galilee
10 Dead Sea

A1.3 Economic Indicators

General characteristics

Table 5. ***The Israeli Economy – Facts and Figures*, 1986 to 2001***

(Source: Bank of Israel Report, 2001 –
based on the Central Bureau of Statistics)

	1986-1989	1990-1992	1993-1996	1997-1999	1999	2000	2001
Average population (thousands)	4407	4911	5473	5974	6121	6283	6437
Population growth rate (%)	1.6	4.3	2.6	2.5	2.5	2.6	2.4
Employed Israelis (thousands)	1420	1573	1900	2083	2137	2221	2270
GDP (in billions of NIS, 2001 prices)	260	307	373	429	429	468	465
GDP growth rate (%)	3.6	6.4	5.5	2.9	2.6	6.4	-0.6
GDP/capita (in thousands of US$, current prices)	8.7	12.1	15.1	17.1	16.7	17.9	17.2
Unemployment rate (%)	7.1	10.5	7.8	8.3	8.9	8.8	9.3
Inflation rate (over the year, %)	18.2	15.0	11.1	5.6	1.3	0.0	1.4
Current account deficit (% of GDP)	0.2	1.1	4.8	2.7	2.9	1.2	1.5
Foreign currency balances (in billions of $)	5.2	6.2	8.6	22.3	23.2	23.8	24.1
Net foreign debt (% of GDP)	47.0	28.5	24.2	12.2	9.9	6.4	3.9

* Annual averages

Table 6. ***The business sector in Israel***
Source: Bank of Israel Report, 2001

Sector	Percentage of GDP
Industry	23.9%
Agriculture and gardening	3.3%
Transportation and communications	12.2%*
Construction	6.6%
Commerce and services	51.2%
Electricity and water	2.8%*
TOTAL	100.0%

* Infrastructure sectors

A1.4 Division into Water Regions

In principle, Israel should only be examined as a single geographic entity for the following reasons:

Freshwater

The National Water Carrier (NWC) connects all major sources of freshwater into a single network (see Map 3). Water can be transferred from one region to another, so that water from one aquifer may be used in a different geographical region. In addition to the NWC which transfers water from the Sea of Galilee in the north to the center and the south of the country (Negev), there are some additional major pipelines:

- Connection of the coastal aquifer (in the west) to the Jerusalem metropolis,
- Connection of the NWC to the Northern Coastal Plain and Western Galilee (in the north), and
- Connection of the Hula Valley (near the source of the Jordan River) to the Mountains of Galilee.

Recycled water

The Shafdan, a plant for the treatment of urban and industrial effluent of the greater Tel Aviv metropolitan area (which includes more than 30% of the country's population), is responsible for transferring recycled water to the southern region (Western and Northern Negev) for agricultural use.

Two large additional networks convey recycled effluent from the Jerusalem metropolis to the Negev Plain and from the Haifa metropolis to the Western Jezreel Valley, respectively.

Pricing policy

Water prices by quality and sector (agricultural, industrial, urban) are more or less uniform throughout the country.

Water institutions

According to the Water Law of 1959, all water in Israel is public property. Accordingly, water administration is highly centralized, with utilization controlled by the Water Commission.

Some 65% of the water in Israel is supplied by the national water company, Mekorot, (wholly owned by the government) which is also the sole owner of the National Water Carrier and the Shafdan.

A small number of regions are not linked to any of the aforesaid water systems. They are mainly in the east, and include the Beit Shean Valley, the Harod Valley, the Jordan Rift and the Arava (see Map 3). Therefore, although the country can be considered a single region, the demand and supply data will distinguish between these two sub-systems, denoting them the National System and the Peripheral System.

A2. Existing Conditions of Israel's National Water Economy

A2.1 The Israeli water economy is in the midst of a severe crisis whose main features are:

- Freshwater* deficit: Emanating from a decline in sources (Sea of Galilee, Mountain aquifer, Coastal aquifer) to levels that disallow pumping and production. Consequently, there is an increasing shortage of water for agricultural purposes (which is flexible) and even for industrial and domestic consumption.
  Israel has very belatedly commenced the processes for the desalination of saline water and seawater and therefore, additions to the water resources will only be tangible in the years to come.
  The agricultural sector's transition from freshwater to recycled wastewater is rather slow. As a result, in the short term it will be incumbent on Israel to drastically reduce the supply of freshwater for agricultural purposes. This will have significant consequences on the agricultural sector and its recovery in the future is uncertain.
  In the event of drought in the coming two to three years, supplying water for domestic and industrial needs will also be in jeopardy.
- Deterioration of water quality: Continual salination of the coastal aquifer due to seawater intrusion caused by over-pumping. The over pumping caused a severe decline in the water levels. This is particularly prominent in the Sea of Galilee. Qualitatively, it is most noticeable in the highly saline coastal aquifer.
  Hydrologists and planners are debating whether the aquifer can be rehabilitated or, if under the prevailing deficit conditions, it is better to continue reducing the water levels and accept the aquifer's salination, in turn mandating future desalination of the water prior to its use. This debate also reflects the issue of the burden that will befall future generations.
- Environmental crisis: The rivers and the Sea of Galilee basin are drying up and/or being contaminated by untreated effluent and garbage.

Among the many factors contributing to the crisis (some overlap and they are not listed in order of importance):

- Over-pumping of the aquifers, resulting in water level decline and salinity.
- Some decline in the natural renewal of the aquifers due to climatic changes in the eastern Mediterranean region.
  The observed phenomena include:
  - Increase in extremes and differences: More drought years, more very rainy years, and fewer years with average precipitation.
  - Reduction in precipitation in northern Israel (including the Sea of Galilee basin) and an increase in the annual average rainfall in southern Israel.

  There is still no accepted scientific explanation for these phenomena, but meteorological forecasts predict that these trends will intensify.

- "Hydropolitics" – The Israel water system is very vulnerable to public-political pressure, with the agricultural lobby in the forefront.
- Population growth and economic development, resulting in increased domestic and industrial consumption.
  These demands are rigid and have not been accompanied by an increase of sources and/or a reduction of the more flexible needs of the agricultural sector.
- Increase in the demands of neighboring entities following political agreements (Jordan and the Palestinian Authority (PA)).
- Public-political-economic debate regarding water allocation and pricing: Essentially, the debate is divided between the economic approach (Ministry of Finance) that calls for allocation based on a price system that includes the shadow price of water on the one hand, and the agricultural sector that requests quota-based allocations and water price adjustments based on ability to pay, i.e., subsidy, on the other hand. In practice, a combined and non-uniform allocation system developed, based on tiered prices and quotas.
- Continuing impotence of the regulator – the Water Commission (linked to hydropolitics). In 1996 the Water Commission was transferred from the Ministry of Agriculture to the Ministry of Infrastructure. The purpose of this transfer, inter alia, was to reduce sectoral considerations on the water economy. The move had limited effect and did not prevent the crisis.
- Noncompetitive structure of the system for allocating water to consumers – the strong centralized system of the government company, Mekorot, and its powerful workers' committee. Mekorot supplies more than half the water in Israel.
- Divergence among the government and the public authorities that control the water economy (with obvious conflict of interests arising among them).
- Lack of synchronization of the different needs that the water economy has to fulfill.
- Neglect, apathy, lack of awareness and minimal enforcement regarding environmental-ecological concerns.

* Freshwater refers to desalinated and natural freshwater
Reclaimed effluence and recycled wastewater are used interchangeably.

A2.2 An analysis of the processes that characterize Israel's water-shortage problem and strategy illustrates that:

a. The main quantitative expression of the crisis is the severe reduction in the ability to produce freshwater from the aquifers (approx. 500MCM) without operating additional wastewater reclamation systems and desalination plants.
b. The agricultural sector bears the brunt of the cuts (since the demand of the other sectors is rigid). Its allocation was recently reduced by about 40%.
c. The strategy for stabilizing the water economy is based on intensifying desalination of seawater and reclaiming wastewater for agricultural purposes. At the same time, hydrological rehabilitation of the natural

aquifers (reduction of the hydrological deficits) will not allow increased pumping as was customary prior to the crisis, and apparently one of its causes.

d. These processes have implementation limitations. Consequently, in the medium term the water mix at the disposal of the agricultural sector will be altered (which will influence its geographical distribution) and its overall consumption will not increase.

e. In the long term, assuming that reasonable quantities will be desalinated, the agricultural sector will only revert to its pre-crisis size.

f. The significance for the agricultural sector is:

- A sharp drop in fresh water allocated for export crops, particularly:
  Citrus – 120 MCM
  Cotton – 70 MCM
  Avocado and others – 10 MCM
  Total reduction 200 MCM
  These crops use mainly recycled wastewater. The water made available by reducing these crops can be redirected for growing vegetables for the local market and feed for dairy farming.
- As a result of the population growth and the stagnation of crop yields (in comparison to the pre-crisis years), fresh vegetable food imports will probably increase.

B. WATER DEMAND AND SUPPLY

B1. Water Demand

***Table 7.* Domestic Demand for Water (MCM/year)** (1)

Year	m^3 / capita	National System Demand	Peripheral System Demand	Total Demand
1998	115	669	25	694
2000	110	659	25	684
2002 Estimate	108	655	25	680
2010 Projected	120	844	31	875
2020 Projected	130	1080	40	1120

***Table 8.* Industrial Demand for Water (MCM/year)**(1)

Year	Freshwater			Saline Water	Recycled Water	Total
	National System Demand	Peripheral System Demand	Total Demand			
1998	91	2	93	36	0.2	129
2000	93	2	95	37	0.2	132
2002 Estimate	92	2	94	37	0.4	131
2010 Projected	107	3	110	44	13.0	167
2020 Projected	126	4	130	51	16.0	197

B1.1 Agricultural Consumption

Background

a. The agricultural sector bears the brunt of the drastic cuts in water supply mandated by the water crisis and the decline in freshwater supply from 1998 to 2002. (1998 represents an average year, and data for 2002 reflect the situation after several drought years.)
b. The government has decided to allocate 1150 MCM/year to the agricultural sector, composed of 530 MCM/year freshwater and the rest, recycled and saline water.
c. It is estimated that the aquifer deficit and Mekorot's ability to develop new water (desalination and recycling) will enable achieving the aforesaid goal only in 2010.
d. Future agricultural demand will probably be strongly affected by the extent to which the suggested price reforms are applied.
e. The agricultural demand for recycled water will be affected by quality (see below).
f. The following balances do not include floodwaters. (An average of 15 MCM/year, according to current catchment and reservoir capacities).

Table 9. ***Agricultural Consumption (MCM/year) Sources: (1) and data from the Consumption Division of the Israel Water Commission (hereinafter: (2)). See Map No. 3***

