WaterStrategyMan
EVK1-CT-2001-00098

DELIVERABLE 4

SYSTEMATIC TYPOLOGY OF COMPREHENSIVE PROBLEMATIQUE

Prepared by the
National Technical University of Athens

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Preface

The formulation of a typology is an integral part of the Diagnostic Stage of the WaterStrategyMan project, the goals of which are to enhance the understanding of water deficient watershed functions, and to contribute to the selection of regions representative of water deficiency in Southern Europe. The research pathway with which the WSM Project is developing, is presented in Figure 1.

The research logic follows a sequence of co-dependent steps:

1. The initial stage of the project involves the identification of the range of circumstances (WP1), the development of methodology (WP4), and the Workshop on Existing Circumstances.
   - The purpose of WP1 is to identify and analyze water deficient regions, determine the range of circumstances relating to the water deficiency in those regions, and collect data that will be used for the identification of Types of regions.
   - The purpose of WP4 is to research the existing literature and determine appropriate methodologies for assessing and forecasting water availability and demand, and for estimating the economic and environmental costs of water management interventions, to suit the project purposes.
   - Following these two steps, the results of WP1 are presented and critically evaluated in the Workshop on the range of circumstances (WP2), where the required methodological steps for developing and evaluating alternative water management options are also discussed. The Workshop provides the basis for the following two WorkPackages, WP3 and WP5.
2. WP3 involves the formulation of a systematic typology of comprehensive problematique on existing conditions in Southern Europe, and the identification of representative Paradigms for water deficient regions. The expected outcomes of this WorkPackage include:
   - The formulation of a classification scheme suitable for the purposes of the project, and using that for the determination of regional types with similar characteristics.
   - The conceptualization of Paradigms representative of Water management practices and concepts in these groups of regions, and
   - The selection of regions representative of each group, to be further researched in Case Studies. A Case Study refers to the analysis of a Paradigm as that applies in a specific Region. These Case Studies will be performed by the six Case Study

Partners, and are aiming at the analysis and determination of Strategies for water deficient regions, a set of responses to existing and emerging conditions aiming at Integrated Water Resources Management.

3. WP5 involves the development of a Decision Support System (DSS) that will be used to support and assess the findings of the Case Studies. Available tools for the assessment of water resources availability and use are reviewed, and the most appropriate of these for the regions identified are selected. These tools are then tested and adapted for the project methodology.
4. Simultaneously to the DSS Tool, a GIS Database will be constructed to be used by the Tool, using data that will be collected for the Case Study regions.
5. The Tool and Database findings and results will be discussed in the Workshop for Presenting Findings and Training on DSS (WP7). This Workshop aims to:

- Present and discuss results of the previous stages of the Project,
- Validate the developed methodology and selected tools and prepare the development of water management scenarios in the identified Paradigms, and
- Train participants on the DSS and methodology application issues.

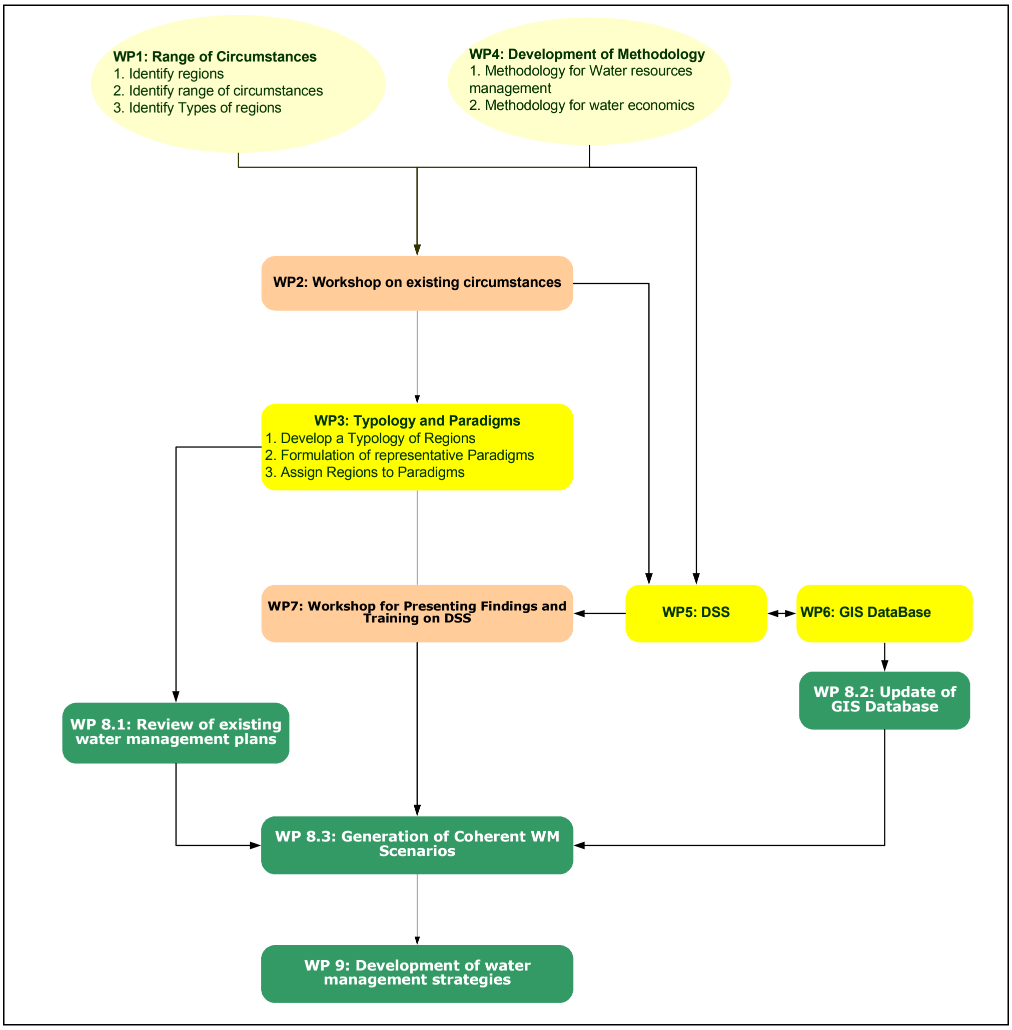

Figure 1. Research steps and data information flow in the WSM evolution

6. The following step involves the generation of water management scenarios for the Case Studies. The main objective of the WorkPackage is the development and assessment of distinct scenarios on water demands and availability. The main inputs for the development and evaluation of alternative water allocation scenarios will be the GIS database for each Paradigm to be built in WP6, and the methods, models and tools chosen in WP5.

7. The scenarios will be evaluated and will be used to formulate strategies for potential improvement of water management in the selected paradigms in WorkPackage 9. Work Packages 9, 10 and 11 are referring to the development of Strategies, Guidelines and Protocols of Implementation. The Strategies will be formulated using coherent water management scenarios for each case study, which will then be evaluated using the DSS Tool, in order to obtain the most appropriate management methods for each region, according to the proposed scheme. Such Strategies will then further be analyzed into

Guidelines, and Protocols of Implementation will be developed. These three interrelated stages involve:

- The development of alternative integrated water resources management options, for each paradigm.
- The development of guidelines, standards and principles for judgment and determination of appropriate water management strategies for water deficient regions.

The development of a protocol that will incorporate the guidelines and the identified ranges of existing circumstances and will provide codes for accepted as appropriate and correct policies of integrated water planning.

Interrelation between the Typology and Paradigm Development

The formulation of the Typology of regions is part of WorkPackage 3 of the WSM project. This WorkPackage also involves the conceptualization of Paradigms representative of water deficient regions. Figure 2 presents the interrelation of the two approaches.

In both cases, the sample of regions is analyzed with respect to the particular characteristics of each region.

- The Development of a Typology aims at:
  - Gaining a better understanding of the characteristics of the natural and man-made environment of the regions, with respect to the use and management of water resources
  - Forming groups of regions sharing similar natural and anthropogenic characteristics
  - Selecting regions representative of each group, to be further analyzed in the Case Studies
- The Development of Paradigm Types aims at:
  - Gaining a better understanding of the forces that drive decision-making processes in the regions selected, and the current management practices in response to water shortages
  - Forming groups of regions sharing similar approaches to water management
  - Selecting regions representative of each group to be analyzed in the Case Studies.

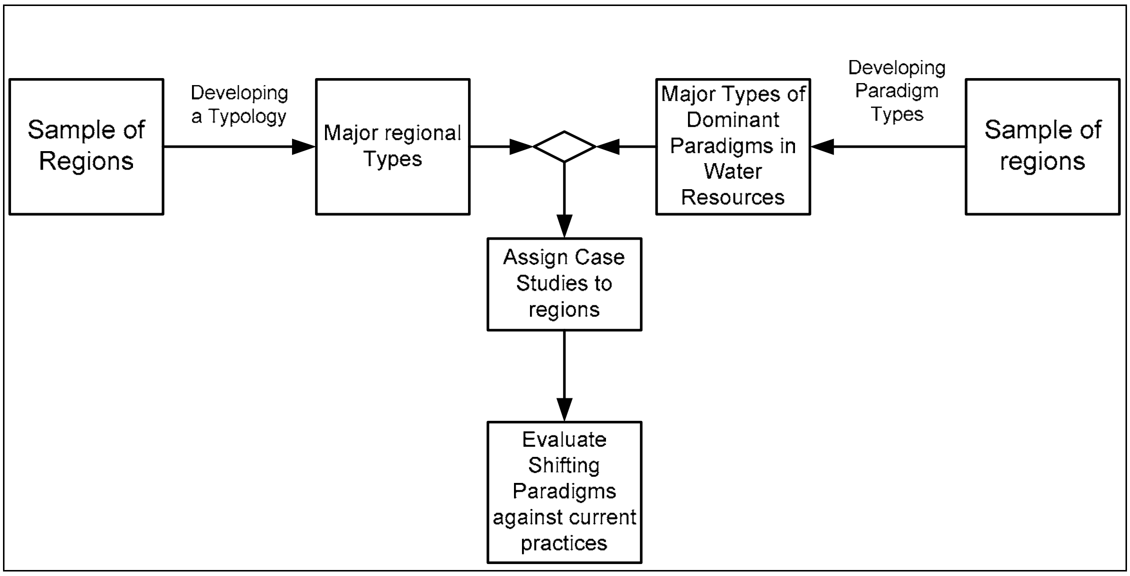

Figure 2. The interrelation of the Typology and Paradigms

Essentially, the process of the Work Package aims at performing an in-depth analysis and increasing the understanding of the functions of Water Resources Management Systems.

- The Typology forms the first level of this process, where the interactions of the Natural Environment and the Human Interventions are analyzed. The synthesis of this approach, in terms of groupings based on **crucial parameters** of the Water Deficit Characteristics that will emerge, will then be used in the second level, the formulation of Paradigms.
- In the Paradigms analysis stage, the Water Deficit Characteristics are analyzed with respect to the Current and Potential Water Resources Management Practices. Through the region groupings that will be formed in the two approaches, it will be possible to determine regions representative of the groups formed, and assign Case Studies to them.
- Finally, during the Case Study analysis stage, the parameters of Water Resources Management Plans will be researched in terms of formulation and evaluation of scenarios for each Case Study. The synthesis of these scenarios is expected to yield Strategies for Water Resources Management under each identified Paradigm.
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Summary

This document is the Deliverable on the **"Systematic typology of comprehensive problematique"** of the WaterStrategyMan (WSM) Project (EVK1-CT-2001-00098). The Deliverable summarizes the research that was carried out in the Work Package 3 of the project, "Developing a Systematic Typology of Comprehensive Problematique"which according to the contract aimed "to formulate a typology of water deficient regions in terms of water resources, water supply and use patterns, water management practices and policy-making functions, which will be used for the selection of representative Paradigms (Deliverable on the **Set of Representative Paradigms for water deficient regions**). The typology should be developed on a common analysis framework, able to depict the factors that affect the formulation and operational efficiency of an integrated water resources management approach."

The objectives of this Deliverable are:

- To present the regions selected and analyzed in each country,
- To illustrate the commonalities, similarities, differences and gaps among them, and
- To develop a classification scheme and through the analysis of the selected regions to formulate a typology of regions in terms of Drivers and Pressures leading to water deficiency, and Responses to these.