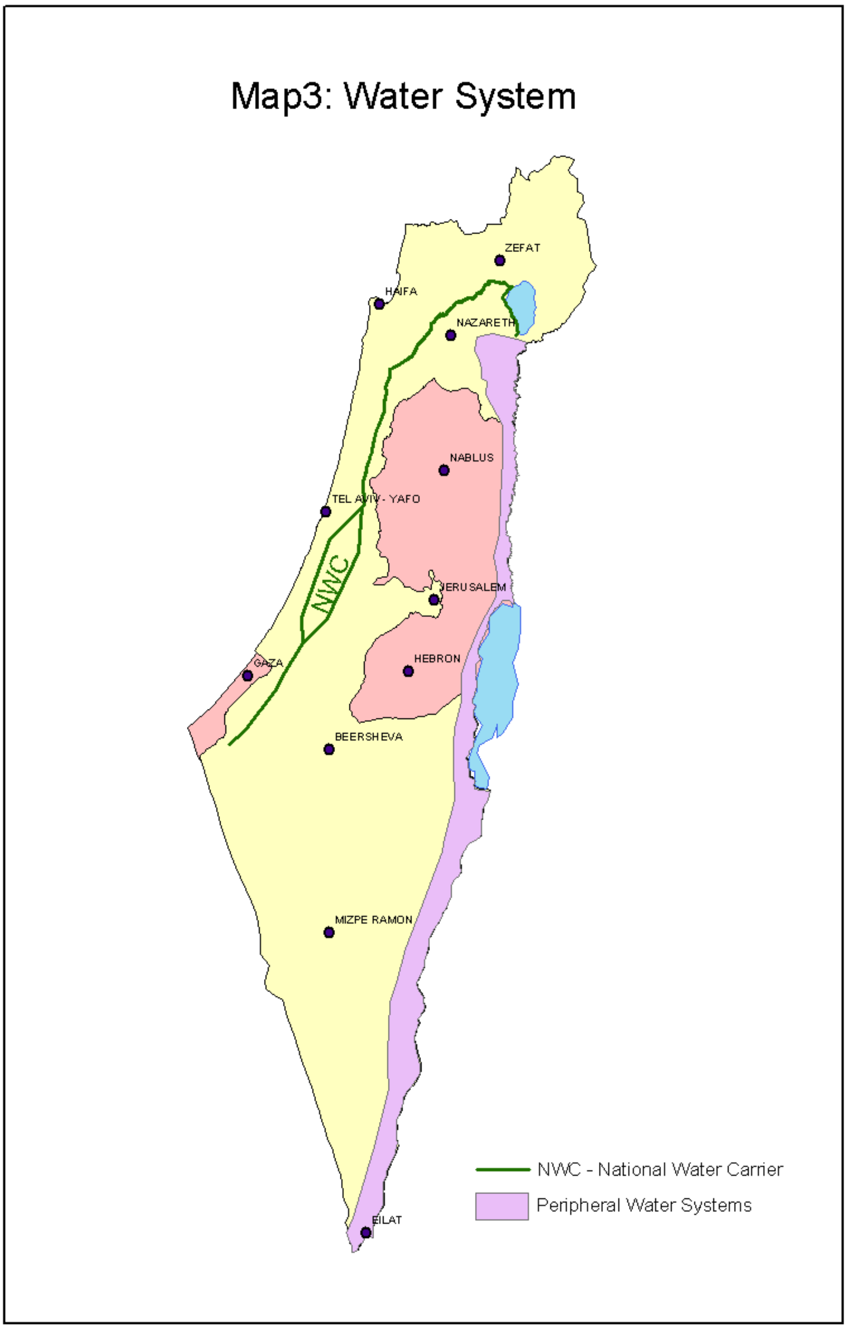
		1998	2000	2002	2005	2010
National System	Fresh	774	651	270	470	470
	Recycled	269	270	279	339	409
	Saline	30	30	30	30	30
	Total	**1073**	**951**	**579**	**839**	**909**
Peripheral System	Fresh	86	81	82	71	60
	Recycled	7	9	16	27	36
	Saline	160	162	160	160	160
	Total	**253**	**252**	**258**	**258**	**256**
TOTAL	Fresh	860	732	352	541	530
	Recycled	276	279	295	366	445
	Saline	190	192	190	190	190
	TOTAL	**1326**	**1203**	**837**	**1097**	**1165**

Seasonal Distribution: Summer consumption (May – September): 65% of the annual consumption in a regular year and 60% in a drought year.

Notes:

1. 1998 serves as the representative year for the 1990's decade.
2. 1999 to 2001 were drought years with minimal precipitation.
3. 2002 is an average rainfall year, but the hydrological crisis is very evident because of the paucity of the aquifer reserves and the severity of salinity, due to over-pumping during the previous drought years. The year 1999 (drought year) had a balance similar to that of 1998.

4. In general, the shortage is not only a function of the precipitation level of a specific year, but mostly, a consequence of the pumping policy for the aquifers in past years.



B1.2 Water Allocations for Jordan and the Palestinian Authority (PA)

According to the peace agreement with Jordan, Israel is committed to supply:

- 35 MCM/year from the Beit Shean springs.
- 20 MCM/year restoration of Yarmuk River water, from the Sea of Galilee.
  Note: In years of shortage, taken from the Israeli source in the Sea of Galilee.

The agreement with the PA calls for:

- 31 MCM/year from the national system: (Mountain Aquifer).
- _4 MCM/year from other sources.
  Total= 35 MCM/year
  ===========
- In addition, the PA pumps 27 MCM/year from the Mountain Aquifer.
  Note: We estimate that these quantities will have to be significantly increased in the future. According to the Master Plan (1), a growth rate of 4.3%/annum is anticipated and it is reasonable to assume that demand will increase accordingly.

Total net supply to Jordan and the Palestinian Authorities – 97 MCM/year.

***Table 10*. Summary of Water Demand by Water Type (MCM/year)** (1) + (2)

		1998	2000	2002 (estimate)	2010 (projected)
National system	Fresh	1629	1495	1106	1609
	Recycled	269	270	279	457
	Saline	30	30	30	30
	Total	1928	1795	1415	2095
Peripheral System	Fresh	120	113	114	100
	Recycled	7	9	16	52
	Saline	196	199	197	159
	Total	323	321	327	311
Total	Fresh	1749(78%)	1608(76%)	1220 (70%)	1709 (71%)
	Recycled	276(12%)	279(13%)	295 (17%)	509 (21%)
	Saline	226(10%)	229(11%)	220 (13%)	189 (8%)
	TOTAL	2251(100%)	2116(100%)	1735 (100%)	2407 (100%)

***Table 11*. Summary of Water Demand by Sector**

	1998		2000		2002 (estimate)		2010 (projected)	
Domestic	694	31%	684	32%	680	39%	875	36%
Industrial	129	6%	132	6%	131	8%	167	7%
Agricultural	1326	59%	1204	57%	837	48%	1165	48%
Environment	4	-	2	-	2		40	2%
Jordan & PA	98	4%	94	4%	85	5%	160	7%
TOTAL	**2251**	100%	**2116**	100%	**1735**	100%	**2407**	100%

B2. Water Supply

B2.1 Freshwater

There are seven major freshwater basins: six are underground aquifers and the seventh is the Sea of Galilee. The three largest basins are the Mountain Aquifer, the Coastal Aquifer and the Sea of Galilee. They are connected via the National Water Carrier. Pumping from the aquifers varies from year to year by the recharge level and the salination level. Continual seawater intrusion to the Coastal Aquifer because of over-pumping has led to severe quality deterioration. The Saline Water Carrier, a system for diverting saline springs that used to flow into the Sea of Galilee, has led to increased water quality in this basin. The Sea of Galilee basin also includes some springs. In general, Israel is currently undergoing a hydrological crisis in the form of large water deficits in these three basins. Eliminating this deficit is one of the major challenges facing the water economy of Israel in the coming decade.

***Table 12*. Salinity Levels and Long-Term Average Recharge by Water Resource** (see Map No. 4)

Source: Israeli Geological Service, Hydrological report, 2000

Basin	Salination Level (mgchlorine/liter)	AverageAnnual-Recharge (MCM)
1.Coastal Aquifer	190-320	300
2.Mountain Aquifer	210	360
3.Sea of Galilee Basin	180	550
4.Western Galilee	250	90
5.Carmel	250	40
6.Negev and Arava	320	90
7.Eastern Mountains	150	60
TOTAL		1490

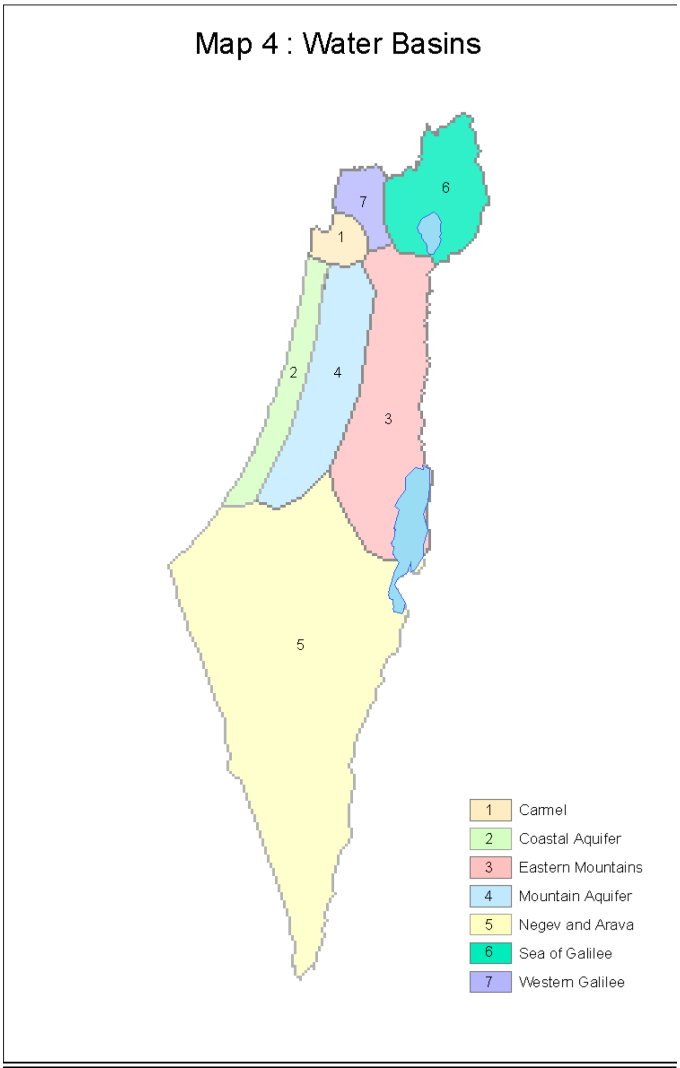


Table 13. Annual water balance

	Flows (MCM/y)
Precipitation	***7000***
Surface water evapotranspiration losses	***5000***
Surface water flows	***150***
Groundwater flow	***50***
Net potential surface and groundwater available	***1800***
Net exploitable surface and groundwater	

Source: Gvirzman Haim, 2002, Unpublished Manuscript

B2.2 Desalinated Water

(a) **Desalinated seawater**:

Currently, the desalination plant in Eilat produces 3-5 MCM/year, using water from the Red Sea. In addition, plans have been completed for desalination plants along the Mediterranean coast: 50 MCM/year in Ashdod and 50 MCM/year in Ashkelon, with an option to expand to 100 MCM/year. Tenders are planned to be issued in 2003 or 2004 for an additional 250 MCM/year.

(b) **Desalination of saline water** (from salinated aquifers and wells): Currently 1-3 MCM/year are being treated, and in the coming years desalination of an additional 40 MCM/year is planned.

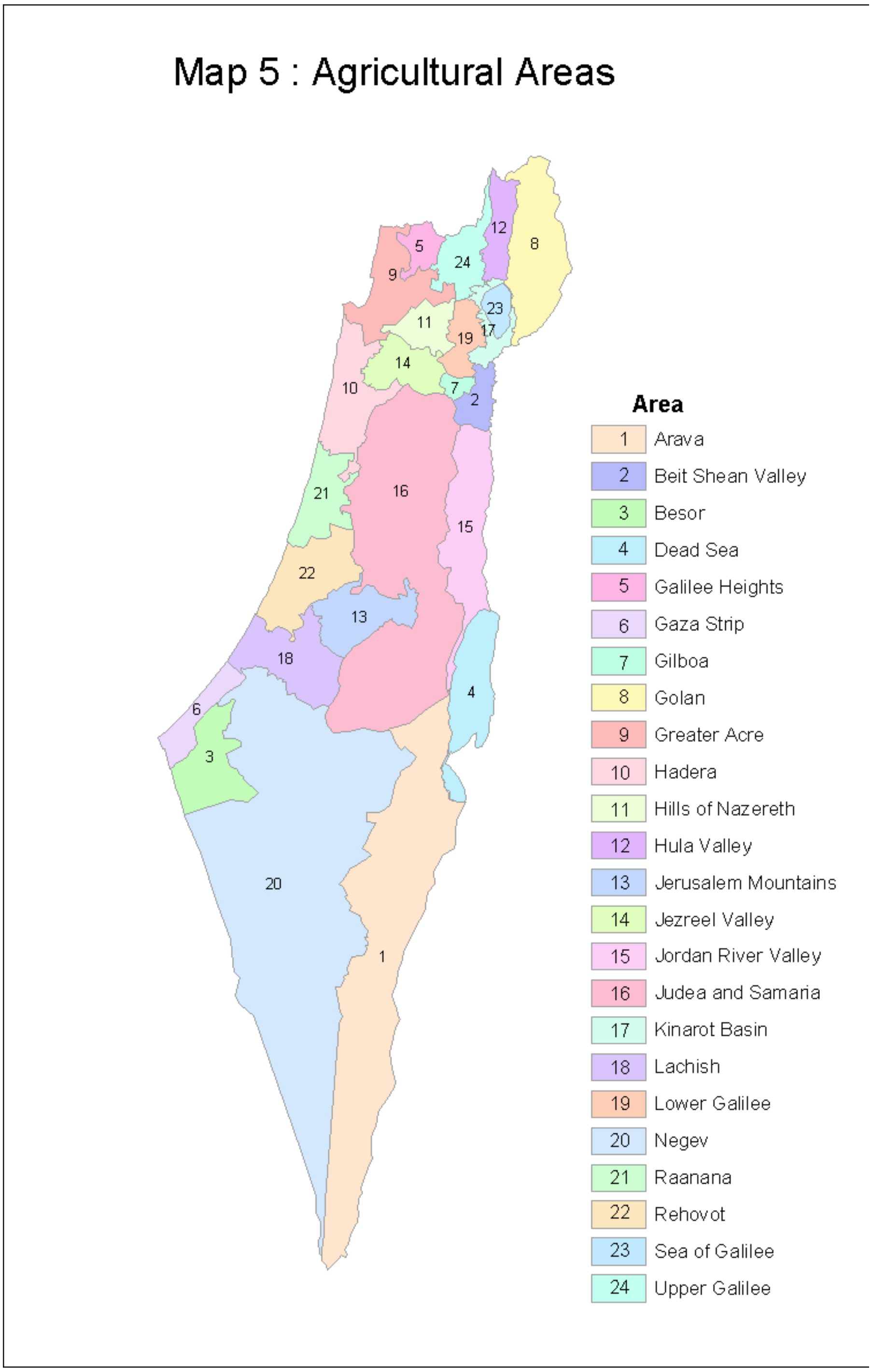
B2.3 Recycled Water

Below is a list of the main facilities for recycling wastewater. All of them are partially or wholly owned by Mekorot. (**(see Map No. 5)**

Facility	Water source	Agri./other consumption region	MCM 2002 (est.)	2010 (project.)	Current treatment quality	Notes
Shafdan	Greater Tel-Aviv area	Western, Northern and Central Negev, including S.A.T.	110	140	Tertiary +	Allowed for incidental drinking
Haifa Area Association	Greater Haifa area	Western Jezreel Valley	30	45	Secondary+	
Jerusalem	Jerusalem & Beit Shemesh	Judean mts., Judean plains & Lachish region	15	20	Tertiary	
Hefer Valley	Netanya	Hefer Valley	8	12	Tertiary	
Hadera	Hadera	Coastal plain & Iron River	7	10	Secondary+	
TOTAL			170	227		
% of total wastewater			52%	45%		

An additional 25 small and intermediate sized sewage treatment installations are in operation. Their treatment quality is generally "Secondary".