The present document has been prepared by the NTUA, using data provided by:

- The NTUA (Greece)
- ProGEA S.r.l. (Italy)
- The Hebrew University of Jerusalem (Israel)
- The Water Development Department and Aeoliki Ltd. (Cyprus)
- INSULA (Spain)
- The University of Porto (Portugal)

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1. Introduction

The formulation of a Typology of the characteristics of water deficient regions involves developing a common analysis framework in terms of the natural conditions and the human environment in the regions analyzed. This will allow the highlighting of the commonalities and gaps among representative regions and watersheds in Southern Europe. Finally, it will depict the factors that affect the outlining and operational efficiency of water resources management approaches. The objectives of this Deliverable are:

- To present the regions selected and analyzed in each country,
- To illustrate the commonalities, similarities, differences and gaps among them, and
- To develop a classification scheme and through the analysis of the selected regions to formulate a typology of regions in terms of Drivers and Pressures leading to water deficiency, and Responses to these.

Table 1. Definitions of Terms

Term	Definition
Paradigm	The word Paradigm describes a school of thought on prioritising during the selection of Policy Options, for the Management of Water Resources. The Dominant Paradigm is the current school of thought for each region; the shifting paradigm is an alternative prioritising of policy options, and respective actions, aiming at achieving Integrated Water Resources Management, which is slowly becoming a necessity due to the increasing challenges of managing the water resources, particularly in water deficient regions, in a sustainable way.
Strategy	The set of actions / sequence of responses to existing and emerging conditions, that is suited / available aiming at the fulfilment of a selected goal (in the case of the project the goal is that of Integrated Water Resources Management).
Guidelines	A set of (relatively generalised) instructions that analyse a strategy into actions required set within a time framework.
Protocol of Implementation	A set of step-by-step analytical instructions that need to be taken in order to effect a specific task in the framework of a strategy.
Case Study	The application of a Paradigm on a selected Region.
Scenario	Developments which can not be directly influenced by the Decision Maker such as Weather, Market Prices.

The Typology is a key step of the research process, as it is through it that the selection of Case Studies will be made. Fifteen candidate regions were selected in the initial reports of the six participating countries, which were analyzed as to their specific characteristics. The Typology attempts to develop a classification scheme to form **Types** of regions that share similar characteristics and properties and finally to select **representative cases of each Type** in the subsequent stage of Paradigm formulation.

2. The methodological approach

The methodology followed for the formulation of Typologies was structured in three major steps:

- **Step 1: Selection of the Sample of Regions.** The selection criteria are detailed in the following section of this chapter.

- **Step 2: Data selection and collection** The data selection and collection involved four distinct stages:

  - The selection of a set of indices. This was an important stage, as it would ultimately influence the quality of analysis; it is described in section 2 of this chapter
  - The data collection stage
  - The data verification stage, and
  - The conflict resolution stage, where discrepancies and conflicts were resolved.

- **Step 3: Data Analysis.** The analysis of data was also performed in 4 stages:

  - The first stage involved the determination of the range of circumstances. The data for all regions was examined and the gaps and commonalities among regions, as well as the data ranges, presented in section 4 of this chapter.
  - Secondly, a classification scheme was developed, described in detail in chapter 3.1, which could be used to assess the data obtained. The classification was effected in three separate approaches, based on the:
    - Natural conditions (Drivers) and the
    - Human Pressures (Pressures) that result into the conditions of water deficiency, as well as
    - The Responses to these conditions.
  - Thirdly, for the analysis of the quantitative data for the Human Pressures classification approach, an appropriate statistical analysis methodology was selected based on the multivariate methods of cluster and factor analysis, further described in chapter 3.
  - Finally, the distinguishing parameters in each classification approach were identified, and then used to form a synthesis of regional types, described in chapter 3.5.

2.1. The sample of regions

Regionalization of the participating countries was a key step for the selection of a representative sample of regions. It was important to select a suitable range of regions in terms of water deficiency, in order to ensure that the analysis outcomes can eventually apply to as wide a range of water deficient areas as possible, to emphasize the regionality of water shortages, and to study those particular areas by way of characteristic case studies. There can be great differences among various regions even within a country (e.g. in terms of available resources and precipitation), so the selection of the appropriate regions was of great importance.

For that purpose, a total of **fifteen regions** in **six participating countries** (Cyprus, Greece, Israel, Italy, Portugal and Spain) were selected as **candidates for Case Studies**, for which the range of circumstances was determined, and from which the Case Studies final selection will be made based on the outcome of the Paradigm Analysis. These regions were selected based on the following criteria, or their combinations:

- The existence of Natural Aridity in the areas,
- The existence of Water Shortages on a permanent or seasonal basis due to natural or man-made reasons, or the recurrence of drought and/or flood cycles,
- The insufficient efforts of water resources management in the areas,
- The lack of proper administrative or institutional framework for the effective water resources management,
- The socioeconomic conditions in the areas that affect the management of water resources.

In order to determine the existing conditions in the fifteen candidate regions in terms of water resources and supply, use patterns, water management practices and policy-making functions, regional reports and matrices of circumstances were developed. The regional reports and reasons for selection by each country are presented in full in Annex I, while the Matrix of circumstances for each region is presented in Annex II. In this section, a brief description is provided for the areas analyzed.

In Greece:

- Attica prefecture that hosts over forty percent of the total population in Greece concentrated in the Capital city and the surrounding areas, with limited natural resources and haphazard development.
- Thessaly region, where large plains are intensively cultivated, requiring great quantities of irrigation water, due mainly to the crops selection.

- Cyclades, a complex of islands in the central Aegean Sea, which attract large numbers of tourists in the summer months, in a fragile area with limited natural resilience.

In Italy:

- Emilia Romagna, which hosts several large cities, has significant agricultural activities and also attracts a great number of tourists, leading to conflicts between the users over water allocation, environmental degradation and water resources overexploitation.
- Belice Basin, an area with intensive agriculture, where low rainfall as well as the inadequate infrastructure and the lack of even water distribution, does not allow full irrigation.

In Israel:

- Tel Aviv, an area with large population and significant industrial activity.
- Arava, which hosts mainly rural scattered population that is occupied with agriculture.

In Cyprus:

- Akrotiri, which hosts the urban area of Limassol and also significant cultivated plains.
- Germasogeia, an area with both agricultural and tourist activities, where water resources system is the most intensively exploited in Cyprus.
- Kokkinochoria, where tourist resorts have been developed and high efficiency irrigation is used.

In Spain:

- Canary Islands, a region that is made up by a group of volcanic islands, where the existence of intensive agriculture characterized by high water consumption, the very rapid rise of population and the spectacular development of mass tourism create serious conflicts and risks with regard to water availability.
- Doñana, which includes one of the most important wetlands of Europe, the Doñana National Park, but at the same time its surroundings host a large population.

Finally, in Portugal:

- Sado, an area where irrigation, industry and power generation demands are all of great significance.

- Guadiana, where irrigation demand and the poor water quality create deficit problems.
- Ribeiras do Algarve, a region that attracts a large number of tourists, especially in the dry semester and where there is also a lot of pressure due to irrigation water uses.

2.2. In search of Indices and Typologies

All classification schemes are based on selected indices that are used to accurately describe the classification subjects' characteristics. In the past, different types of indices have been proposed to describe and assess the state of water resources, water management and the sustainability of management schemes in water deficient regions. A brief description of such indices and classification schemes follows.

2.2.1. Climatic and natural conditions classification

During the length of efforts to classify regions on the basis of water resources, attempts have been made to produce classifications based on the natural conditions alone, which were mostly based on climatic criteria. This limitation on natural conditions however means that these classifications, although still very widely used, and despite their usefulness for assessing certain aspects of the water deficiency issues, are not suitable for presenting the **full extent** of issues surrounding water deficiency. Three of the most significant approaches are presented, the aridity index, the Köppen climate classification, and the global Ecoregions.

Köppen System of climate classification

A widely used classification of world climates, based on the annual and monthly averages of temperature and precipitation, on which Thornthwaite's system that follows was also based. The original Köppen classification system has been revised several times, modified and refined from its initial form. Köppen related the distribution and type of native vegetation to the various climates, in a scheme that employs five major climatic types. Each type is designated by a capital letter, A, B, C, D and E. Each group contains subregions that describe special regional characteristics, such as seasonal changes in temperature and precipitation.

Köppen's system has been criticized on two accounts; firstly, its boundaries do not correspond to the natural boundaries of each climatic zone, and secondly, it implies that there is a sharp boundary between climatic zones, when in reality there is a gradual transition.

Aridity index based on Thornthwaite

There are variations over the definition of aridity and the boundaries of arid regions. Aridity is usually taken as a situation in which rainfall is less than half the value of potential evapotranspiration. This methodology was developed by Thornthwaite and adopted for the determination of areas susceptible to desertification, those with arid, semi-arid and dry sub-humid climates. This index is defined as the ratio between the amount of rainfall and potential evapotranspiration, that is, the maximum water loss that is possible through evaporation and transpiration, determining the categories Hyperarid, Arid, Semi-Arid, Dry Sub-humid and Moist Sub-humid. This index can be used to express limited water resources in a region.

Table 2. Classification by Aridity Index

Type	Aridity Index
Hyper-arid	<0.03
Arid	0.03 - 0.20
Semi-arid	0.21-0.51
Dry sub-humid	0.51-0.65
Moist sub-humid	>0.65

Thornthwaite developed a classification system for climates, utilizing temperature and precipitation measurements, and relating natural vegetation to climate. Using the precipitation to evapotranspiration index, the Thornthwaite system defines five major humidity regions and their characteristic vegetation: rain forest, forest, grassland, steppe, and desert.

To better describe the moisture available for plants, Thornthwaite proposed a new classification system that emphasized the concept of *potential evapotranspiration*, which is the amount of moisture that would be lost from the soil and vegetation if the moisture were available. Thornthwaite incorporated potential evapotranspiration into a moisture index that depends essentially on the differences between precipitation and potential evapotranspiration. The index is high in moist climates and negative in arid climates. An index of 0 marks the boundary between wet and dry climates.

Particularly for droughts most risk assessment efforts are using drought indices in order to provide reference points for drought duration, severity and time of occurrence. Palmer (1965) presented an index that may be used in drought analysis as well as in providing information about drought characteristics. This index is a function of runoff, evaporation, moisture recharge, and carryover of moisture from previous precipitation events. The Palmer index is widely and successfully used in the United States, however it should be applied with caution in other geographical locals.

Classification by Ecoregions[1]

Environmental issues are better addressed in the context of areas defined by natural features rather than by man-made boundaries. Growing awareness that the natural resources of an area do not exist in isolation, but instead they interact, has led to delineating and managing ecosystems rather than individual resources. Ecosystems of different size occur on many geographic scales, smaller ones embedded in the larger systems. Any large portion of the earth's surface over which the ecosystems have characteristics in common is called an ecoregion.

Although ecoregions can be defined climatically, they can be better defined by combining and rearranging the climatic types to maximize correspondence with major plant formations. Through this process, **Bailey** (1998) mapped the earth into zones he called ecoregion provinces. He recognized eighty-six subdivisions, which he grouped into fifteen divisions, and then further simplified this classification of ecosystems by grouping the divisions into four large regions called domains. He recognized four such subdivisions: polar, with no warm season; humid temperate, rainy with mild to severe winters; humid tropical, rainy with no winters, and finally dry, which is defined on the basis of moisture alone and transects the other three, otherwise humid domains.

A brief description of these domains, after Bailey:

- In the very high latitudes lies the polar domain, differentiated on the basis of ice formation and plant development into icecap, tundra, and subarctic taiga divisions.
- In the mid latitudes is the humid temperate domain of mid-latitude forests, differentiated on the basis of rainfall (steppe vs. desert) and winter temperature (cold vs. warm) into tropical/subtropical steppe, tropical/subtropical desert, temperate steppe, and temperate desert.
- In the low latitudes lie the humid tropical domain, differentiated on the basis of rainfall seasonality into savanna and rainforest divisions.

Each of these subdivisions is associated with a particular climate type, vegetation and soil structure.

2.2.2. Classification based on Human Pressures

Following the classification efforts based on natural conditions alone, which do not offer a full picture of the processes, attempts were also made at forming classification schemes that assess the human impacts on the system. These approaches assess the interaction of man with the environment, to produce measures that can be used on different geographic scales, from the local to the national level. The development of these approaches is a key step

[1] Bailey, RG. 1998: Ecoregions: The Ecosystem Geography of Oceans and Continents. New York, Springer-Verlag

towards Integrated Water Resources Management. Two of the leading approaches in Europe are presented here, of the Mediterranean Blue Plan, and the 2000 EU Water Framework Directive.

Plan Bleu Indicators

These indices broadly measure the pressures exerted on the resource by man. They indicate a rough probability of pressures on water, not taking into account the water demand of the natural environment or the variability of resources and demand in time and in space. Although they do not reveal all aspects of water shortages, they provide an initial threshold estimate beyond which chronic water shortages may appear.