Additional notes: It is estimated that about 100 MCM/year currently flow into the sea. The possibility of using a large quantity of recycled wastewater for agricultural purposes is dependent on upgrading it to a quarternary quality level (suitable for all crops), decreasing the salinity level (desalination of wastewater or the water entering the city), and pooling the water recycled in the winter for consumption in summer. Upgraded quality is also needed for river rehabilitation.



The section on demand and supply is summarized in the next table. The supply and the demand mix are presented for a normal year selected from the past decade, a year during the current hydrological crisis, and an average year in the future:

Table 14. General Water Balance (MCM/year)[(1)] + estimates

	Normal year (1998)	Drought year (2002 estimate)	Future average year (2010)
Demand by sector:			
Domestic	694	680	875
Industrial	129	131	167
Agricultural	1326	837	1165
Jordan & PA	97	86	160
Environment	5	1	40
Total	2251	1735	2407
Demand by water type:			
Freshwater	1749	1248	1709
Reclaimed	276	298	509
Saline	226	189	189
Total	2251	1735	2407
Supply:			
Aquifers (including saline)	1975	1432	1398
Desalination	-	5	500
Recycled	276	298	509
Total	2251	1735	2407

C. WATER QUALITY AND ENVIRONMENTAL ISSUES

Water quality is measured according to the following:

- Salinity – refers to the chlorine level in the water (indicated by electrical conduction capacity).
- The presence or absence of chemicals and poisonous contaminants, especially boron, whose presence has a negative impact on crops.
- The level of biological purity (T.S.S., B.O.D.).

The current trend calls for stricter adherence to water purity standards. An inter-ministerial committee (Inbar Committee) of director-generals recently issued a report recommending substantially stricter purification standards for recycled wastewater.

Water quality is multifaceted and has many implications, including:

a. **Water quality for domestic and industrial consumption** – standards and costs.
During shortages it is possible to use high-quality wastewater for some of these purposes: irrigating public parks, certain industrial uses, etc. (some households in Japan use treated wastewater).

When salinity standards are introduced into water purification standards some towns will have to debate the economic-structural issue of the "location" for removing salts, i.e., desalination at the "city gates" or desalination of the wastewater at the "exit".

b. **Water quality for agricultural consumption** – Factors influencing the possibility of irrigating crops with wastewater include:
   - Ministry of Health requirements.
   - Salinity level as per the flora-agricultural requirements.
     The salinity level is a function of the water's salinity "at the city gates" (entry water), with an added 70-100mg chlorine/liter.
     It is important to note that as more desalinated water becomes part of the Israel water economy; the average salinity level of the entry water will be reduced.
   - The environmental impact of using recycled wastewater, particularly in sensitive areas above aquifers. Such use must be approved by the Ministry of the Environment and the Health Ministry.
     Also to be taken into account is the environmental impact of drainage to the rivers in terms of the biological purity level.

   Notes:
   - Some salinity problems may be solved by diluting saline water with fresh or desalinated water.
   - The standards for recycled wastewater at the sewage treatment facility exit are currently being updated and expanded (Director-generals Committee, Inbar Committee).
   - Boron – Crops are particularly sensitive to boron. In some areas the recycled wastewater is rich in boron due to the water entering the city from wells with high boron concentrations. This is an acute problem, particularly in the southern Arava and the date plantations there since Eilat's wastewater is its main water source. Most of Eilat's water comes from desalinated Red Sea boron-rich water.

c. **The interface between water quality and various environmental issues**
   A major part of the hydrological crisis is also an environmental crisis, with continuous pollution of the rivers, aquifers and other natural resources. Serious ecological damage affecting unique natural resources and landscapes often result.
   - Technically, treated sewage may be used for agricultural purposes, diverted to rivers or the sea or a combination of them.
     The effect of diverting the treated sewage on the "receiving" environment and the subsequent environmental demands affect the technology and the development of water treatments.
     Agricultural use of wastewater above an aquifer may contaminate it, in turn arousing the issue of sustainable water resources and the problem of creating (or preventing) damage for generations to come.
     Dumping in rivers may influence their flora and fauna. Fish and other animals are extremely sensitive to chlorine.
     The Barcelona Accord of the Mediterranean countries restricts drainage to the sea.
   - The effect on the Sea of Galilee:

The amount of water pumped from the Sea of Galilee, especially during a hydrological crisis year, influences its water quality. Consequently, over-pumping may disturb the ecological balance of the algae in the biotope and cause a steep rise in the water's turbidity. This, in combination with a drastic reduction of the water in the lake (due to the large gap between reserves and pumping), greatly detracts from the ecological and scenic (tourism) value of the area.
The crisis of the Sea of Galilee not only illustrates, but also is symptomatic of the water crisis in Israel.

d. Economic Facets of the Issue of Quality

The demand for a higher level of water quality has clear economic implications. The debate focuses on who is to carry the financial burden of upgrading the water treatment plants: the local authorities based on the principle that the "polluter pays", the farmers, the consumers or the government (representing social-environmental interests).
The indecisiveness on these important matters and the resulting imbalance between sewage supply and treatment, together with agricultural demands and drainage solutions, are some of the reasons for the slow transition by farmers to recycled wastewater and is part and parcel of the overall crisis.

e. **Water Allocations for the Environment, Landscape and River Rehabilitation**

(i) Freshwater: In the current state of drought and water scarcity, there is no allocation of water for environmental enhancement and the natural flow in almost all the rivers is practically nonexistent. This is a consequence of the extremely low aquifer level.

(ii) Recycled wastewater:

- Currently about 15 MCM/year are utilized for river rehabilitation, 85% of which are recycled for agricultural irrigation.
- The government has decided to increase this amount to 40-50 MCM/year, 75% of which will be restored to the water economy.

D. PUBLIC REGULATION AND INSTITUTIONAL STRUCTURE

D1. Description

The table below is a partial description of the entities involved in regulating and allocating resources to the water economy.

The large number of parties involved is most apparent, as are the implications of the subsequent bureaucratic maze that hinders initiative and change.

Table 15. Public entities involved in regulating and allocating water resources.

Entity	Regulatory and Implementation Authority
1. Water Commission (Min. of Infrastructure) (Until 1996- Min. of Agriculture)	• Aquifer pumping policy (Operations Comm. of the Hydrological Service) • National & regional planning of installations (Planning Division), and desalination tenders • Allocation of quotas for all water types (Consumption Division) • Encouraging saving water in the various sectors • Approval of wastewater reclamation projects • Participation in setting water prices • Equalization Fund
2. Ministry of Agriculture	• River drainage and flood prevention (Drainage Division) • Grant approval for investment in irrigation projects (Investment Administration) • Right of veto on water prices
3. Ministry of the Environment	• Initiation and approval of all river administrations' projects (in conjunction with the Jewish National Fund-KKL) • Authorization for irrigating with recycled wastewater above aquifers • Authorization to dump wastewater into rivers and the sea
4. Ministry of Health	• Purification standards for all water types and all their uses • Authorization for irrigating areas adjacent to wells
5. Ministry of the Interior	• Municipal Water Company Law • National linear schemes (TAMA-34) for water and sewage • Setting local authority water prices (approval by the Min. of Finance) • Approval of district linear schemes (TAMA) for development of rivers and their environs
6. National Sewage Administration (Min. of Infrastructure)	• Approval of sewage treatment facilities • Allocation of funding to local authorities for sewage treatment
7. Ministry of Finance (Budget Division)	• Approval of Mekorot water prices • Allocation of financial resources (including subsidies} to the water economy and Mekorot • Initiation of many structural changes in the

	framework of the "Arrangements Law"
8. Ministry of Justice	• Defending the State in Supreme Court appeals, especially in precedent-setting cases (numerous cases arise in the water economy) • Approval of legislation drafts
9. Parliamentary Finance Committee	• Approval of water prices (there is a strong agricultural lobby in this forum.) • Approval of structural changes in the framework of the "Arrangements Law" and the national budget
10. Parliamentary Economic Committee	• Established a sub-committee on the water economy crisis. It is a parliamentary investigative committee that is to submit recommendations
11. Jewish National Fund (KKL)	• Provides funding for reservoirs after having been approved. Implementation usually carried out by them • Partner in the River Restoration Administration and in funding
12. Israel Lands Administration (Ministry of Infrastructure)	• Allocation of land for wastewater reservoirs and desalination plants

Many of these bodies are divided into sub-divisions having authorization and regulatory powers. Various branches of the same body frequently do not adhere to a uniform policy.

D2. The Water Supply Institutional Structure

D2.1 Fresh and saline water:
- 63% Mekorot (Government company, operates the national water system)
- 8% Local authorities, private production
- 29% Private production for agricultural consumption, half of it by 4 large water cooperatives: in the Jordan Valley, Golan Heights, Hula Valley and Gilboa regions

100%

D2.2 Recycled wastewater and supply to the agricultural sector

Currently:
- 67% Mekorot
- 33% Regional cooperatives

100%

D2.3 Desalination:

Mekorot has rights to 50 MCM

The rest is relegated to private producers as per the B.O.T. agreement with the government.

E. WATER PRICING AND COSTS

E1. Water Pricing Policy

Water prices are uniform throughout the country, varying only by sector and quality.

- Prices are set by the government, based on recommendations of the Ministry of Finance and the Water Commission, and approved by the parliamentary finance committee.
- These prices are for water delivered by the national company, Mekorot, which operates the NWC and the Shafdan and supplies some 60% of freshwater consumption and about 50% of recycled wastewater for agriculture.
- Private water producers set prices independently, but are subject to an extraction levy imposed by the government. (This tax is calculated to reflect the "scarcity price" of water.) Production and distribution of recycled water in this sector are subject to the approval of the Water Commission.
- All water production requires the approval of the Water Commission (production quotas) as does all water consumption and sale (consumption quotas). In practice, the latter quotas apply only to the agricultural sector and are not enforced on domestic and industrial use. (Trade in quotas is prohibited by law.)
- Details of water prices are presented below.

E2. Costs

- Freshwater in the national system (Mekorot)

  Average cost: 0.34 US dollar per m^3

  Cost structure: Capital: 40%
  Energy: 28%
  Work and operation: 32%

- Desalination

  Cost as per the latest tender for 50 MCM/year in Ashkelon:
  0.53 US dollar/m^3 to the plant's gate.

  Connection to the national system:
  0.07 US dollar/m^3

  Transport 0.08 US dollar/m^3

  TOTAL 0.68 US dollar/m^3

- Treatment of recycled water

  Costs vary greatly according to type and size of the facility. Larger facilities have cost advantages.