- **The Resources to population index**[2]: Measured in m^3 per capita, the index is the ratio of the average total resources (or flow) measured in hm^3/year, divided by the population of the region at a given time, measured in millions of inhabitants. The index expresses a measure of the sufficiency of the resources for the population.
- **The Exploitation Index of Renewable Resources**. The index, expressed as a percentage, measures the relative pressure of annual production on conventional renewable natural fresh water resources. It is the sum of the volumes of annual conventional renewable natural fresh water production for all uses, including losses during conveyance, referring to a specific year, divided by the volume of average annual flows of renewable natural water resources. Also,
- **The Consumption index of Resources**. Expressed as a percentage, it is the ratio of the annual final consumption divided by the mean annual flow of resource.

The exploitation index expresses the water quantities withdrawn, the consumption index measures the quantities consumed in a percentage of the theoretical total of renewable water resources. According to the Plan Bleu Report[3], indices equal to or greater than 25% are signs of local and circumstantial tensions in quantity and quality. Above 50% they point to more frequent and more regional circumstantial shortages. Towards 100% and especially if above, they indicate generalized structural shortages. In particular the increasing final consumption index illustrates the increasing scarcity of water availability.

The Water Framework Directive Approach

The Water Framework Directive established a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater. The WFD classification methodology approaches water resources from an environmental perspective, and determines different levels of classification of water bodies, from the microlevel

[2] Plan d'Action pour la Méditerranée, Observatoire du Sahara et du Sahel, 1996: Les Indicateurs de l'Economie de l'Eau, Ressources et Utilisations, Document de réflexion

[3] Mediterranean Commission on Sustainable Development (MCSD), 2000: Indicators for the sustainable development in the Mediterranean region

determination of chemical and biological indicators, to the determination of the quality status of entire bodies, to establishing macroscale ecoregions.

This Directive, under Article 8 which establishes "Monitoring of surface water status, groundwater status and protected areas" proposes a comprehensive set of indicators for assessing the quality of waters, as well as a series of standards and measures for the protection and improvement of the quality of waters. These measures, a brief description of which follows, are described in Annex V. The status of water bodies is determined, based on these indicators, to be improved or maintained accordingly.

Regarding Groundwater, the quantitative and chemical status of the resource is monitored. The parameter for the classification of quantitative status is the groundwater level regime. The core parameters for the determination of groundwater chemical status are:

- oxygen content,
- pH value,
- conductivity,
- nitrate,
- ammonium.

The quality elements for the classification of ecological status of Rivers, Lakes, Transitional waters, Coastal waters, and Artificial and heavily modified surface water bodies involve monitoring of:

- parameters indicative of biological quality elements
- parameters indicative of hydromorphological quality elements
- parameters indicative of all general physico-chemical quality elements
    - Thermal conditions
    - Oxygenation conditions
    - Salinity
    - Acidification status
    - Nutrient conditions
    - Transparency, and
    - Tidal regime for the transitional and coastal waters
- priority list pollutants, and
- other pollutants discharged in significant quantities.

Article 6 of the WFD establishes a "Register of protected areas", which according to Annex IV include:

- areas designated for the abstraction of water intended for human consumption,
- areas designated for the protection of economically significant aquatic species,
- bodies of water designated as recreational waters, including areas designated as bathing waters,
- nutrient-sensitive areas, including areas designated as vulnerable zones,
- areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites.

Finally, in Annex XI the WFD also presents a set of ecoregions in the European Union, for rivers and lakes, and for transitional and coastal waters.

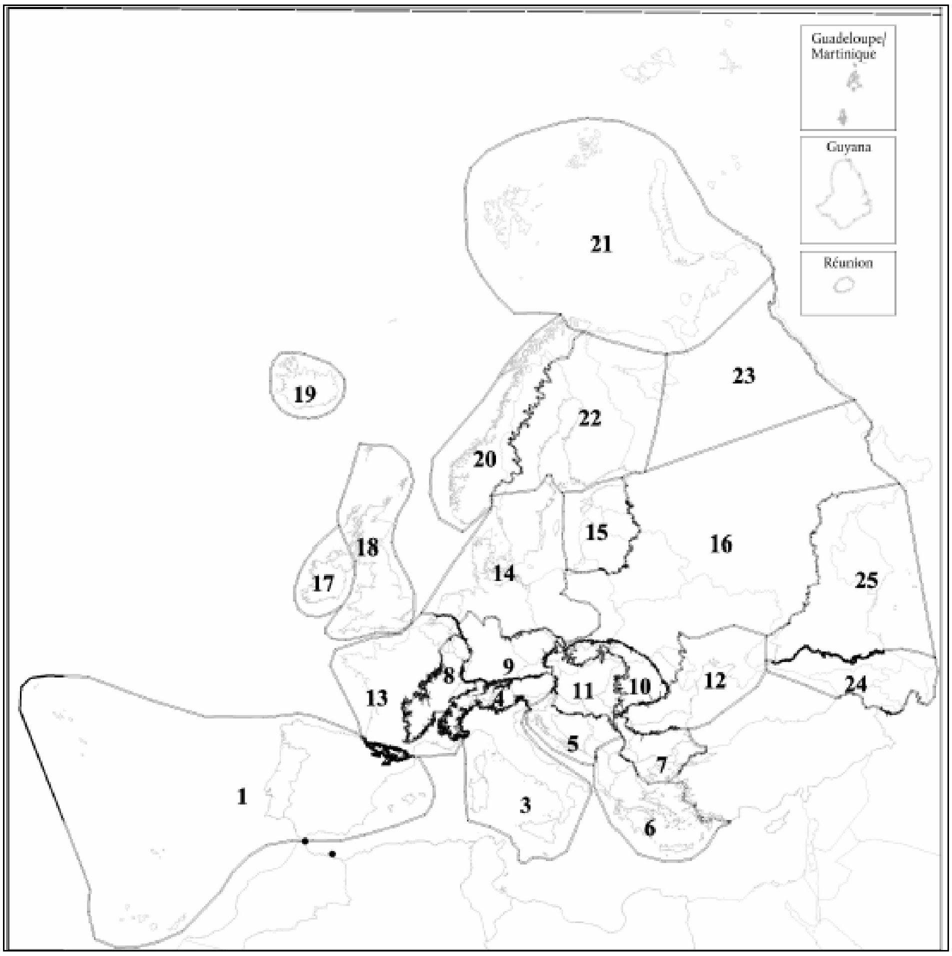

Figure 3. Map A: WFD Ecoregions for rivers and lakes

Map A (Figure 3) presents the WFD Ecoregions for rivers and lakes:

1. Iberic-Macaronesian region

2. Pyrenees
3. Italy, Corsica and Malta
4. Alps
5. Dinaric western Balkan
6. Hellenic western Balkan
7. Eastern Balkan
8. Western highlands
9. Central highlands
10. The Carpathians
11. Hungarian lowlands
12. Pontic province
13. Western plains
14. Central plains
15. Baltic province
16. Eastern plains
17. Ireland and Northern Ireland
18. Great Britain
19. Iceland
20. Borealic uplands
21. Tundra
22. Fenno-Scandian shield
23. Taiga
24. The Caucasus
25. Caspic depression

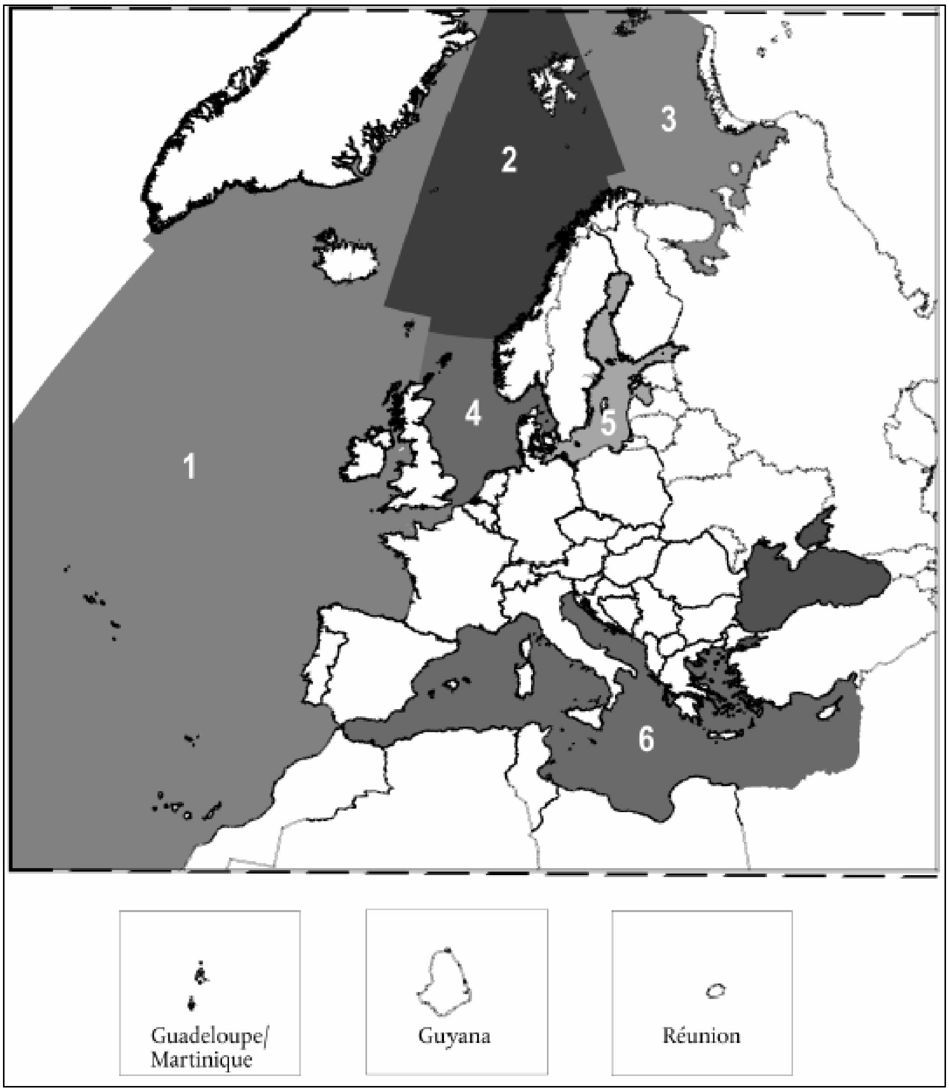

Figure 4. Map B: WFD Ecoregions for transitional waters and coastal waters

Map B (Figure 4) presents the Ecoregions for transitional waters and coastal waters:

1. Atlantic Ocean
2. Norwegian Sea
3. Barents Sea
4. North Sea
5. Baltic Sea
6. Mediterranean Sea

2.2.3. The Responses approach

The methodology used in this document followed up on the previous classification efforts and attempted to establish an analysis framework that would include the climatic and human pressures data. These approaches have in common the fact that they are descriptive of the **Characteristics of Water Deficiency** (Figure 5), in other words, they describe the existing situation in terms of the Natural and Human pressures applied. In this regard, various concepts have been used to exemplify a prevailing confusion among terms which signify "dry environments" or water deficiencies. There are four different terms that are important for some initial separation among types of water deficiences (Vlachos, E.C., 1982; Karavitis, C.A., 1999): -aridity is referred to as a permanent natural condition; - drought may be understood as a temporary climatic phenomenon; - water shortage is associated mainly with small areas of water deficiencies; - desertification is principally a man-made phenomenon altering the ecological regime. It has been suggested that all the above terms and definitions associated with dryness may be considered as a part of a larger process named : xerasia (Vlachos, E.C., 1982).

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Figure 5. Water deficiency characteristics (Vlachos, E.C., 1982).

These approaches however do not present the full set of circumstances that apply in Water Deficient regions, as there is yet another important distinguishing factor that differs among regions. Therefore a third methodological step was introduced into the classification scheme, incorporating the **Responses** to the existing conditions. This allows for a more dynamic approach of the conditions that apply in each region.

2.3. A proposal for a framework of Indices

A classification scheme for water deficient regions would have to be based on indices related to water quality, quantity and management; a matrix of indices was used for quantifying and assessing all aspects of water management in the regions analyzed.

A comprehensive water resources management plan may be centered around descriptive and performance indices. Descriptive indices present the existing conditions, the context of a water resources elements or issues in relation to the principal characteristics (time, geographical local, etc.) through which such elements may be expressed. Thus a first group of descriptive indices may present the water resources natural conditions and the corresponding existing regional context. A second group of descriptive indices may delineate the human induced conditions in the water resources system. Such a group reflects mainly the economic and social development of a region. Finally a third group is concentrated mainly on performance indices. Usually they assess the existing, the current water resources system status (real), with the ideal or desired status (target). Thus, it has to be underlined that such indices are monitoring and representing the results of policy responses generated from the overall water resources management structure.