  Average costs in US dollars/m^3 wastewater

Secondary treatment:	0.39
Upgrade to tertiary:	0.08
Upgrade to wastewater extraction: (desalination from 400mg to 50mg chlorine)	0.15

TOTAL cost of recycling water for broad agriculture
& ecological use 0.62

- Pooling and conveyance of recycled water for agricultural consumption:
  Regional facilities (including land) 0.26 US dollar/m^3
  Large national facilities (Shafdan) 0.35 US dollar/m^3

E3. Consumer Prices of Water in Israel – for consumers linked to the national system, Mekorot

- Local authorities for household use 0.345 US dollar/m^3 (at "city gate")
- Industrial 0.330 US dollar/m^3 (average)
- Agricultural

  Agricultural users of freshwater are subject to tiered pricing and quotas. The farmers pay a reduced price for the first 50% of their quota, a higher price for the second 30%, and the full price for the rest of the quota. Separate rates exist for the Beit Shean Valley (by water type), the Jordan Valley and the Golan Heights that together consume 13% of the freshwater demand by the agricultural sector.

  Water with over 400mg salinity is charged at a lower rate, according to its salinity level.

  The Shafdan charges the same rate for summer and winter consumption, but here too there is a quota.

  Recycled wastewater is charged according to a two-tiered system: the first 50% of the quota at a higher price and the second 50% at a lower rate.

Agri. Water Rates by Type	Price (December 2001) In US dollars/m^3
Fresh – tier A	0.19
Fresh – tier B	0.23
Fresh – tier C	0.31 (Full use of quota averages 0.23)
Fresh – above quota	0.54
Jordan Valley – Fresh	0.19
Beit Shean Valley:	
Fresh	0.13
Saline wells	0.07
Springs	0.04
Saline springs	0.014
Golan Heights	0.21
Saline (average)	0.16
Shafdan – winter	0.15
Shafdan – summer	0.16
Shafdan – above quota	0.54

Other recycled – 1st 50%	0.14
Other recycled – remaining	0.11

- User levies on private producers (water not purchased from Mekorot).
  Production (extraction) levies are imposed on all the producers, including Mekorot, and are intended to reflect the "shadow price". They also pay the production and conveyance costs.

Levies	In US dollar/m^3
Coastal Aquifer	0.10
Other aquifers	0.09
Flood and saline	0.00

- Water costs for domestic consumers
  This is the price to the consumer as charged by the local authorities.
  The maximum price is set by the Ministry of the Interior.
  Pricing is progressive, based on consumption.

Rate	In US dollar/m^3 consumed
Average	1.06
Sewage removal surcharge	0.49

F. MANAGEMENT OPTIONS (Source [(1)])

The crucial action to take immediately in order to cope with the current water crisis is to reduce sharply the supply of fresh water to agriculture (this will naturally entail heavy compensation of affected farmers). At the same time additional marginal water resources, saline water and sewage effluents should be developed. A large scale transition in agricultural water use from good quality water to reclaimed urban and industrial wastewater is expected in the forthcoming years. This shift requires the development of many more environmentally safe water treatment plants, reservoirs and conveyance systems. Treated wastewater can also be used for rivers restoration. A massive desalination of sea water is another important action that will be taken in the near future. In addition to that, the institutional framework and the currently used water allocation schemes should be significantly improved. Below are a few expected developments of additional water sources in the next decade.

Development plans for the Israeli water economy for the next ten years.

1. Desalination of Mediterranean seawater:

Existing decisions	250 MCM/year
Additional needs	350 MCM/year
TOTAL	600 MCM/year

Investment required: 1.4 billion dollars

2. Desalination of saline water (and saline aquifers):
   Amount of water 213 MCM/year (hydrological research is still required)
   Investment required: 320 million dollars

3. Improvement of saline wells (mainly by the municipal authorities):
   Potential water quantities 80 MCM/year
   Investment required: 70 million dollars

4. Wastewater reclamation:

Current amount	280 MCM/year
Planned for end of decade – an additional	230 MCM/year
TOTAL	510 MCM/year

   Investment required (estimate): 600 million dollars for reservoirs and conveyance systems.

   Upgrading wastewater for unlimited agricultural and environmental use, including desalination: 300 MCM/year
   Investment required: (US$2.00/$m^3$) 600 million dollars

5. Additional projects:

Fortification of the supply system along the border	600 million dollars
National filtering systems	50 million dollars
TOTAL	650 million dollars

6. Summary of the Israeli water economy's needs for the next ten years (estimate):
   Note: Implementation limitations may require extending the development into the next decade.

Desalination of seawater	1400 million dollars
Desalination of saline water and wells	390 million dollars
Wastewater reclamation	600 million dollars
Upgrading wastewater	600 million dollars
Additional projects	650 million dollars
TOTAL	3640 million dollars

- The main constraints to the development of desalination projects are:
  - Limited planning Capacity of Governmental entities.
  - Over – bureaucracy and very long politically influenced decision – making process.
  - Macro economics: budget – deficit and recession.
  - Conflicts between Mekorot (operations of main water transportation system) and private investors (B.O.T. bids)

- The main constraints to the development of recycling projects are:

- Difficulties to locate appropriate land for reservoirs.

- Poor quality of treated water.

- Poor coordination between "players": municipalities, farmers, and the government

- The limited ability of the agricultural sector to finance the investment required for the adaptation of irrigation to reclaimed water.

- Unsolved conflict between competing potential users (see below).

- Over bureaucracy and long decision – making process.

G. MAJOR CONFLICTS IN THE ISRAELI WATER ECONOMY AND A SUMMARY MATRIX

Major Conflicts

- Competition between the urban and the agricultural sectors on the limited resources of freshwater. All of the inelastic domestic demand in the steadily increasing urban sector is covered by freshwater supply, and thus a large-scale transition in the agricultural water use from good quality water to reclaimed urban and industrial wastewater is expected.
- Competition between agricultural and ecological utilization of recycled wastewater.
- Competition between farmers in the central and in the peripheral region of Israel for recycled wastewater. Most of the urban and industrial sewage is "produced" in the coastal plain, in the center of the country, while most of the irrigated areas are located in the periphery. The costs of constructing new networks to transport the recycled water (assuring that it will not be mixed with freshwater) and the costs required to prepare new facilities to store excess treated water from winter to summer are of major importance. The spatial distribution of aquifers and the environmental costs associated with irrigation above them, which may pollute the underlying groundwater, should also be considered.
- Conflict between the agricultural and the urban sectors on the purification standards for disposal set for the cities by the government. Another conflict is on how the costs and the benefits associated with recycling should be allocated between the generators of sewage (the municipalities) and the agricultural users. An additional conflict is on how municipalities can be assured that the farmers will not reduce usage suddenly (due to an economic crisis for example) and leave the cities with treated water that they cannot dispose of.

- New and forthcoming partial privatization of water supply are a potential source of conflict between the government-owned company, Mekorot, and private entrepreneurs on two issues: the control of the supply of newly developed water resources (mostly desalinated sea water and recycled wastewater) and the responsibility for the operation of the intra-cities water systems (currently operated by the cities themselves).
- Conflicts between Israel and the Palestinian Authority on the utilization of the Coastal and the Mountain ground water aquifers.

Concluding remarks and a summary table

In spite of the current severe water crisis and the above ongoing conflicts, Israel has a fairly well-organized and developed water economy. Overcoming the crisis mandates significant policy changes and massive investment.

The agricultural sector is the major water consumer and consequently, most of the changes will affect it. A large scale transition in agricultural water use from good quality water to reclaimed urban and industrial wastewater is expected in the forthcoming years. Changes are also needed in different aspects of urban household consumption, especially due to increased demand and the introduction of desalination of seawater. The institutional framework and the water allocation schemes should also be improved. Table 16 below summarizes our repport.

Table16. Israel Summary Matrix

Natural conditions and infrastructure	***Regional Context***	Climate Type	*Dry Subhumid; Semiarid; Arid; Hyperarid*
		Aridity Index	*0.5-0.65;0.2-0.5;0.05-0.2; less than 0.05*
		Permanent Population	*6,200,000*
	Water availability	Total Water Resources / Availability (MCM)	*2251*
		Trans-boundary water	
	Water quality	Quality of surface water	*Good*
		Quality of groundwater	*Average-Poor*
		Quality of coastal water	
	Water Supply	Percentage of supply coming from: ❖ Groundwater ❖ Surface water ❖ Desalination, Recycling ❖ Importing	 *57%* *29%* *14%* *-*
		Network coverage: ❖ Domestic ❖ Irrigation ❖ Sewerage	 *100%* *100%* *80%*
Economic and Social System	***Water use***	Water consumption by category: ❖ Domestic ❖ Transfer to Jordan and the PA ❖ Irrigation ❖ Industrial and energy production	 *31%* *4%* *59%* *6%*
		Population to resources index	
	Water demand	Water Demand trends	*Steadily increasing*
		Consumption index	*Stable per-capita urban consumption*
		Exploitation index	*100%*
	Pricing system	Average household budget for domestic water (pa)	*$90*
		Average household budget for agricultural water	
		Average household income	*$36000 per year*
		Cost recovery	
		Price elasticity	*Agricultural demand is somewhat elastic. Elasticity of urban and industrial demands are small.*
	Social capacity building	Public participation in decisions	*Very High*
		Public education on water conservation issues	*Fair*
Decision Making Process	***Water Resources Management***	Water ownership	*State*
		Decision making level (municipal, regional, national) regarding: ❖ Water supply for each sector ❖ Water resources allocation for each sector	 *National* *National* *National*
	Water Policy	Local economy basis	*National*
		Development priorities	*Recycling and Desalination*

WaterStrategyMan

EVKI-CT-2001-00098

Report on Portugal

Range of circumstances and region analysis

17/06/2002

Preface

This is the report for the deliverable D1 of Work Package 1 of the WaterStrategyMan project. It has been prepared by:

Rodrigo Maia, Professor of FEUP
Ms. Ana Isabel Lopes, Civil Engineer

The Report Contains:

1. An overview of the entire country concerning the analyses of the current situation regarding water resources, demand and supply, and the legal, institutional and administrative framework of water management in the country. It also contains annexed a general overview of the range of circumstances in all 15 River Basins of Portugal Continental territory.
2. The selection of the three river basins to study – Sado, Guadiana and Ribeiras do Algarve –, as candidates for the selection of Paradigms.
3. An analysis of the extended range of circumstances of each selected representative region.

Contents

Abstract

Although Portugal is one of the hydrological richest countries in Europe, severe water shortages are faced in some of its regions. Those shortages occur mostly due to the country's uneven spatial distribution of water resources, to which adds human pressure. Irrigation demands in the dry season, pressure in the country's coastal areas, namely due to tourism (mostly in the South coastal Algarve region), the lack of necessary infrastructure and of an appropriate administrative framework that can manage the available water resources are factors which aggravate the water deficiency country's problem. Through analysis of all River Basins and specific indices, three regions were selected as representative of water deficient river basins: the Sado, the Guadiana and Algarve Coastal River Basins. The range of circumstances in these three regions is analysed and summarized.

Introduction

Portugal shares with Spain the Iberian Peninsula, located in the south-western edge of Europe, of which mainland Portugal occupies 15%. Along with France, Italy and Greece, the two Iberian countries form the so-called group of Southern European Countries (SEC) within the European Union (EU). They are sometimes also referred to as the countries of Mediterranean Europe - a classification in which Portugal is included due to issues related to its physical and biophysical unity and continuity with Spain.

The average annual temperature in the SEC oscillates between 10 and 17ºC and is higher than that in the other countries of Europe, whereas average annual precipitation (840 mm) is only slightly above the overall European average (800 mm/year). However, both extremes of the precipitation range in the five SEC occur precisely in the two Iberian countries: the maximum occurs in Portugal, with around

900 mm/year, whereas the minimum (690 mm/year), which is also the minimum for the EU as a whole, applies to Spain.

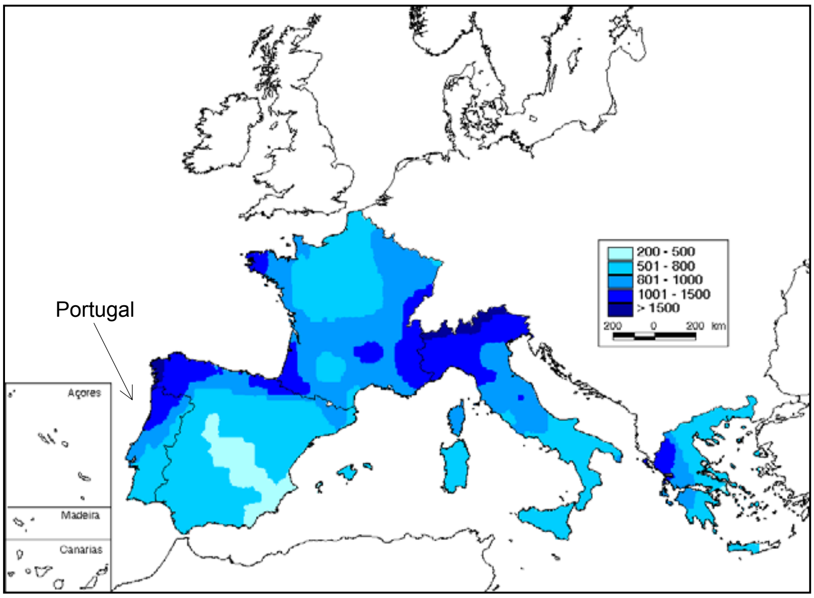


Figure 1. Average annual precipitation in SEC (mm/year)

It is worth noting not only the great spatial variations in the precipitation in the Iberian Peninsula (with minima somewhere in the region of 350 mm/year in the driest zones in Portugal and 200 mm/year in Southeast Spain) as also temporal irregularity in terms of its precipitation distribution, with some regions where maximum rainfall in a single day is sometimes not far short of the whole of the precipitation for the year.

The average effective evapotranspiration in any of the SEC (Southern European Countries) is around 450 to 500 mm, with a maximum of 500 mm in Portugal, while the pattern of the behaviour of the average annual run-off is similar to that of the precipitation.

Due to that inequality in water distribution, both in space and time, and to the high evapotranspiration rate, some areas of Portugal such as Sado and Guadiana basins as also Algarve Coastal River Basins are not only currently facing some short-term water shortage problems as well as some long-term ones are also foreseen.

Aiming to analyse those problems framed into a national water resources reality, this report is divided in three sections, correspondent to different subjects: the first section gives an overview of the country water resources, water demands, as also the analysis of the water's institutional framework, the second part aims to characterize the three candidate regions, and, the third part is an overview of the range of circumstances in all 15 River Basins of Portugal Continental territory. In fact, Portuguese territory includes also, in addition to mainland territory, two groups of islands (Azores and Madeira), but on those islands the water resources characterization is still being carried up by means of Regional Water Plans, and water scarcity problems are only foreseen, at this moment, for Porto Santo island (where desalination is employed), in Madeira's group of islands. We shall then concentrate on mainland territory. Figure 2 presents a map of the correspondent river network and Table 1 a summary of its physical characteristics.

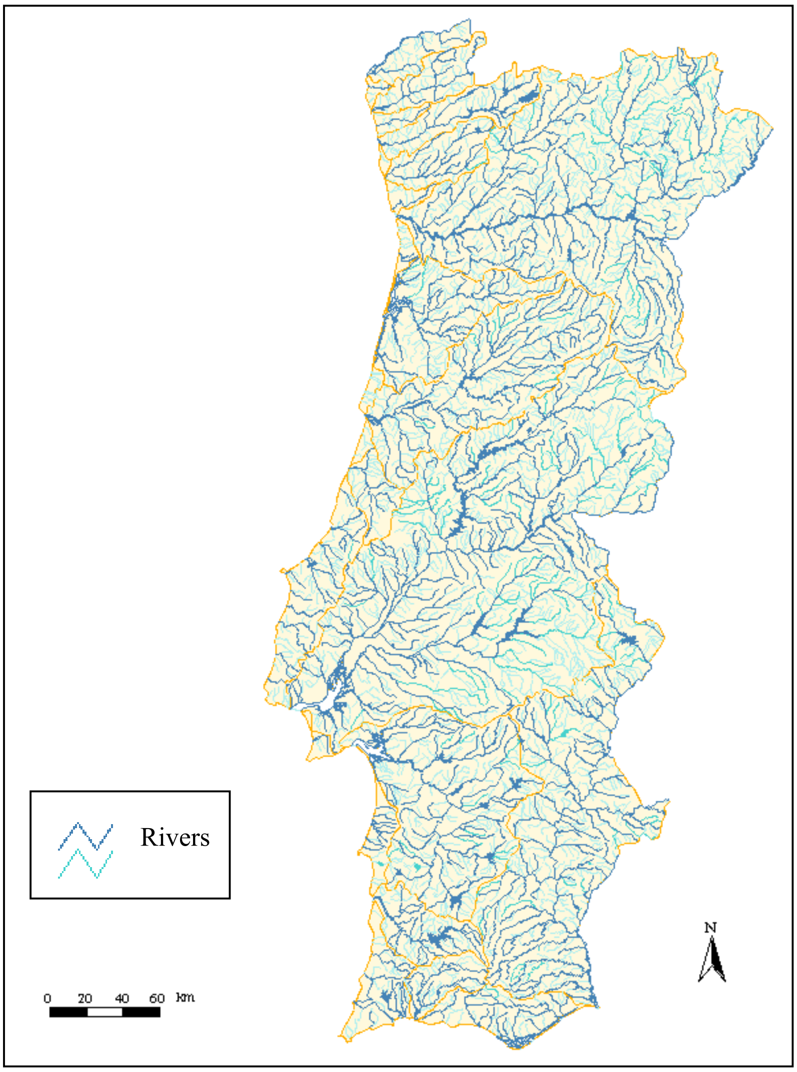


Figure 2: Surface waters in mainland Portugal

Table 1: Summary of mainland Portugal's physical characteristics

Background	**Description**
Climate	The climate in Portugal Continental territory (Mediterranean temperate) is essentially conditioned by its position in relation to the Atlantic Ocean and by the form and positioning of the main mountainous chains. The averaged yearly precipitation in Portugal Continental territory is of about 960 mm, varying from more than 2,000 mm in the northern region to less than 600 mm in Guadiana's basin. The averaged yearly temperature is about 14 ºC, increasing from north to south and west (littoral) to east (Spain), as well as the average yearly sunshine duration. This ranges through minima of less than 1,800 hours/year in northern regions (Minho and Lima's basins) to maxima of more than 3,100 hours/year in southern regions (Ribeiras do Algarve basin).
Geomorphology	Mainland Portugal average altitude is about 320 m, but there is an uneven distribution all over the country, with the mountainous northern regions and the more plain meridional regions. The bigger altitudes are recorded in the interior, north and centre, with the maximum value of about 2,000 m occurring in serra da Estrela, in the limit of Mondego and Tejo basins. South of Tejo basin altitudes are of about 200 m with some, few, mountain chains above this value. The coastal area's altitudes are less than 50 m. Portugal also has an extended coastline.
Geology	On most of the country, soil formations are mainly composed by metamorphic, igneous and volcanic rocks. Some regions (as Tejo and Sado basins and some coastal areas) present tertiary and quaternary deposits with formations mainly composed by limestone and sedimentary rocks.
Ground Water	Most of the country has aquifers of low productivity (on average, 50 $m^3/day/km^2$). Higher productivity aquifers occur: in Tejo and Sado basins, with maximum's of 500 $m^3/day/km^2$; in the centre coastal areas, with 400 $m^3/day/km^2$; in some spots of Guadiana river basin, with 300 $m^3/day/km^2$; and, in the south coastal areas, with 200 $m^3/day/km^2$. The total available ground water is 6956 hm^3/yr.
Surface Water	The total availability in terms of surface water in Portugal Continental territory in an average year (guarantee of 50%) is about 57,000 hm^3. The international rivers are of great importance as they are the bigger river basins of Iberian Peninsula, with more than 40% of the total water resources of Portugal coming from Spain.

Water storage features	The total water storage capacity in mainland Portugal is 7,830 hm^3, with 4,000 hm^3 used for the production of hydroelectric power. Due to Alqueva new multipurpose hydraulic plant this water storage capacity will be highly increased, as Alqueva's useful water storage capacity is of 3,150 hm^3.

1. Overview of the country

1.1 Water Demand and Supply Status

In the last years, due to the National Water Plan and to the River Basins Plans elaboration studies, Portugal has been characterising its water resources, in order of which a lot of effort was made to collect and treat all the related information. This way, data on natural resources, water demand and supply is available, recent and complete, although eventually not homogeneous and accurate. In fact, from the analysis of the referred studies:

- Concerning to water resources characterisation, in quantitative terms, two situations may be distinguished: the surface water case, of which, due to a good quantitative monitoring network, availability of water is nowadays well defined; and the ground water case, of which the information is not so easy to obtain because of the lack of development of the correspondent network. This last is similar to the situation on water quality characterisation, where information is still lacking due to more complex and expensive procedures.
- Concerning to water demand and supply, due to the lack of reliable direct information, the data was estimated by using indirect methods to determine the needs and consumption of the various sectors. These indirect methods considered occupied area, number of workers, raw material and products in the case of industry; irrigation areas, crops types, irrigation systems and efficiency in agriculture water use.

In terms of water supply the percentage of population served is currently of 85% in Continental Portugal, this percentage decreasing to 64% referring to wastewater drainage connections, but only 42% benefiting from treatment facilities. However, the National Water Plan (PNA) prospects as some of the main national short-term water priorities that, by 2006, 95% of the total population should be connected to water supply (having drinking water at home) and 90% served with sewerage and wastewater treatment.

The demands and needs in mainland Portugal increase in the dry semester (from May to October) when the water availability is smaller due to the decrease in precipitation and the increase in evapotranspiration losses. This raise in the demands and needs of water is due to agriculture and tourism. Table 2 presents the monthly average precipitation and potential evapotranspiration and figure 3 shows the real yearly evapotranspiration in Continental Portugal.

Table 2: Monthly average precipitation and potential evapotranspiration in Continental Portugal

Description	Out	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Precipitation (mm)	94	121	136	129	122	108	79	67	37	11	13	44
Potential Evapotranspiration (mm)	72	40	29	30	40	69	94	126	151	177	162	112

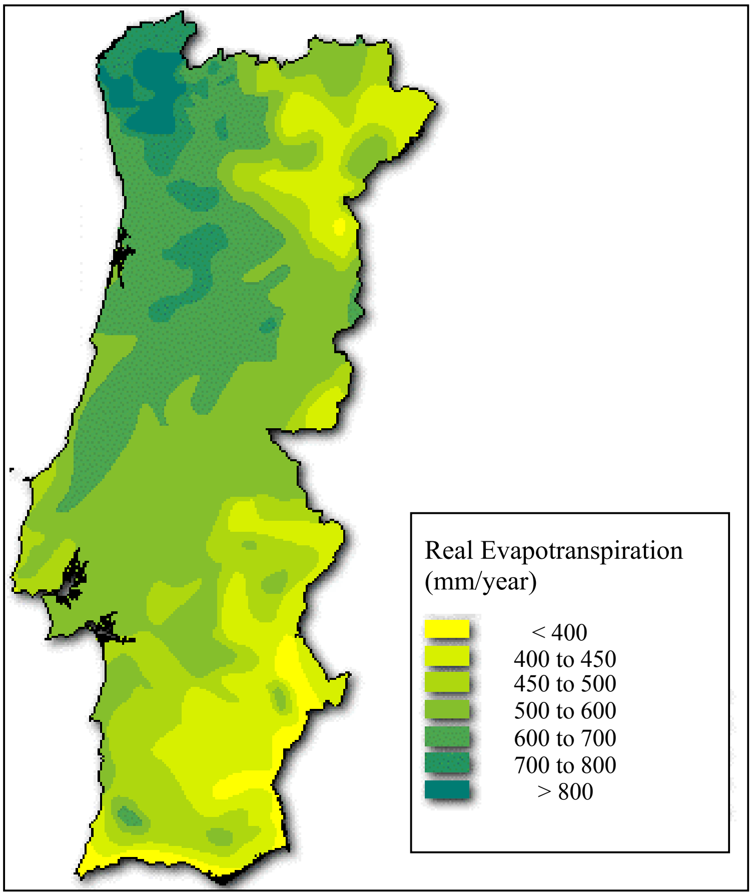


Figure 3: Real Evapotranspiration in Continental Portugal

The high agriculture water consumption (about 74% of the total water uses, one of the highest in European Union countries, and still foreseen to increase in the near future) is in fact one of the causes of water shortage problems, competing with other sectors, namely the water supply sector. Aggravating this situation is the low overall efficiency in agriculture water use (less than 60% North of Tejo, about 60% South of Tejo). The increase of these efficiency values is also a short-term water priority, according to the PNA.

Tourism is concentrated on coastal areas (mainly the southern Algarve region), where the population density has been increasing over the last years, some of which currently facing severe water shortages.

There is an intense use of groundwater resources, especially on agriculture (about 65% of this sector water consumptions), which may lead to an over-exploitation of the aquifers, with effects on water quality on coastal areas due to saline intrusion. Urban water supply overall losses are another problem as they are currently very high, about 33%. The decrease of these values is another of the short term water priorities prospected by the National Water Plan.

Of a total of 60 km^3 per year water resources in mainland Portugal, 25 km^3 per year come from Spain, which account for the importance of water quality in the international river basins, of inter basin water transfers and of agriculture water consumption downstream effects.