In this regard, the selected approach attempted to combine in the following indices descriptive of the natural conditions and regional context, with indices describing the human environment in relation to the water resources, including institutional and economic indices, and finally water policy, administrative and management status at a given time.

Table 3. Indices and assessments for water resources management

Group I	Group II	Group III

Regional Context
• Climate
• Topography
• Vegetation
• Soils
• Demography
 	
Water availability
• Precipitation
• Surface runoff
• Groundwater
• Water storage
• Reuse and recycling
 	
Water quality
• Geological formations
• Effluent type
• Pollution
• Conservation
 	
Water Supply
• Surface water
• Groundwater
• Supply system
• Distribution
	Water use
	• Urban consumption
	• Agricultural consumption
	• Industrial consumption
	• Water Deficits
	
	Water demand
	• Projections
	• Urban
	• Agricultural
	• Industrial
	• Water Budget
	• Efficiency of
	  ○ water use
	  ○ water supply
	
	Pricing system
	• Equity
	• Economic efficiency
	• Revenue sufficiency
	• Resource conservation
	
	Social capacity building
	• Stakeholders integration
	• Public Participation
	• Public integration
	• Conflict resolution
	• Training
		Water Resources Management
		• Social and Legal aspects
		• Organizational framework
		• Planning environment
		• Political environment
		• Time horizon
		
		Water Policy
		• National policy
		• Regional policy
		• Water resources
		  ○ use goals
		  ○ protection goals
		  ○ conservation goals
		• Economic issues

2.3.1. The Matrix of Indices

The matrix that was developed follows; these indices were researched for each of the Regions selected, collecting relevant data to be used for classification.

A. Indices relating to the Natural conditions and infrastructure (the physical environment)

1. Regional Context

- Climate type - according to the Köppen classification (Qualitative Index)
- Aridity index - by the Penman-Monteith calculation (Quantitative Index)
- Permanent population (Quantitative Index)

2. Water availability

- Total water resources / availability – an estimate of the total resources in the area, and, if known, the amount available for use (Quantitative Index)
- Trans-boundary water (Quantitative Index) (Percentage)

3. Water quality

- Quality of surface water (Qualitative Index)
- Quality of groundwater (Qualitative Index)
- Quality of coastal water (Qualitative Index)

4. Water Supply

- Percentage of supply coming from:
    - Groundwater
    - Surface water
    - Desalination, Recycling – includes all water obtained through purification
    - Importing – includes all water that is used in the region but is transported from other regions

- Network coverage (Percentage):
    - Domestic
    - Irrigation
    - Sewerage

B. Indices relating to the Economic and Social system (the human environment),

1. Water use

- Water consumption by category (Percentage):
  - Domestic
  - Tourism
  - Irrigation
  - Industrial and energy production

- Resources to population index - calculated as RP = Total Resources / population (Quantitative Index)

2. Water demand

- Water Demand trends - if the water demand in the area is increasing, decreasing or is stable (Qualitative Index)
- Consumption index - calculated as CI = Water consumed / Total Water Resources (Percentage)
- Exploitation index - calculated as EI = Water distributed / Stable Water Resources (Quantitative Index)

3. Pricing system

- Average household budget for domestic water –the percentage of the average household income used to pay for the domestic supply of water
- Average household budget for agricultural water –the percentage of the average household income of farmers used to pay for irrigation water
- Average household income – the average in the region (Quantitative Index)
- Cost recovery – estimate of the degree of recovery of the costs of water provision (Qualitative Index)
- Price elasticity **–** the change in demand, when there is a change in price, defined as the change in demand divided by the change in price (Qualitative Index)

4. Social capacity building

- Public participation in decisions - the degree of public participation in decisions involving water management (Qualitative Index)
- Public education on water conservation issues - the degree of education of the public regarding water conservation (Qualitative Index)

C. Indices relating to the Decision Making process (the management processes)

1. Water Resources Management

- Water ownership – is water private or state-owned (Qualitative Index)
- Decision making level– at what lever are decisions made regarding the allocation and the management of resources to uses:
  - Water supply for each sector (Qualitative Index)
  - Water resources allocation for each sector (Qualitative Index)

2. Water Policy

- Local economy basis – what are the main economic activities in the area (Qualitative Index)
- Development priorities – what are the development priorities for the region (Qualitative Index)

2.4. Overview of regional characteristics

This section presents the Regional characteristics, as those have been analyzed in the Matrix of Circumstances. Regarding the data collected in the Matrices for each Region, a categorization by index category is attempted, as those were defined in this Deliverable; Indices relating to the natural conditions and infrastructure, Indices relating to the Economic and Social system, and Indices related to the Decision Making Process

2.4.1. Natural conditions and infrastructure

Figure 6 shows the Permanent Population of the 15 Regions Selected; there is a wide variety of regions in that respect, ranging from populations under 100,000 inhabitants to over 3 million.

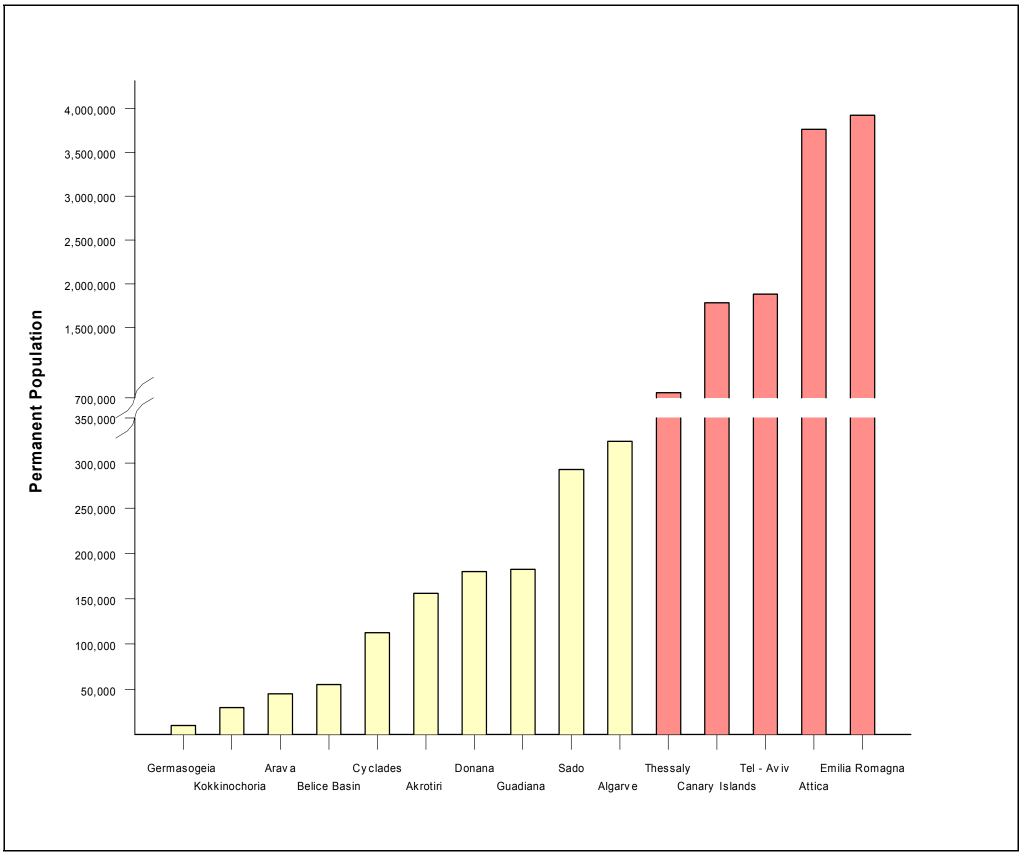

Figure 6. Permanent population

Table 4 presents the occurrence of water transfer in the Regions (inter-basin or trans-boundary); of the 15 regions, only in two, Emilia-Romagna and Doñana, there is no water transfer. Figure 7 presents Thornthwaite's Aridity index and the Water Resources in each of the fifteen regions.

Table 4 Occurrence of trans-boundary or inter-basin water transfer

Yes	No
Attica Cyclades Guadiana Kokkinochoria Arava Belice Basin Akrotiri Germasogeia Tel Aviv Sado Algarve Thessaly Canary Islands	Emilia-Romagna Doñana

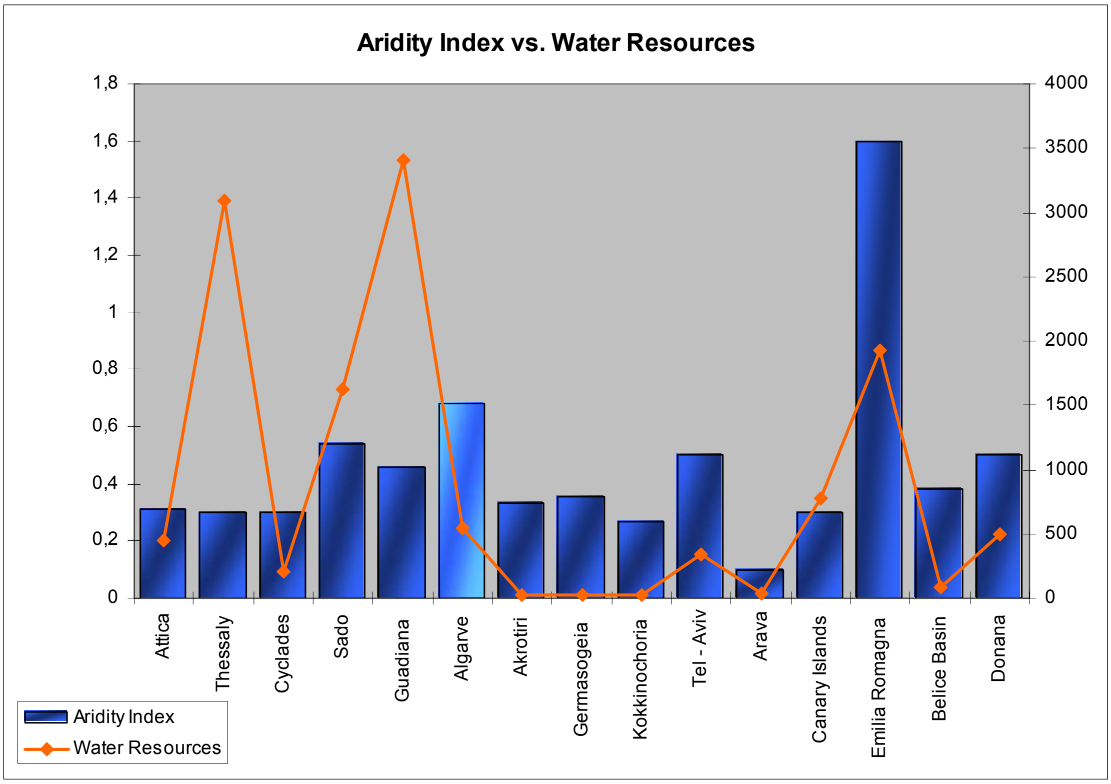

Figure 7. Aridity index and total water resources in the 15 regions

Figure 8 presents the sources of water supply in each region. The 15 Regions can be divided into three major groups:

- those that utilize importing as the primary means of obtaining water (which includes only two Regions, Attica and Kokkinochoria),

- those that utilize mostly Surface water, and
- those that utilize mostly Groundwater.

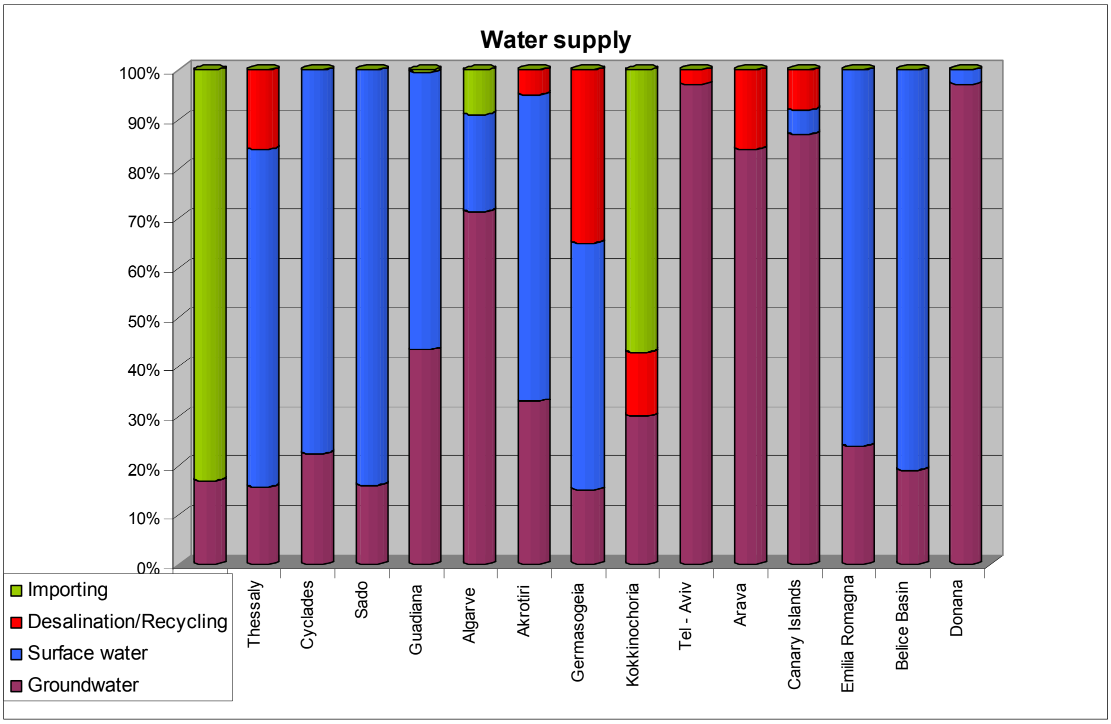

Figure 8. Sources of water supply

2.4.2. Economic and Social system

Figure 9 presents the water consumption by sectors. Despite the importance of tourism in many of the Regions analyzed, the Domestic sector, which includes Tourism consumption, is only the dominant water use in Attica and Tel Aviv, while in the majority of regions Irrigation is by far the most water-demanding use, with the exception of Sado and Emilia-Romagna where industrial usage of water exceeds the other uses.

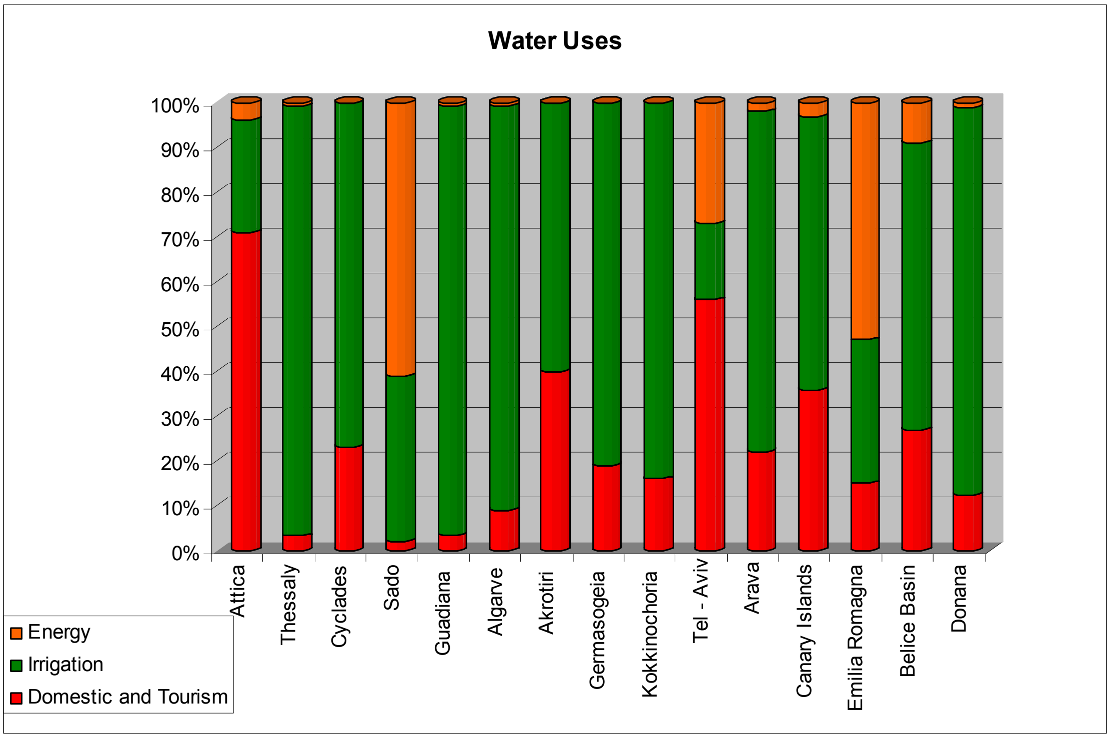

Figure 9. Dominant water uses in the 15 Regions

In Table 5 the water demand trends are presented for the 15 Regions, most of which show increasing trends. The exception to that is Attica, where the trend is towards a decrease in water consumption, and Thessaly, Arava and Emilia-Romagna where the water demand appears to have stabilized.

Table 5. Water Demand trends

Trend	Regions
Increasing	Cyclades Sado Guadiana Algarve Akrotiri Germasogeia Kokkinochoria Tel Aviv Canary Islands Belice Basin Doñana
Stable	Thessaly Arava Emilia Romagna
Decreasing	Attica

Figure 10 presents the Consumption and Exploitation indices in the 15 regions. With the exception of Thessaly and Guadiana, the Consumption index in all the other areas is over the threshold of 50%, whereas the Exploitation index ranges from low levels in Guadiana, the Cyclades and Thessaly to 100% and over.

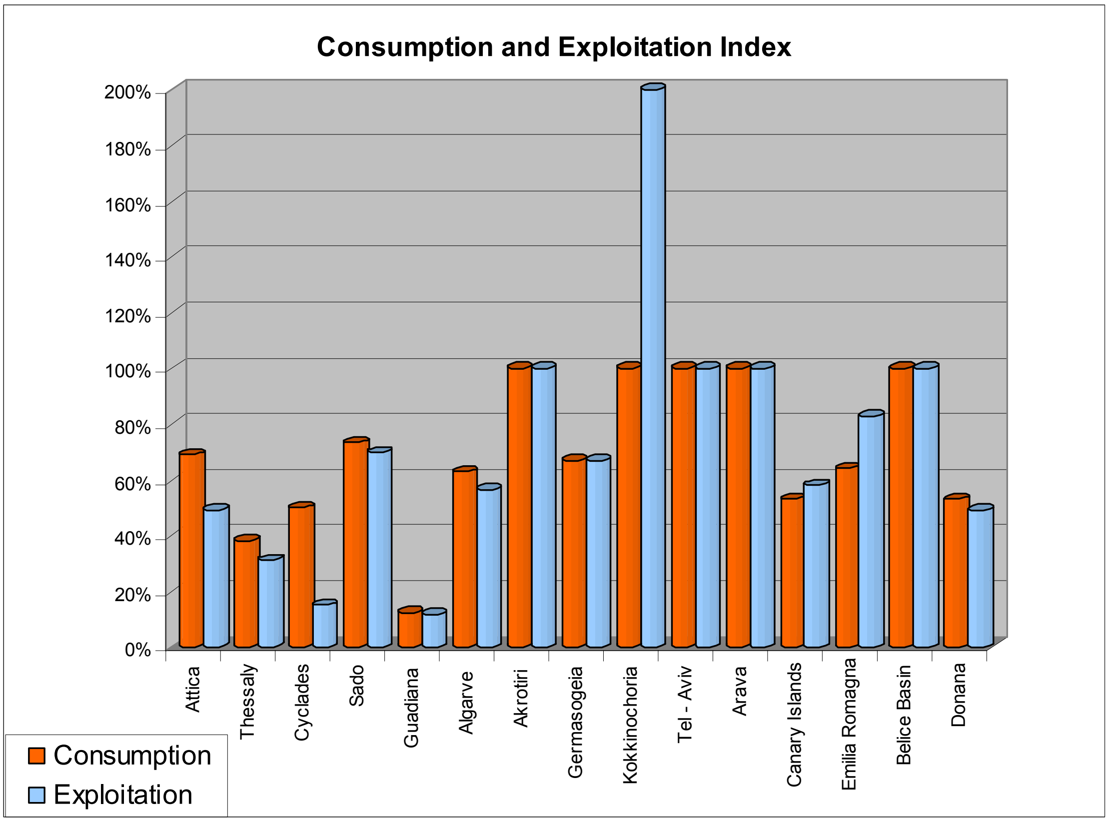

Figure 10. Consumption and Exploitation Indices

Table 6 and Table 7 present the economic aspect of the water sector. Cost recovery is low in Thessaly and the Cyclades in Greece, in the three Cypriot and the three Portuguese regions; it is considered average in the Spanish Regions, and good in the Italian and Israeli Regions as well as in Attica. Regarding price elasticity, in none of the regions has it been characterized good, it appears to be fair only in Attica and Arava, and poor in all three Cyprus Regions and Doñana. Figure 11 presents the average income in each of the 15 regions.

Table 6. Cost recovery

Level	Regions
Good	Attica Emilia Romagna Belice Basin Tel Aviv Arava
Average	Canary Islands Doñana
Poor	Thessaly Cyclades Sado Guadiana Algarve Akrotiri Germasogeia Kokkinochoria

Table 7, Price Elasticity

Level	Regions
Fair	Attica Arava
Average	Thessaly Cyclades Sado Guadiana Algarve Tel Aviv Canary Islands Emilia Romagna Belice Basin
Poor	Akrotiri Germasogeia Kokkinochoria Doñana

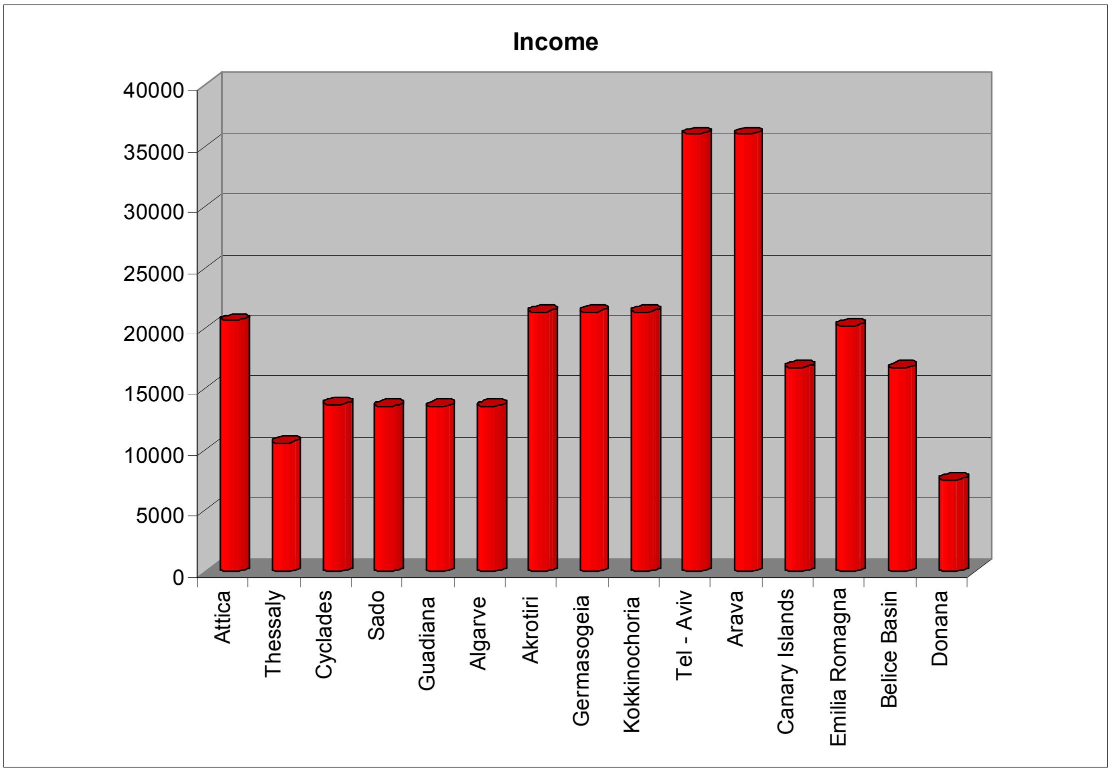

Figure 11. Average Income

Public Participation in Decisions and Public Education in Water Conservation Issues, as shown in Table 8 and Table 9, are both poor in the three Portuguese regions, the Canary Islands and Belice Basin, both average for Emilia-Romagna, and both above average in the two Israeli and the three Cypriot regions. In Doñana, although education is average, the participation is good, whereas participation in all three Greek regions is poor, even though education is good in Attica and of average level in Thessaly and the Cyclades.