Tables 3 and 4 present, respectively, the available resources (surface water and groundwater) and the water consumption for each sector, per river basin, in Portugal Continental territory.

Table 3: Available Resources

River Basin	Water Availability (hm^3)		
	Surface Water *	**Exploitable Groundwater**	**Total**
Minho	8465	80	8545
Lima	3065	149	3214
Cávado	2099	161	2260
Ave	1048	139	1187
Leça	94	22	116
Douro	17841	773	18614
Vouga	1732	404	2136
Mondego	3430	578	4008
Lis	225	224	449
Ribeiras do Oeste	267	208	475
Tejo	14021	2667	16688
Sado	918	796	1714

Mira	291	53	344
Guadiana	3156	429	3585
Ribeiras do Algarve	327	272	599
Mainland Portugal	56979	6956	63935

* Regularized flow (including affluences from Spain)

Table 4: Water consumption

River Basin	Water Consumption (hm^3)													
	Supply			Tourism			Irrigation			Industry			Energy Production	Total
	Surface Water	Ground Water	Total	Surface Water	Ground Water	Total	Surface Water	Ground Water	Total	Surface Water	Ground Water	Total		
Minho	0.93	2.95	3.88	0.005	0.015	0.02	30	50	80	0.038	0.086	0.124	-	84.024
Lima	2.50	4.64	7.14	0.042	0.078	0.12	60	100	160	9.227	1.050	10.277	-	177.537
Cávado	10.38	2.60	12.98	0.144	0.036	0.18	75	160	235	1.702	1.024	2.726	-	250.886
Ave	15.47	4.62	20.10	0.123	0.037	0.16	65	210	275	3.370	4.588	7.958	-	303.218
Leça	25.56	0	25.56	0.220	0.000	0.22	5	25	30	10.738	5.340	16.078	-	71.858
Douro	63.71	23.56	87.27	0.526	0.194	0.72	405	940	1345	8.067	26.360	34.427	87.63	1555.047
Vouga	10.92	21.20	32.13	0.061	0.119	0.18	75	280	355	24.314	4.070	28.384	-	415.694
Mondego	19.39	16.51	35.90	0.151	0.129	0.28	160	465	625	66.139	4.900	71.039	-	732.219
Lis	1.35	7.63	8.97	0.012	0.068	0.08	20	30	50	0.051	0.359	0.41	-	59.460
Ribeiras do Oeste	39.53	13.89	53.42	1.325	0.465	1.79	45	110	155	0.875	2.966	3.841	-	214.051
Tejo	139.08	81.68	220.75	1.777	1.043	2.82	710	1280	1990	45.402	101.163	146.565	476.98	2837.115
Sado	5.84	18.49	24.33	0.134	0.426	0.56	295	145	440	33.827	23.989	57.816	672.35	1195.056
Mira	0	0.88	0.88	0.000	0.010	0.01	75	20	95	0.030	0.036	0.066	-	95.956
Guadiana	8.69	5.33	14.02	0.849	0.521	1.37	225	175	400	2.335	0.928	3.263	-	418.653
Ribeiras do Algarve	11.14	10.70	21.84	5.580	5.360	10.94	80	225	305	0.302	2.054	2.356	-	340.136
Mainland Portugal	354.48	214.68	569.16	11.603	7.027	18.63 (2)	2325	4215	6540	206.417	178.915	385.332	1236.96(1)	8750.082

(1) Surface water

1.2 Environment and protection

Several conflicts arise due to the quality of water for the several uses. There is a weak treatment capacity of the polluted charges, namely the ones produced by urban and industrial water supply. The pressure is higher in the coastal areas, where population is concentrated, thus the quality of surface waters on those areas is not, currently, for most of the rivers, as good as of upstream stretches, except on some bordering areas. On figure 4 it can be seen the loads affluent to the hydric environment in Portugal Continental territory. Urban wastewaters are responsible for more than 57% of these pollutant loads.

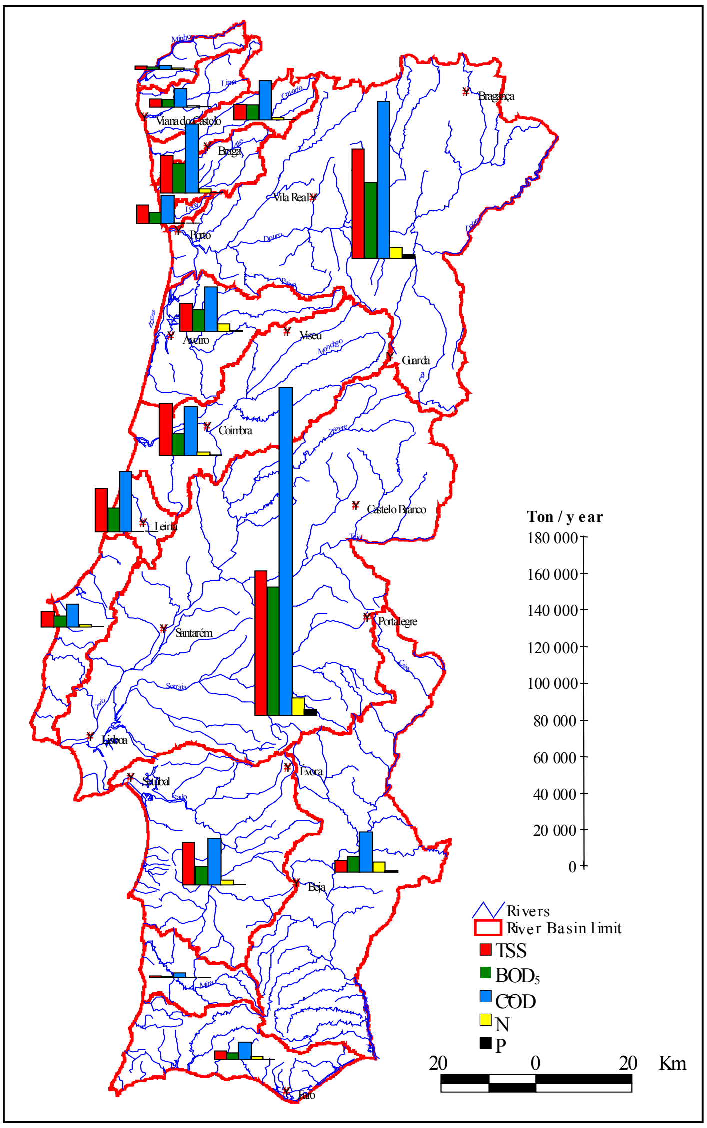


Figure 4: Loads affluent to the hydric medium in Portugal Continental territory

Major water quality problems occur on the shared rivers bordering stretches, where the quality of surface waters is inadequate, according to legislation, similarly to some downstream stretches and to almost all coastal areas, with values of pollutant loads exceeding the recommended for human consumption. Another problem is that mainly in the south of Portugal, water levels decrease significantly in the summer, in some rivers, creating higher concentrations of pollutants. As to coastal waters the quality is generally good, with some spots of fair and poor quality, as Porto's metropolitan area.

Due to the insufficient monitoring network the only data available in terms of quality of groundwater relates to the water consumption's most important aquifers. Although nitrates pollution can occur in superficial water and in groundwater, the higher values occur in the last one, as a consequence of the intensive use of fertilisers in agriculture. Figure 5 shows the most important aquifers in mainland Portugal, as well as the quality of ground water for domestic water and irrigation water purposes. As can be seen in the monitored aquifers the quality is in overall good, with the exception of Algarve's region and some areas of Mondego, Tejo and Guadiana's basins. Due to the over-exploitation of certain aquifers there is the risk of saline intrusion, which is already happening in some areas of Algarve and Vouga (Aveiro's region).

Concerning to shortages of water it shall be referred that drought situations occur in Portugal mainly in the North interior (bordering) regions (Douro basin) and especially on the South (of the Tejo river). Nevertheless, in terms of guarantee of water supply to populations in periods of water shortage, problems are centred mainly in the southern region. On that zone, due to small Portuguese storage capacity (currently about 42% of the river basin internal natural water resources for the Tejo – the highest value on Portugal – and 18% for the Guadiana, which compares to about 200% for this river's Spanish case), an inevitable mismatch of water availability and water needs has been specially visible on dry years, leading to shortages of water and to full utilisation of existing regulating structures.

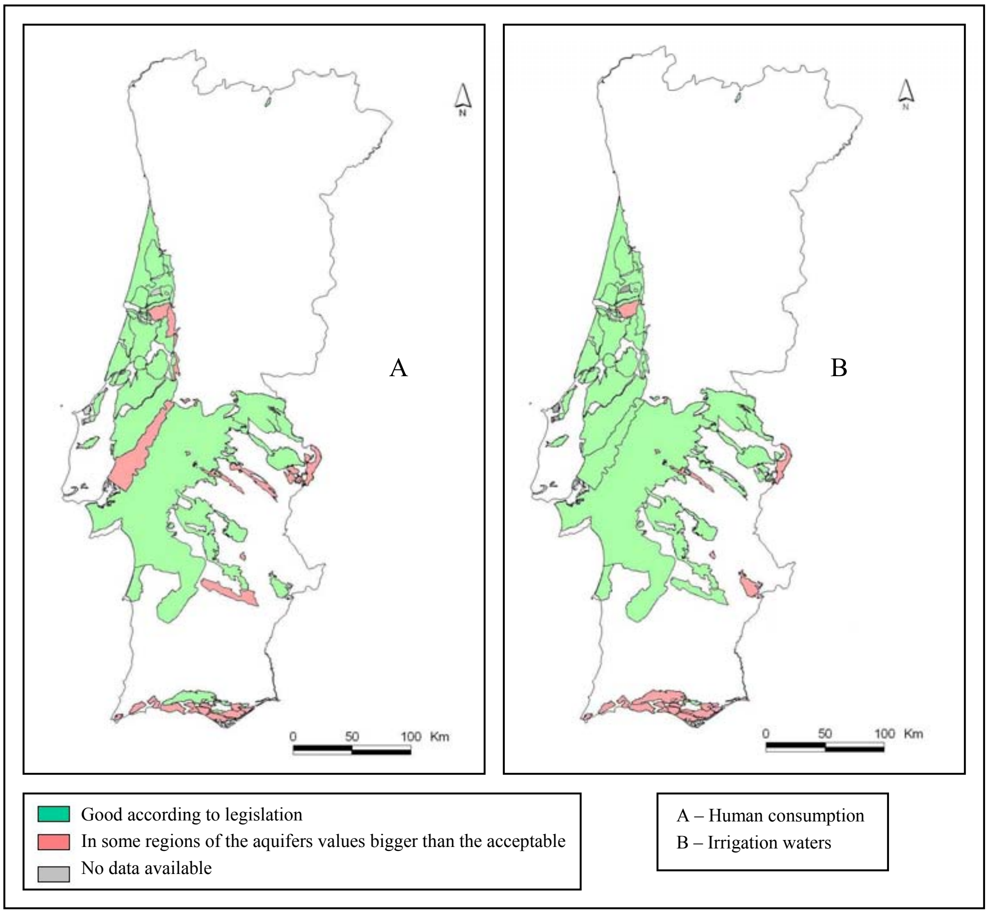


Figure 5: Quality in ground waters for different sector uses

1.3 Water laws and regulations

Portuguese water laws and regulations are framed under the respect of International Law, bilateral Portuguese-Spanish shared river agreements and of European Union Water policy and Directives, to which evolution and inter-relation (in some cases still) has to be adapted.

The main aim of the Portuguese-Spanish still active bilateral international rivers Conventions (dating to 1964 and 1968) was to rule the share of water and hydroelectric potential production of bordering river stretches. The 1998 "Convention on Cooperation for Portuguese-Spanish River Basins Protection and Sustainable Use" envisages to co-ordinate efforts on shared river basins management, aiming to attain improved risk prevention and ecosystem protection on those basins, respecting modern principles of international law. That Convention is clearly framed (Maia,

1999) by the UN 1991 Espoo Convention, the UN 1992 Helsinki Convention – both of them ratified by the EU and, therefore, with principles that any EU member can apply to –, and not only by (the time) active EU Directives but also by the principles of the 2000 approved Water Framework Directive. Furthermore, and although not yet active, the UN 1997 approved "Convention on the Law of the Non-Navigational Uses of International Watercourses" can also be considered a reference Law.