Table 8. Public Participation in Decisions

Level	Regions
Good	Tel Aviv Arava Doñana
Fair	Akrotiri Germasogeia Kokkinochoria
Average	Emilia Romagna
Poor	Attica Thessaly Cyclades Sado Guadiana Algarve Canary Islands Belice Basin

Table 9. Public Education in Water Conservation Issues

Level	Regions
Fair	Attica Akrotiri Germasogeia Kokkinochoria Tel Aviv Arava
Average	Thessaly Cyclades Emilia Romagna Doñana
Poor	Sado Guadiana Algarve Canary Islands Belice Basin

2.4.3. Decision-Making process

In Table 10 there are two distinct groups of regions, according to the partial privatization or not of water as a resource. In Greece, Israel and Italy, water is state-owned; in Cyprus, Spain and Portugal, there is private ownership of the resource.

Table 10. Water ownership

Ownership	Regions
State	Attica Thessaly Cyclades Tel Aviv Arava Emilia Romagna Belice Basin
Public / Partly Private	Akrotiri Germasogeia Kokkinochoria Sado Guadiana Algarve Canary Islands Doñana

In Table 11 the level of decision making regarding the water supply, and the resource allocation among the different sectors. The water supply is delivered on a National level in the Cypriot and Israeli Regions as well as in Attica, and on a local or regional level in the other regions. The allocation of resources however is effected on a National level in Greece, Cyprus, Portugal and in Tel-Aviv, and is regional in Italy, Spain and Arava.

Table 11. Decision-Making level

Sectoral Water Supply		Sectoral Water Resources Allocation	
Level	**Regions**	**Level**	**Regions**
National	Attica Akrotiri Germasogeia Kokkinochoria Tel Aviv Arava	Regional / Local	Emilia Romagna Belice Basin Arava Canary Islands Doñana
Regional / Local	Thessaly Belice Basin Cyclades Sado Guadiana Algarve Canary Islands Doñana Emilia Romagna	National	Attica Thessaly Cyclades Sado Guadiana Algarve Akrotiri Germasogeia Kokkinochoria Tel Aviv

Table 12 and Table 13, finally, present the current major economic sectors, as well as the development priorities for each Region.

Table 12. Local Economy basis

Sector	Regions
Primary Sector	Thessaly Arava
Tertiary Sector	Attica Cyclades Algarve Canary Islands Tel Aviv
Primary / Secondary	Sado
Primary / Tertiary	Guadiana Akrotiri Germasogeia Kokkinochoria Emilia Romagna Belice Basin Doñana

Table 13. Development Priorities

Priority	Regions
Urban Growth	Attica
Agriculture	Thessaly Sado Guadiana
Tourism	Cyclades Canary Islands
Tourism / Agriculture	Algarve Akrotiri Germasogeia Kokkinochoria Belice Basin Doñana
Supply Enhancement Demand Management	Tel Aviv Arava Emilia Romagna

3. Classification

3.1. The approach in developing Typologies

Aridity and Water deficiency are central concepts in the development of Water Resources Management Plans and Strategies. These conditions in Southern European – Mediterranean areas are due mostly to the arid or semi-arid conditions. The water stress may be a permanent feature of an area or a temporary, isolated occurrence; it may be year-long, or seasonal through the summer months.

The level of variability among such regions indicates that a systematic approach should be taken towards forming a classification scheme, or Typology, that will allow the formation of groups of regions that share similar characteristics. In order to analyze the Typology, it will first be necessary to clarify the categories that are selected. The DPSIR (Driving-Forces–Pressure–State–Impact–Response) Indicators, adapted by J. Walmsley[4] (Figure 9, presented in greater extent in Annex III), provide a useful framework for the formulation of a classification scheme.

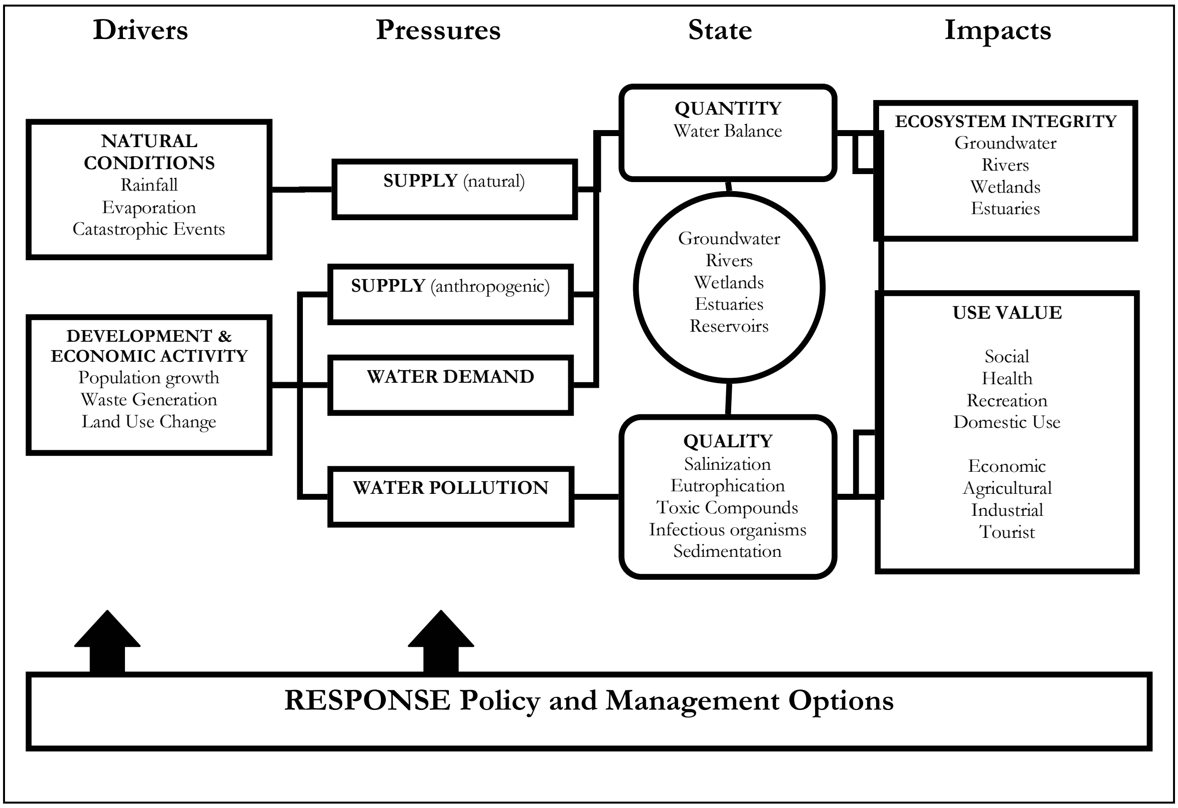

Figure 12. Schematization of the DPSIR framework

[4] Framework for measuring sustainable development in catchment systems, Environmental Management, Vol. 29. No2. 2002

The constituents of a **State** of water deficiency, as can be seen in Figure 12, are the **Drivers** and **Pressures** that are applied on the system. That **State** in itself leads to **Impacts** on the human and natural environment, the **Responses** to which feed back onto the **Drivers** and **Pressures**.

Based on this scheme, classification will be attempted in three separate approaches, which respectively address:

- The **Drivers** that lead to water deficiency. The regions are classified based on the duration of the water deficiency as well as the causative agent of the water deficiency. These variables are also to a large extent quantifiable and suitable for analysis. The 15 regions are separated into four groups, the members of each group having similar deficit characteristics.
- The **Pressures** applied in the area. The Water Supply and Consumption characteristics in particular, which are quantifiable, as these relate to managing the Demand under shortage conditions. The 15 regions are classified into three groups on the basis of the water supply, and four groups on the basis of the sectoral consumption of water.
- The **Responses** to those Pressures and Drivers. The regions are classified according to the actions selected to respond to water deficiency, within the Policy Options available. Despite not always being quantifiable, such responses are very specific and distinct, and provide important analysis criteria. The 15 regions are classified into groups based on the specific actions selected within each Policy Option available for dealing with water deficiency.

3.1.1. The statistical analysis

Classification of regions is conducted through cluster analysis and factor analysis, and then the results are compared in order to obtain a more robust conclusion.

Cluster analysis is an analytical technique that can be used to develop meaningful groups of cases. The objective of cluster analysis is to classify a sample of cases into a small number of mutually exclusive groups based on the similarities among the cases. There are no a priori assumptions or hypotheses, and the groups are not pre-defined. Instead, cluster analysis techniques attempt to identify interdependencies among a number of variables without treating any of them as dependent or independent. Furthermore, cluster analysis is only descriptive and has no inference properties.

There exist a lot of algorithms used for forming clusters. In the present work the hierarchical procedure based on an agglomerative method was followed. The purpose of the agglomerative methods is to join together cases into successively larger clusters, using some measure of similarity or distance. Each case starts out as its own cluster and in subsequent steps the two closest clusters (or cases) are combined into a new aggregate cluster, thus reducing the number of cluster by one in each step. Eventually, all cases are grouped into one large cluster. Agglomerative methods differ by the formula used to measure distance or similarity between cases and the rule used to determine when two clusters are sufficiently similar to be linked together (agglomerative or linkage rule).

The Euclidean distance measure was used to compute the similarities between cases. It simply is the square of the geometric distance in the multidimensional space. This method has the advantage that the distance between any two cases is not affected by the addition of new cases to the analysis which may be outliers.

The Ward's method was used as a linkage rule. This method uses an analysis of variance approach to evaluate the distance between clusters. It attempts to minimize the sum of squares of any two clusters that can be formed at each step/ In general, this method is regarded as very efficient, however, it is biased toward the production of clusters with approximately the same number of cases.

Factor analysis is a multivariate technique that can be used to gain an overall understanding of the main dimensions underlying classifying variables. It addresses the problem of analyzing the structure of the interrelationships among a number of variables by defining a set of common underlying dimensions, known as factors.

The Principal Components Analysis (PCA) and the varimax rotation method were employed to extract the factors (Principal Components). The PCA method assumes that all the variability in a variable should be used in the analysis and derives factors that contain small proportion of unique variance (variance associated with only a specific variable).

3.2. A classification based on Drivers

The term "Aridity" is used for regions that are generally, or at least periodically, dry. It can be both an ecological fact of nature, measurable and objective, and a human derived condition. In Southern Europe water deficiency originating from aridity is becoming a major constraint for the economic welfare and sustainable regional development. On the other hand, regions that may not conventionally be classified as "Arid" that are relatively rich on water resources can be water deficient, due to mismanagement of the resource. The **Drivers** that can lead to a State of water deficiency can therefore vary, so the nature of the water deficiency is one factor that needs to be determined.

The main characteristics of these Southern European regions are the high spatial and temporal imbalances of water demand and supply, seasonal water uses that strive for inadequate water resources and poor institutional water management. Therefore, the other characteristic that requires determination is the timescale of the water deficiency. Figure 13 presents an attempt to classify the 15 regions according to the Water Deficiency Characteristics of each region within a grid, separating them into four types, based on the duration of the deficiency and its cause:

- Type 1, Temporary, natural-induced water deficit.
- Type 2, Temporary human induced water deficit, which is the type where most cases are falling in.
- Type 3, Permanent natural water deficiency.
- Finally, Type 4, Permanent human induced water deficiency.

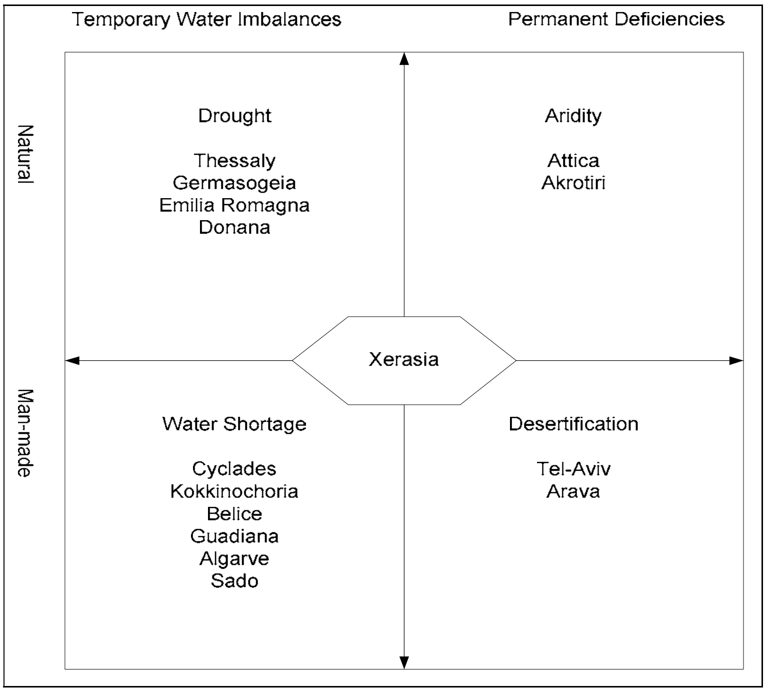

Figure 13 Typology of regions selected (adapted from Vlachos E.C., 1982)

3.3. A classification based on Pressures

3.3.1. Classification according to water supply sources

A combined approach based on the multivariate methods of cluster and factor analysis was followed, in order to classify the 15 regions into a small number of meaningful groups on the basis of the water supply sources utilized in each region. The analysis was based on the four quantitative indices representing the percentage of water supply coming from **groundwater**,

surface water, **desalination – recycling** and **importing**. Mean values and standard deviations for all variables are presented in Table 14.

Table 14. Summary statistics of the four water supply indices

Variable	Ground water	Surface Water	Desalination Recycling	Importing
Mean Value	0.448	0.388	0.064	0.100
Standard Deviation	0.325	0.352	0.100	0.250

Figure 14 presents the profiles of all regions on the three variables representing the sources of water supply. This diagram can be used for a preliminary screening for outliers. As can been seen from, there is no obvious outlier that has all extremely high or low values.

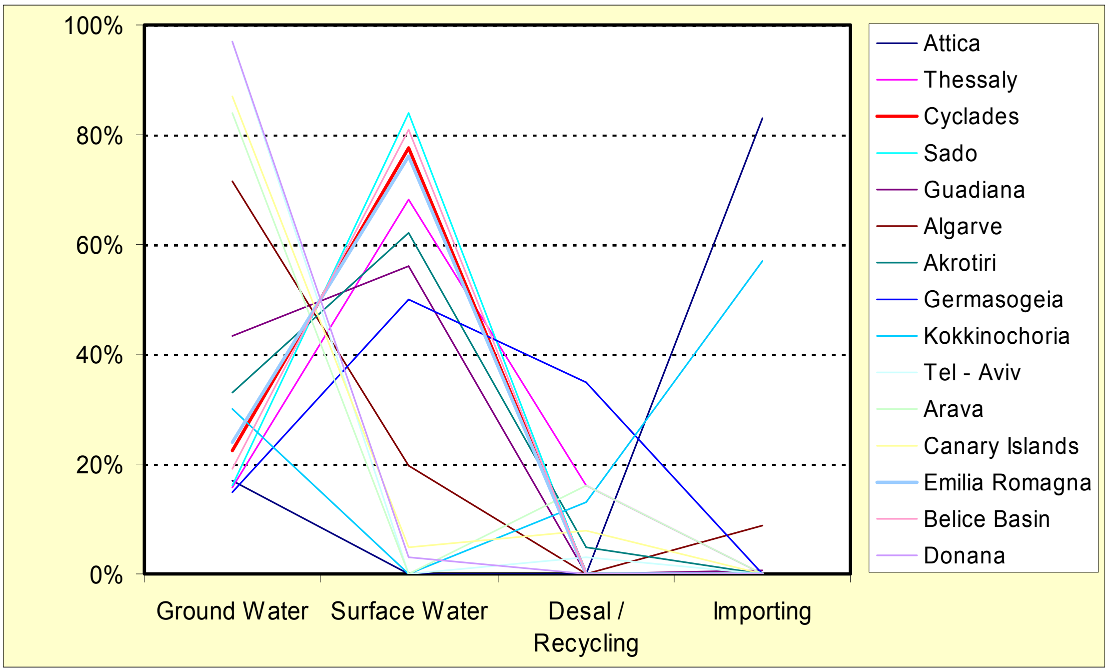

Figure 14. Profile diagram for all regions

Figure 15 displays the dendrogram of the hierarchical cluster analysis, calculated using the Ward's agglomerative procedure and squared Euclidean distance as the distance measure. It is clear that three main clusters are formed:

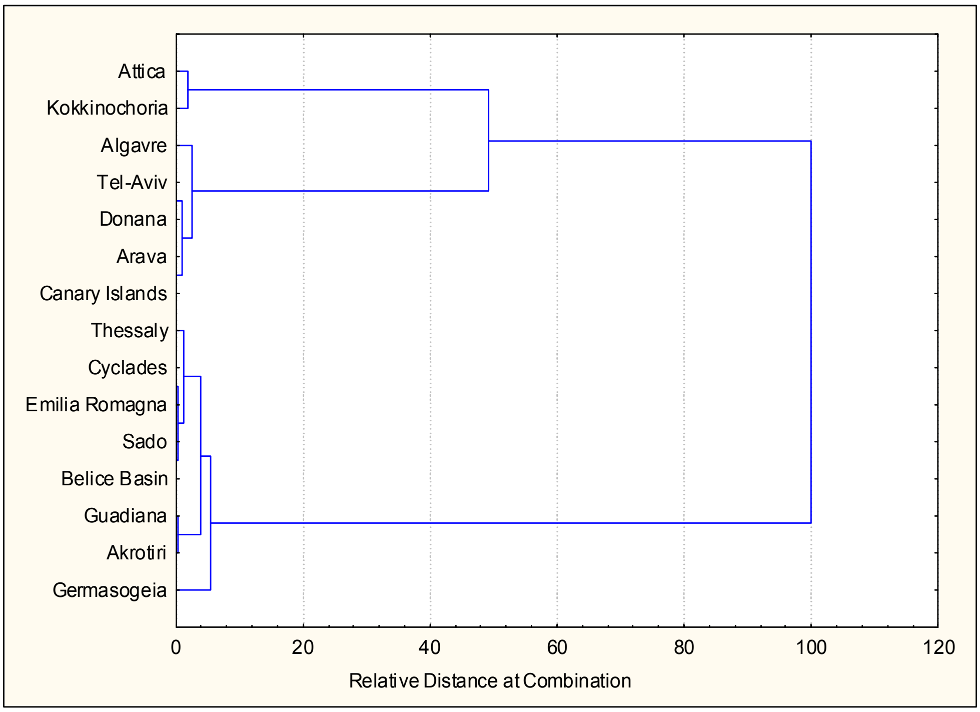

Figure 15. Dendrogram obtained for classification according to water supply sources

- **Cluster 1** includes only two regions (Attica and Kokkinochoria).
- **Cluster 2** includes five regions (Algarve, Tel-Aviv, Doñana, Arava and Canary Islands).
- **Cluster 3** includes eight regions (Thessaly, Cyclades, Emilia Romagna, Sado, Belice Basin, Guadiana, Akrotiri and Germasogeia).

Information essential to the interpretation of results is provided in Figure 16. For each cluster, the mean of each of the four clustering variables is plotted along with the mean of all regions. The following conclusions can be conducted by examining the patterns of the three cluster profiles:

- Cluster 1 is characterized by high values in **importing water** and low values in ground and surface water.
- Cluster 2 is characterized by high values in **ground water** and low values in surface and importing water.
- Cluster 3 is characterized by high values in **surface water** and low values in ground and importing water.
- All clusters have similar values of desalination-recycling water.

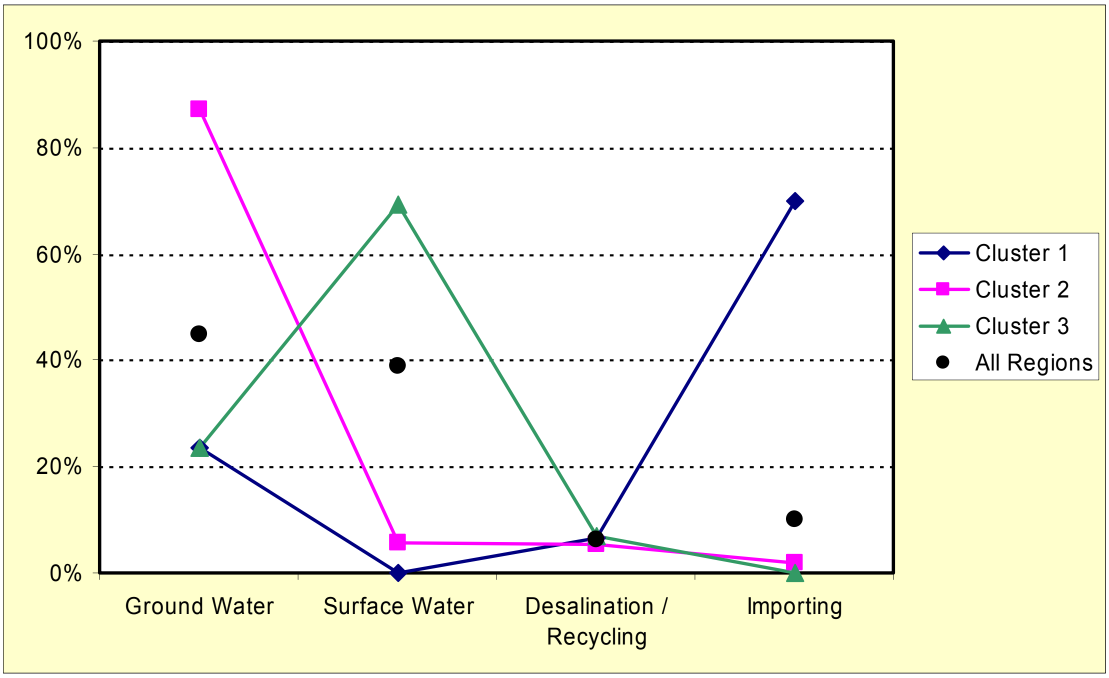

Figure 16. Profile diagram for all clusters on the water supply sources

These conclusions are summarized in Table 15.

Table 15. Clustering by water supply sources

Cluster	Regions	Major Source
1	Attica Kokkinochoria	Importing
2	Algarve Tel Aviv Doñana Arava Canary Islands	Groundwater
3	Thessaly Cyclades Emilia Romagna Sado Belice Basin Guadiana Akrotiri Germasogeia	Surface Water

Principal components analysis was performed on the data matrix consisting of the three quantitative indices representing the percentage of water supply coming from groundwater, surface water, and importing. Desalination-recycling water was excluded from the analysis, since, as shown from the previous analysis, its effect on the final results is negligible. The factor matrix obtained by PCA was subjected to a varimax rotation, with the results summarized in Tables 16 and 17. Only factors with eigenvalues greater than one were considered in the interpretation

Table 16. Summarized results of the principal components analysis for water supply sources, showing loadings and score coefficients on the first two factors

Variable	Factor Loadings		Factor Score Coefficients	
	Factor 1	Factor 2	Factor 1	Factor 2
Groundwater	0.960	-0.257	0.597	-0.273
Surface Water	-0.871	-0.477	-0.489	-0.311
Importing	-0.011	0.996	-0.080	0.785

Table 17. Eigenvalues and variance explained by the first two factors in the principal components analysis for water supply sources

	Factor 1	Factor 2
Eigenvalue	1.736	1.230
Percentage of variance	57.9%	41.0%
Cumulative percentage	57.9%	98.9%

Figure 17 shows a plot of 15 regions on the first two axes extracted by the analysis. . As can been seen from Table 17, the percent variance accounted by the two principal factors (Factor 1 and Factor 2) is 98.9%. The separation of regions into the three groups, as resulted by the cluster analysis, is very clear.

The factor loadings, presented in Table 16, represent the correlations between the three indicators and the two factors. It is clear that Factor 1 is highly correlated with the indicators representing the percentage of water supply coming from groundwater (positive correlation) and surface water (negative correlation), while Factor 2 is highly correlated with the indicator representing the percentage of water supply coming from importing (positive correlation). According to these remarks, the interpretation of clusters shown in Figure 17 is in agreement with the conclusions conducted by the cluster analysis.