The Portuguese legislation (still) excludes from the hydro public domain groundwater and surface private water, relating to principles dating back to 1919 (Water Law) and 1966 (Civil Code). The juridical regime on the utilisation of the hydro domain was revised and reviewed in 1994, together with a new institutional framework definition. Since then Portuguese water management model is founded on shared responsibilities between a National Water Institute (INAG) and the Regional Environmental and Territorial Planning Boards (DRAOT's), both firstly under the Ministry for Environment and Natural Resources, which later turned into Ministry of Environment and of Land-Use Planning (MAOT) – and just more recently (2nd semester 2002) into Ministry of the Cities, Environment and Land-Use Planning (MCAOT)[1]. That was due to a set of diplomas:

- Decree-law nº 45/94 of 22 February 1994, which regulates the water resource planning process and the drafting and approval of water resource plans.
- Decree-law nº 46/94 of 22 February 1994, which establishes the licensing regime for water use under the jurisdiction of INAG.
- Decree-law nº 47/94 of 22 February 1994, which establishes the economic and financial regime on public water under the jurisdiction of INAG.

These legislation principles and institutional organisation entail on the 1997 Environmental Basis Law principles (Law 11/87, EBL), by which (i) it was already stated that a national co-ordination of environmental and land-use territory policies should occur (which in fact came to occur formally in 1999, with the creation of MAOT) and the river basin was stated as the water resources management unit.

More broadly, the national Portuguese legal framework may be described as based on three different areas: juridical instruments for water protection, juridical framework for administrative procedures and administrative institutions. The two last will be

[1] The former nomination will be mostly kept along the text

described further when referring to institutional organisation and constraints. Concerning to the juridical water protection main regulations one may distinguish:

1. Direct ruling
   - Water Quality Norms: (i) General: DL 236/98 and (ii) Special (e.g., dangerous substances discharges, for activity sectors, etc.)
   - Water Quality Zones, p.e., by Protected Areas Definition and River Basin Plans (RBP) definition.
   - Water Resources licensing, as referred reporting to DL 46/94, based on a methodology of licence of the use and not of the economic activity, but these obliged to environmental impact assessment (DL 69/2000 or DL 194/2000)
2. Indirect ruling
   - Financial and fiscal instruments, as referred reporting to DL 47/94, but very ineffective
   - Planning instruments: (i) National Environment Policy Planning and the Conservation of Nature National Strategy (defined by EBL), (ii) RBP and National Water Plan definitions (as defined by DL 45/94) and (iii) Special Planning Instruments (p.e., DL 236/98, on: action for reduction of pollution of internal fishing water and of coastal waters; on quality improvement on bathing waters; on plans for water irrigation; and, on reduction of dangerous substances).

Concerning to water supply and drainage systems, the Portuguese system was long developed based on regional administrative boards, i. e., municipality boards, usually via municipal water companies with management directly controlled and ruled by the municipality. Following a change on the legal framework in 1993, by which not only multi-municipal systems were promoted (and five created by Dec-Law 379/93) as also private capital access to economic water supply and drainage activities was open (Dec-Law 379/93), and after definition in 1994 (Dec-Law 319/94) of the concession regime basis for those systems, several municipal and pluri-municipal were created and/or explored on a concession basis – the last mostly by public owned companies ruled under private law rules and the former (operating on that basis) more open to private capital and management. In 1998 (Dec-Law 58/98) the municipalities were allowed also to create autonomous (and with their own capital) urban water/drainage companies.

1.4 Institutional Framework and constraints

As previously referred, the current institutional water management model is founded on the sharing of the management of domestic water resources between two institutions under the Ministry of Environment and Land-Use Planning (MAOT, currently MCAOT) – INAG (national) and the DRAOT's (regional). These last correspond to rename (when that Ministry was created, in 1999) the former Local Environmental and Natural Resource Boards (DRARN's) created in 1993, with district boundaries defined in accordance with the remits of the administrative Local Coordination Commissions (CCR's) and with no correspondence with the river basin areas (figure 6). Five DRAOT's do exist (Northern, Central, Lisbon and the Tagus Valley, the Alentejo, and the Algarve), causing that in some instances the management of a river basin' water resources is due to more than one Regional Board.

Table 5 shows the hierarchical institutional responsibility distribution not only between those referred MAOPT boards but also for other relevant water policy related Ministry's boards.

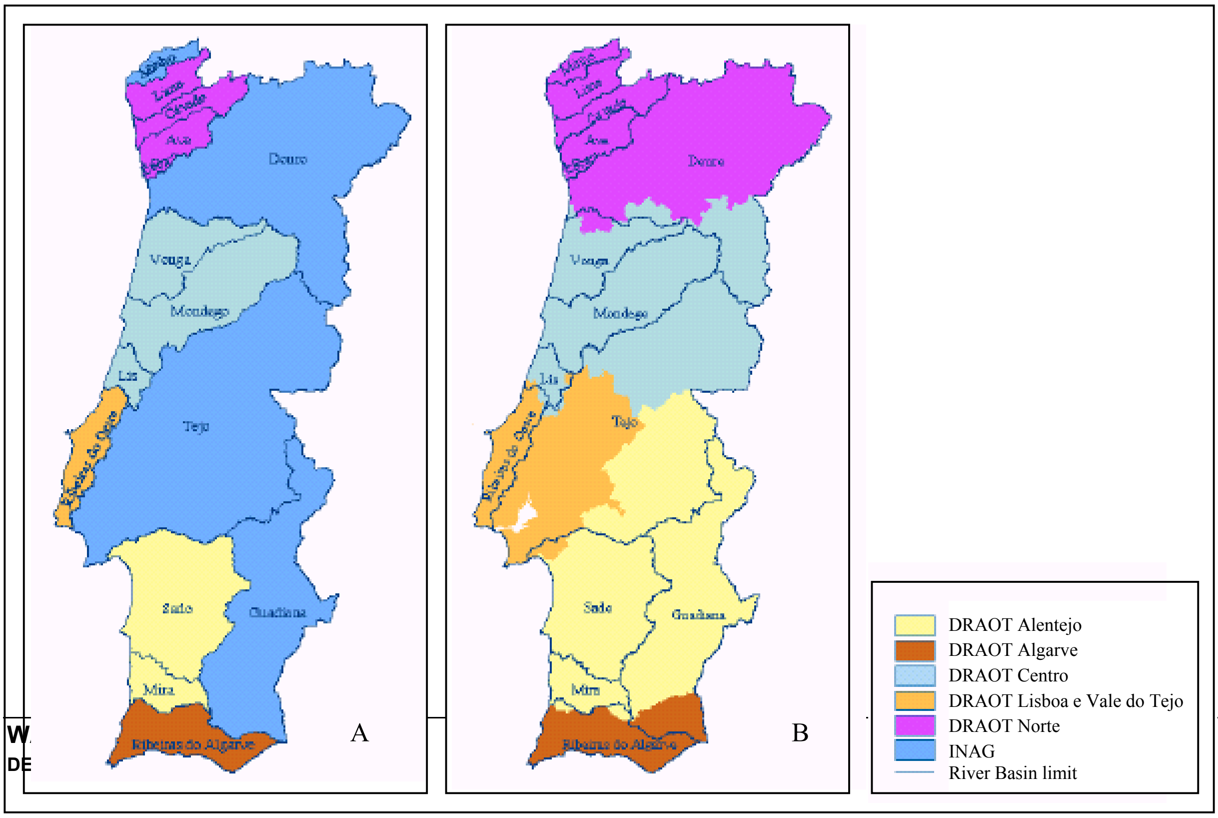


Figure 6. Maps of River Basins (A) and DRAOT's (B)

It becomes visible that although the relevant role of INAG, it is not possible, in a legal sense, to name a true water authority in Portugal – and that is reflected on the water legislation framework and application (Aires, 2001):

- Decree-law nº 45/94 – by which not only the now MCAOT Table 5's referred institutions as also the National Water Council and the River Basin Councils were created with defined responsibilities – made INAG responsible by drafting the River Basin Plans (PBH's) for the International Rivers as well as the National Water Plan (PNA) and defined as the 5 Regional Boards task drafting the River Basin Plans for the national rivers, according to their area of jurisdiction. Drafting of the PBH's did start only late 1997 and was completed October 2000 (for the international basins) and February 2001 (for the national basins). The National Water Plan was completed in August 2001.

- Decree-law nº 46/94 ruled the licensing regime for water use but in fact effective licensing did not effectively occur, which may be regarded as one of the major flaws of the current water resource management system in that the Regional Boards, have failed to secure the registration, cadastral survey and licensing of all water occupations and uses. This led to gaps in basic information which namely had consequences and constrained PBH's drafting and that will have repercussions in the implementation of Directive IPPC on integrated pollution prevention and control.

- Decree-law nº 47/94 ruled the economic and financial regime on public water, aiming to ease the financial burden on the water management institutions, but was mismanaged in its application due to the wrong (political) implementation timing and also because it was intended to encompass all users instead of focusing on the more important and significant uses.

Table 5. Responsible Authorities in the Water Sector

Agency /Authority	**Responsibilities**
Ministry of Environment and of Land_use Planning (MAOT, currently MCAOT)	To define, co-ordinate and execute environmental policy and territory ruling, namely: a) To manage on a global and integrated form national water resources in order to achieve a temporal balance between water availability and demand and to control pollution, safeguarding hydric environment. b) To guarantee integrate and sustained coastal management, Namely based on different institutions, as INAG, DRAOT, DGA and ICN.
INAG	Responsible by the prosecution of national policies on water resources and water supply and drainage, namely. - To develop information systems on national water availability and needs - To promote an integrated planning on a river basin basis as also of the littoral - To promote conservation of national water resources on quantity and quality, etc.
DRAOT	Promote and execute at regional level the environmental and territory ruling policy
DGA	Co-ordination, study, planning and inspection of environment and natural resources sectors
ICN	Nature Conservation, national coordination
Ministry of Agriculture, of Rural Development and Fishing (MADRP)	Some of its attributions interfere with water resources
IHERA	To develop information systems on water needs and current utilisation of water resources in agriculture To support water resources conservation and use and hydro-infrastructure development on agriculture
DGF	To co-ordinate and support the execution of the policy on fishing river basin internal resources
Ministry of Economy (ME)	Responsible by national energy industry development
DGE	Responsible by the conception, execution and assessment of national energy sector policy, aiming to use national resources.
Ministry of Health (MS)	Competencies on public health with implications on water resources

Coastal management duties are currently assigned to INAG (although its organic law does not contemplate any Services Directorate or even a Division exclusively dedicated to coastline issues), with all the mainland coastline being into its jurisdiction, except for the port areas (under the jurisdiction of Port Local Boards) and the areas of special interest for nature protection and conservation, which were assigned to the Nature Conservation Institute (ICN). The Coastline Planning Schemes (POOC's) drawn up by INAG and ICN have seen their integration goal hindered and truncated because the port zones were excluded, as they did not come under the same Ministry. Also all the estuaries are under the jurisdiction of port entities that manage vast areas, aiming to account for large expansion plans and the need for maintenance of navigation channels. The Water Framework Directive, with its integrating approach and vision, now entails that both the transition and coastal waters are managed in conjunction with the whole of the river basin area, which will force an adjustment to the present institutional model.

Concerning to water supply and residual water, and following a 1993 legislation framework change, as already referred, there was a relevant last decade development of private and (mainly) public water industry, based on a concession contract. The scope of the concession on water supply and drainage systems is to substitute municipal responsibilities in what concerns abstraction, treatment and distribution of urban water and to collect and treat water effluents, and this may imply construction, repair and maintenance of the systems. Currently, (mostly primary) water supply for 70% of the population and also of 60% for (main) wastewater drainage and treatment systems is of responsibility of "Águas de Portugal Group", an holding company (with major public capital, under private right statutory rules) ruling over 12 companies with concession on multi-municipal main water supply/drainage systems and 7 companies (plus 3 with no major participation) with concession on municipal secondary (domestic) water supply/drainage systems – this adding to its' 14 companies (of which 13 with major participation) with concession on municipal urban solid waste. The full private concession systems are still only a few and mostly operating on municipal concession of urban water supply/wastewater drainage and treatment secondary (domestic) network systems, whereas the majority of these systems is currently managed and operated directly by municipalities and/or municipal companies. A specific regulator institution (IRAR) was created in 1998 (DL

326/98), with the purpose of ruling over multi-municipal and municipal concession explored urban water supply, residual water and solid waste systems, in order to protect and safeguard citizen interests and rights.

Concerning to Public Consultative Bodies on water issues, one shall emphasise:

- The National Water Council (CNA), created by Article 9 of Decree-Law nº 45/94 of 22 February 1994 and presided over by the Minister for the Environment and Land-Use Planning, is a national planning advisory body on which the Public Administration as well as the most representative professional and economic bodies concerned with the various uses of water are represented, and is aimed to deliver expert opinions to support decision-making, as well as to inform the relevant Plans (as in the case of the PBH's for international rivers). It is also its task to oversee the drafting of the National Water Plan and inform the proposal thereof before its approval.

- The River Councils (RC), created by Article 11 of Decree-law nº 45/94 of 22 February 1994, on which are represented both the Public Administration and the users, are entrusted with overseeing the drafting of the River Basin Plans and with informing such plans, as well as rule on, and promote, actions in respect of a number of issues relating to water resource management within each river basin.

Apart from the participation of elements representing agricultural irrigation associations and sector of activity's end users on RC's, in addition to NGO's (on both CNA and RC), the populations do not have real formal participation on water resources issues.

As referred before, Table 5 shows also some Ministry's (other than MCAOT) involved on water (or related) policy issues. Some of that involvement is also related (or responsible) by constraints facing the water sector, enhancing natural, human technical and financial constraints (Table 6).

Table 6. Constraints facing Portuguese water resources

Category	Constraints
Natural	Uneven spatial and temporal water resources distribution Large dependence on transboundary water
Human	Uneven population distribution, mainly on coastal areas Tourism pressure is located essentially on those areas Agriculture water use is largely dominant Demand peaks on the dry season Lack of environmental awareness
Technical	Old agriculture infrastructure Lack of proper irrigation techniques Big water supply network losses
Juridical	Deficit of execution of water and environmental laws (water resources laws are very often ineffective) Juridical system deficiencies (no clear "rules of game"; different institutions with overlapped and no co-ordinated responsibilities) No clear fundament on water quality rules definition No legal framework for multiple uses plants No actual national Water Law
Financial	A non effective economic and financial regime (leading to poor financial resources for water authorities) Pricing of water is (namely in agriculture) distorted and largely subsidised Insufficient data for costs characterisation
Administrative and institutional	Management of water resources is not made on a River Basin basis No real National Water Authority Need to articulate the different water management entities (namely for multiple use plants) Incipient participation of Civil Society Insufficient law monitoring and enforcement Insufficient administrative human resources

1.5 Management, institutional and policy options

As already referred, the Portuguese water administrative regions do not actually coincide with the river basins, although water resources' planning is made (by law, since 1994) on a river basin basis. Nevertheless, that is due to change shortly under the current re-structure of the Portuguese institutional framework system. Meanwhile, a National Water Plan and the 15 Continental River Basin Plans were approved in

2001, already taking into account Water Framework Directive compliance needs. In order to that, Portugal shall create River Basin Districts and Administrations and that is already foreseen by the "Lei da Água" (National Water Law) proposal presented last 22 of March, taking into account Spanish reality for the case of the shared river basins. In fact not only the adequacy and compliance with European Union Water policy are pushing to internal development of the country own water reform policy and institutions, but also that shall respect and profit from a bilateral (with Spain) co-operation tradition and agreements, namely the "Convention on Co-operation for Protection and Sustainable Use of Portuguese-Spanish River Basins", active since January 2000.

The Portuguese National Water Plan (approved by the end of 2001), other than deciding eventual inter-basin water transfers and co-ordinate planning actions with Spain, is aimed to co-relate and co-ordinate the River Basin Plans measures and actions. The fundamental articulation between those Plans is made though general and specific measures, in order to achieve short, mean and long term (from 2006 to 2020) quantitative and qualitative goals on water resources different domains and issues. The different problems and causes were identified by the PNA as also an aimed set of measures and actions, as referred on Tables 7 to 13, each of which relating to one of seven action axis.

Table 7. PNA's Legal and Institutional Framework action axis

Program	**Measures**	**Main Interventions**	**Types**[2]
Implementation of the New Portuguese-Spanish Convention	Portuguese-Spanish shared river basins	- Definition of bilateral joint measures - Definition of environmental flows - Definition of estuaries management measures - Water monitoring of international river stretches	P; External Relations P; External Relations P; P&P; External Relations P&P; External Relations
Legal and Institutional Framework adequacy	Legal Framework adequacy	- Elaboration of the "Water Law" - Compilation of Water legislation - Establishment of a coastal waters' legal framework - Implementation of a integrated system for cadastral and licensed use	L&I L&I L&I L&I; P&P
	Administrative Reinforcement	- Adequate Administration to the implementation of RBP	L&I; P; E&F

[2] P - Planning; L&I – Legal and Institutional; E&F – Economy and Finance; P&P – Projects and Program

		- Promote and educate human resources on water resources management	P&P
	Identify and create River Basin Districts and Administrations		P; L&I; E&F

Table 8. PNA's Environmental Sustainability action axis

Program	**Measures**	**Main Interventions**	**Types** (See Table 7)
Protection, Rehabilitation and Promotion of water resources quality	Control of quality of all types of water	- Classification and control of surface water/groundwater, according to different uses - Elaboration of Plans of action to achieve aimed quality - Establishment of discharge rules function of receiving water quality goals	P&P P P; L&I
	Assessment and control pollution sources	- Elaboration of Plans of action to improve quality of water on sensible or degraded water or riparian areas - Delimitation of protection areas to surface/groundwater abstractions due to dangerous substances - Assessment and control of discharges of polluting discharges - Promote application of Good Agriculture Code Practise	L&I P&P P&P P&P
	Protection of origins of water for water consumption	- Elaboration of an intervention plan for each drainage basin - Delimitation of protection areas to surface and groundwater for water consumption	P P&P
	Minimization of drought effects	- Establishment of a methodology (i) to characterise drought periods (ii) to manage water resources on drought - Elaboration of a Contingency Plan for drought periods	P P P&P; L&I
	Minimization of pollution accidents	- Elaboration of Emergency Plans for accidental pollution cases	P&P; L&I
Reduction and	Urban and industrial	- Construction or	P&P; E&F

Control of Topic Pollution	drainage and treatment wastewater systems	rehabilitation of small urban centre systems - Promotion and creation of pluri-municipal systems	P&P; L&I
Environmental and Biologic Conservation	Environmental Flows (E. F.)	- Study of E.F. regimes - Adequate hydraulic plants to guarantee permanent E.F.	P P&P; E&F
	Ecosystem conservation and rehabilitation	- Assessment of environmental risks - Management and recuperation of fluvial ecosystem	P P; P&P; E&F

Table 9. PNA's Sustainable Demand Management action axis

Program	**Measures**	**Main Interventions**	**Types** (See Table 7)
Guarantee of water supply for human use and for activity sectors	Domestic and industrial supply	- Promotion and creation of pluri-municipal systems - Increase of level of water supply guarantee, by creation of reserves - Construction and rehabilitation of infra-structure	P&P; E&F P&P; E&F P&P; E&F
	Irrigation	- Increase of level of water supply guarantee, by creation of reserves - Construction and rehabilitation of infra-structure	P&P; E&F P&P; E&F
Conservation of water resources	Efficiency on use of water: domestic and industrial supply	- Promotion of efficient use of water - Identification and reduction of systems' water losses and of non-accountable consumption	P&P P&P
	Efficiency on use of water for irrigation	- Identification and reduction of systems' water losses and more rational use of water	P&P

Table 10. PNA's Integrated Management of Water Resources action axis

Program	**Measures**	**Main Interventions**	**Types** (See Table 7)
Valorisation of Hydro Domain	Recreation and leisure	- Elaboration of plans for fluvial beaches (f. b.) - Creation of f. b.	P P&P
	Fluvial navigation	- Development of commercial navigation	P; P&P; E&F
	Sediment	- Elaboration of plans for river sediment extraction	P
	Other uses	- Wastewater reuse	P; L&I; P&P
Planning and Management of Hydro Domain	Hydro domain Planning	- Classification of river network - Hydro domain delimitation criteria and definition - Main Estuaries and lagoons integrated management plans	P P; L&I P; L&I

	Floods Prevention and Minimisation	- Elaboration of flood zoning maps - Elaboration of Emergency Flood Contingency Plans - Execution of Non-structural flood defence measures	P&P P; L&I P&P
	Conservation of fluvial network systems	- Re-naturalisation of river channels and banks	P&P

Table 11. PNA's Economic and Financial Sustainability action axis

Program	Measures	Main Interventions	Types (See Table 7)
Promotion and Consolidation of Water Market		- Assessment of fiscal instruments - Definition of financing models - Analysis of adequacy of management entities to the water market	E&F E&F E&F
Economic and financial regime application	User-pay principle	- Implementation of the principles of user-pay and polluter-pay principles - Revision and application of E&F regime to public hydro domain - Studies on water pricing - Establishment of a water pricing policy - Definition of E&F regime applicable to (i) domestic water supply and (ii) irrigation systems	P&P; E&F E&F; L&I E&F P; E&F L&I
	Cost of water	- Assessment of all costs to be internalised - Assessment of real costs of the systems - Establishment of "rough water" price - Studies for fixing taxes and tariffs	E&F; P&P E&F;P&P E&F E&F; P

Table 12. PNA's Citizen Information and Participation action axis

Program	Measures	Main Interventions	Types (See Table 7)
Divulgation and Awareness		- Campaign to increase awareness on water issues - Formation and information on water	P&P P&P

		resources environmental sustainability	
Promotion and Users Participation		- Environmental water issues education	P&P

Table 13. PNA's Knowledge, Study and Applied Research on Water Resources action axis

Program	**Measures**	**Main Interventions**	**Types** (See Table 7)
Monitoring and Information Systems	Monitoring systems	- Improve monitoring of: (i) surface water (ii) groundwater - Ecological and biological monitoring network - Sediment transport monitoring network - Implantation of climate network - Coordinated coastal monitoring system	 P&P P; P&P P; P&P P; P&P P; P&P P&P
	Cadastral, information systems and GIS	- Urban water supply and wastewater infrastructure (i) cadastral system (ii) quality control system - Creation of a system to support water resources management - Maintain and explore an effective water resources information system	P&P P&P P; P&P P&P
Studies and Investigation		- Development of hydrological and hydraulic studies - Development of DSS on economic water use - Characterization and assessment of fluvial, estuarine and coastal ecosystems	P&P P; P&P P; P&P
Assessment of National Water Plan (PNA) and River Basin Plans (RBP's)		- Systematic assessment of the Plans - Control of Plans application	P&P P&P

The National Water Plan prospects as main national short term water priorities:

- In domestic water supply, in 2006 95% of the total population should be able to have drinking water at home; currently, that percentage is of 85%.
- In relation to wastewater, in 2006 there must be 90% of the total population served with sewerage and treatment; nowadays the percentage of population served with residual water drainage is of 64%, with only 42% covered by treatment facilities.
- Development of new irrigation areas, namely the ones predicted due to Alqueva new multi-purpose hydraulic plant in construction.
- An increase of the agriculture water use overall efficiency (currently still with values on a 40 to 50% range on most of the traditional irrigation processes regions) and a decrease on urban water supply overall losses (currently 33%).
- To achieve a national wide water monitoring automatic network, in order to monitor and control, namely water quality.
- To achieve Water Directive Framework scheduled actions and aims.

1.6 Conclusions

Some major problems and constraints should be emphasised, distinguishing different water related issues and conflicts of use:

- Several bilateral real (or eventual) conflicts due to Portugal and Spain shared rivers and related water issues, namely: (i) management of extreme hydrologic situations; (ii) establishment of environmental flow regime for different guarantee levels (humid, normal, dry and very dry years); water quality control; inter basin water transfers; water pricing policy and water prices differences.
- Intense use of groundwater resources, namely on agriculture (accounting for 65% of this sector water consumptions), leading to an over-exploitation of the aquifers, with effects on water quality on coastal areas due to saline intrusion.
- High agriculture water consumption (currently more than ¾ of all consumption and still foreseen to increase in the near future), competing for the use of freshwater with the water supply sector.

- Irrigation water prices strongly subsidised and distorted, but (according to EU policy) tending to reflect real cost – and this will cause conflicts on a "real water price" policy implementation on different regions and between sectors.
- Tourism concentrated mostly on south coastal region where (i) there is often (mostly on dry semester) a water resources shortage, (ii) deficiencies on water supply and (iii) competition between different sector (urban and agriculture) uses.
- Water abstractions quality and polluted discharges control needing to be truly improved, with measures involving all sector uses as also as a true improvement of the (still) weak overall effective national wastewater treatment capability and coverage.
- Priority of uses and environmental needs, namely on water scarcity periods, which need to be defined and considered on water shortage contingency plans (due to be elaborated) and be taken into account, namely on various (although quantitatively small) internal inter-basin water transfers due to different sector water uses and interests.
- Water and Environmental laws, which are currently ineffective due to (i) juridical deficiencies, (ii) different institutions with overlapped and/or no co-ordinated responsibilities, (iii) inexistence of legal framework (e.g., on multiple uses plants) and (iv) to the current no-existence of a Water Law.
- Water resources management, which is currently (still) made on a river basin basis and needs to be effectively improved by means of the implementation of the recently active River Basin Plans, making it necessary (i) to adequate the Water Administration to that aim and (ii) to identify and create River Basin Districts and Administrations.