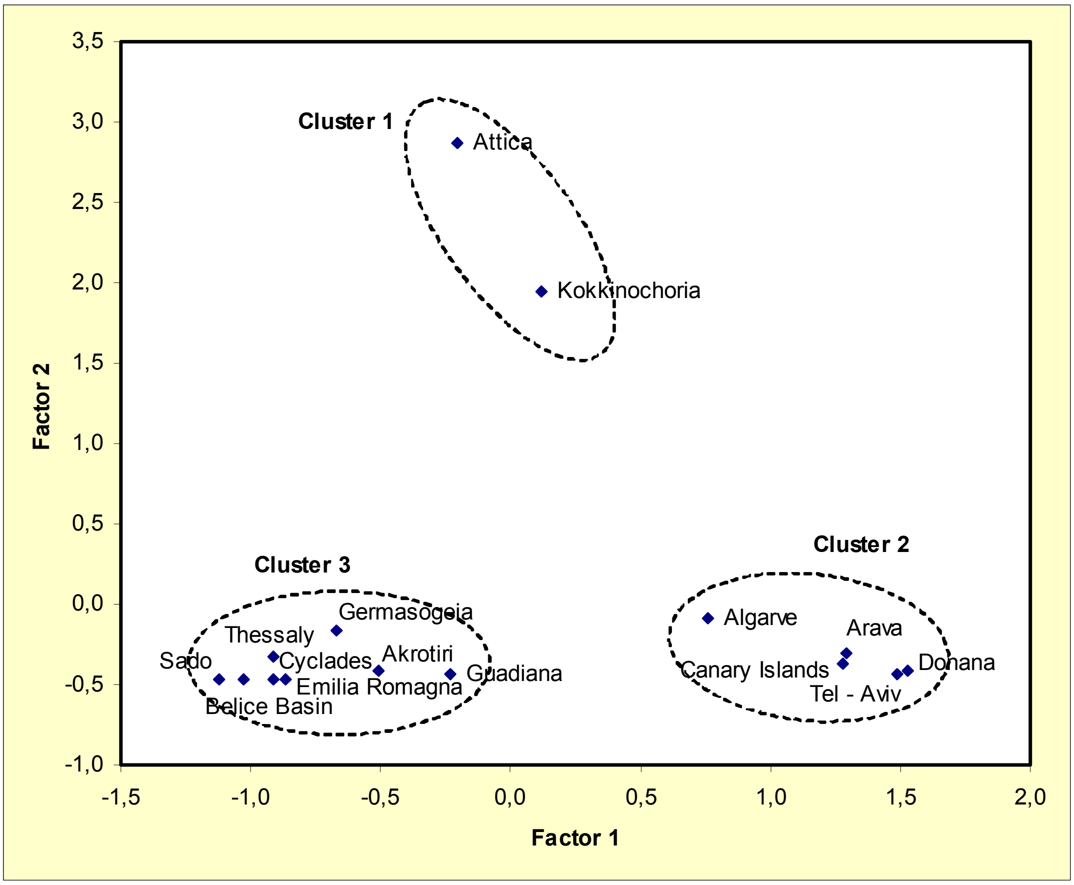

Figure 17. Plot of regions on the first two axes extracted by principal components analysis

3.3.2. Classification according to sectoral water consumption

The same cluster and factor analysis approach was followed, in order to classify the 15 regions according to the water consumption by sector. The analysis was based on the three quantitative indices representing the percentage of water consumption in **Domestic-Tourism** sector, **Irrigation** and **Industry-Energy** production. Mean values and standard deviations for all variables are presented in Table 18.

Table 18. Summary statistics of the four water consumption indices

Variable	Domestic Tourism	Irrigation	Industry Energy
Mean Value	0.235	0.651	0.108
Standard Deviation	0.198	0.262	0.200

Figure 18 presents the profiles for all regions on the three indices representing the sectoral water consumption. Again, there is no obvious outlier that has all extremely high or low values.

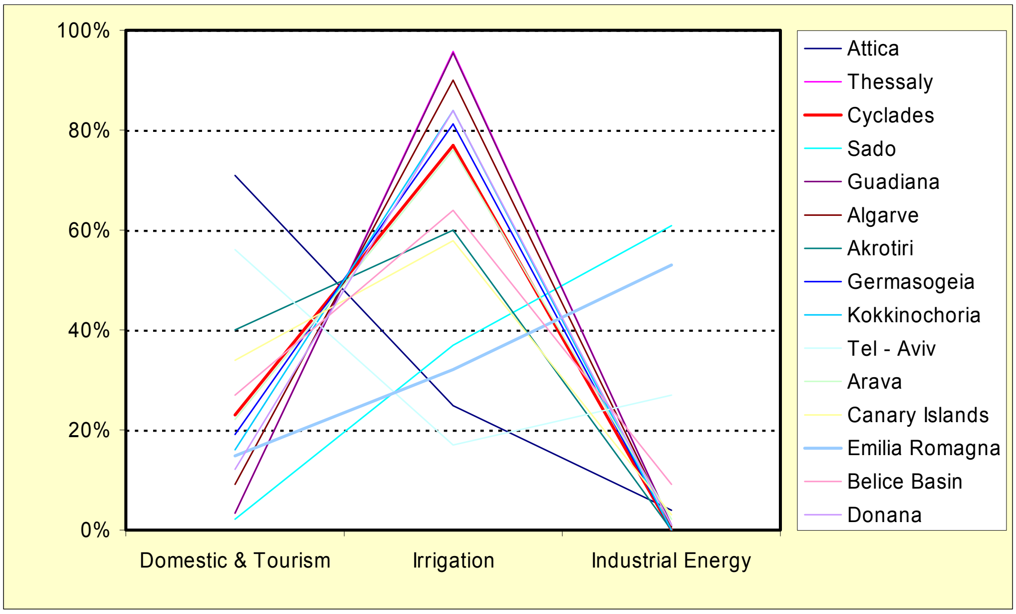

Figure 18. Profile diagram for all regions

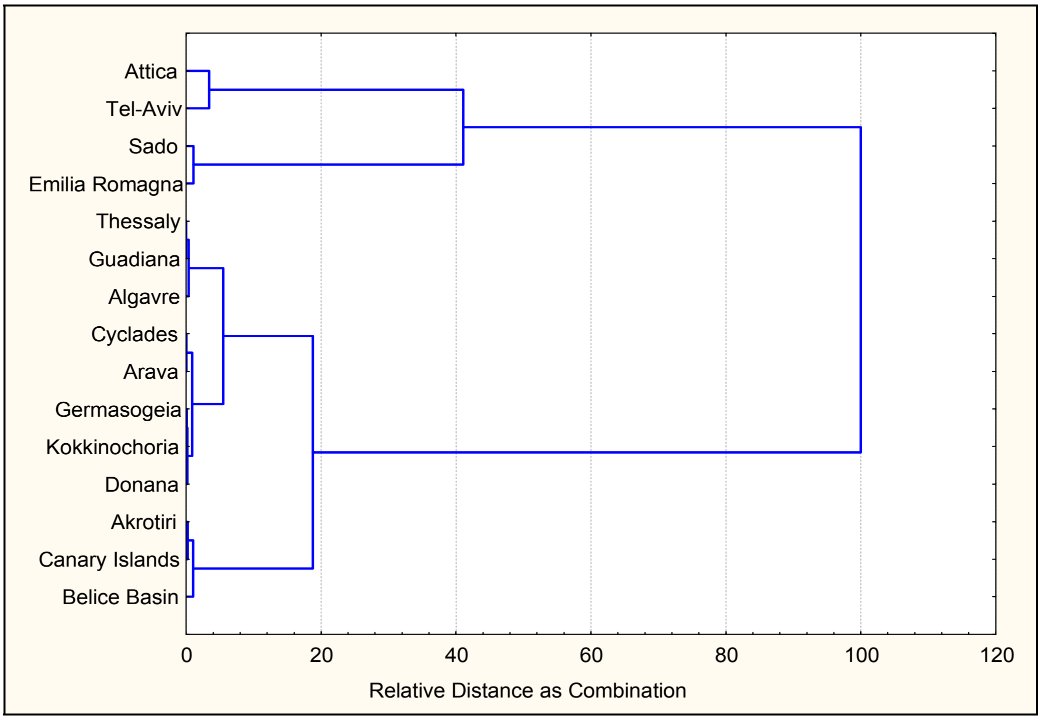

Figure 19. Dendrogram obtained for classification according to the sectoral water consumption

Figure 19 displays the dendrogram of the hierarchical cluster analysis, calculated using the Ward's agglomerative procedure and squared Euclidean distance as the distance measure. It is clear that four main clusters are formed:

- **Cluster 1** includes two regions (Attica and Tel-Aviv).
- **Cluster 2** includes two regions (Sado and Emilia Romagna).
- **Cluster 3** includes eight regions (Thessaly, Cyclades, Guadiana, Algarve, Germasogeia, Kokkinochoria, Arava and Doñana).
- **Cluster 4** includes three regions (Akrotiri, Canary Islands and Belice Basin).

Information essential to the interpretation of results is provided in Figure 20. For each cluster, the mean of each of the three clustering variables is plotted along with the mean of all regions.

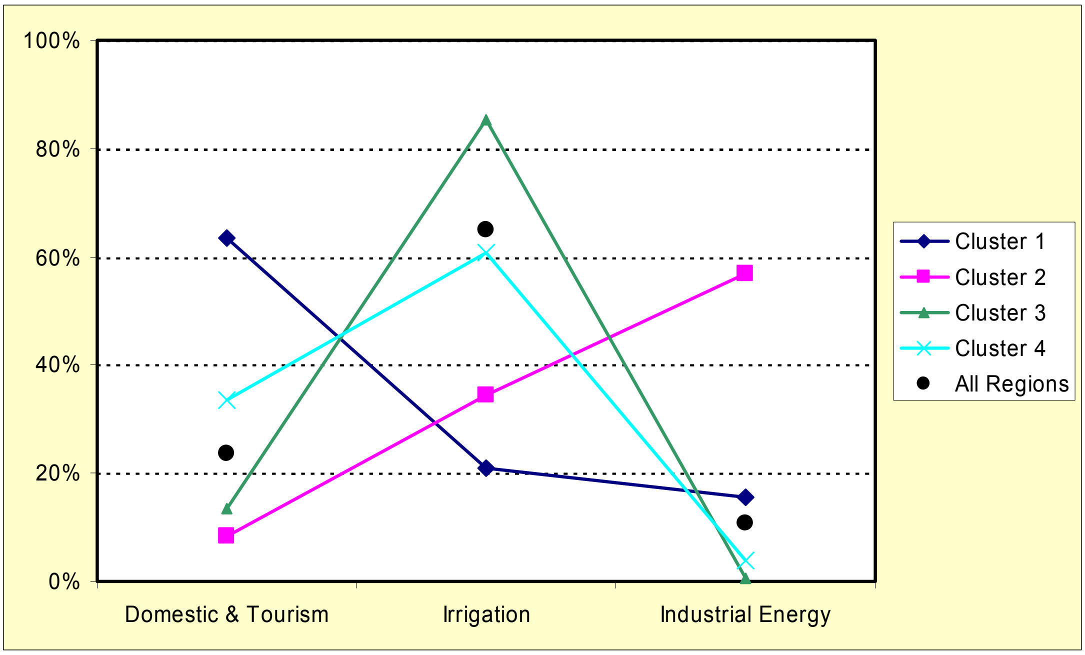

Figure 20. Profile diagram for all clusters on the sectoral water consumption

The following conclusions can be conducted by examining the patterns of the three cluster profiles:

- Cluster 1 is characterized by high values in **domestic** and **tourism** consumption and low values in irrigation consumption.
- Cluster 2 is characterized by high values in **industrial** and **energy** consumption and low values in the other two sectors.

- Cluster 3 is characterized by high values in **irrigation** consumption and low values in domestic-tourism consumption.
- Cluster 4 is characterized by values near the all-regions mean values for all sectors.
- Irrigation is by far the most water-demanding use, with the exception of the regions of the first and second clusters.

These conclusions are summarized in Table 19.

Table 19. Clustering by sectoral water consumption

Cluster	Regions	Major Sector
1	Attica Tel Aviv	Domestic and Tourism
2	Sado Emilia Romagna	Industry / Power Generation
3	Thessaly Cyclades Guadiana Algarve Germasogeia Kokkinochoria Arava Doñana	Irrigation
4	Akrotiri Canary Islands Belice Basin	All sectors

Principal components analysis was performed on the data matrix consisting of the three above quantitative indices. The factor matrix obtained by PCA was subjected to a varimax rotation, with the results summarized in Tables 20 and 21. Only factors with eigenvalues greater than one were considered in the interpretation

Table 20. Summarized results of the principal components analysis for sectoral water consumption, showing loadings and scores on the first two factors

Variable	Factor Loadings		Factor Score Coefficients	
	Factor 1	Factor 2	Factor 1	Factor 2
Domestic-Tourism	-0.062	0.998	-0.222	0.721
Irrigation	-0.707	-0.706	-0.377	-0.377
Industrial-Energy	0.998	-0.063	0.721	-0.222

Table 21. Eigenvalues and variance explained by the first two factors in the principal components analysis for sectoral water consumption

	Factor 1	Factor 2
Eigenvalue	1.874	1.125
Percentage of variance	62.46%	37.49%
Cumulative percentage	62.46%	99.9%

Figure 21 shows a plot of 15 regions on the first two axes extracted by the analysis. . As can been seen from Table 21, the percent variance accounted by the two principal factors (Factor 1 and Factor 2) is 99.9%. The separation of regions into the three groups, as resulted by the cluster analysis, is very clear.

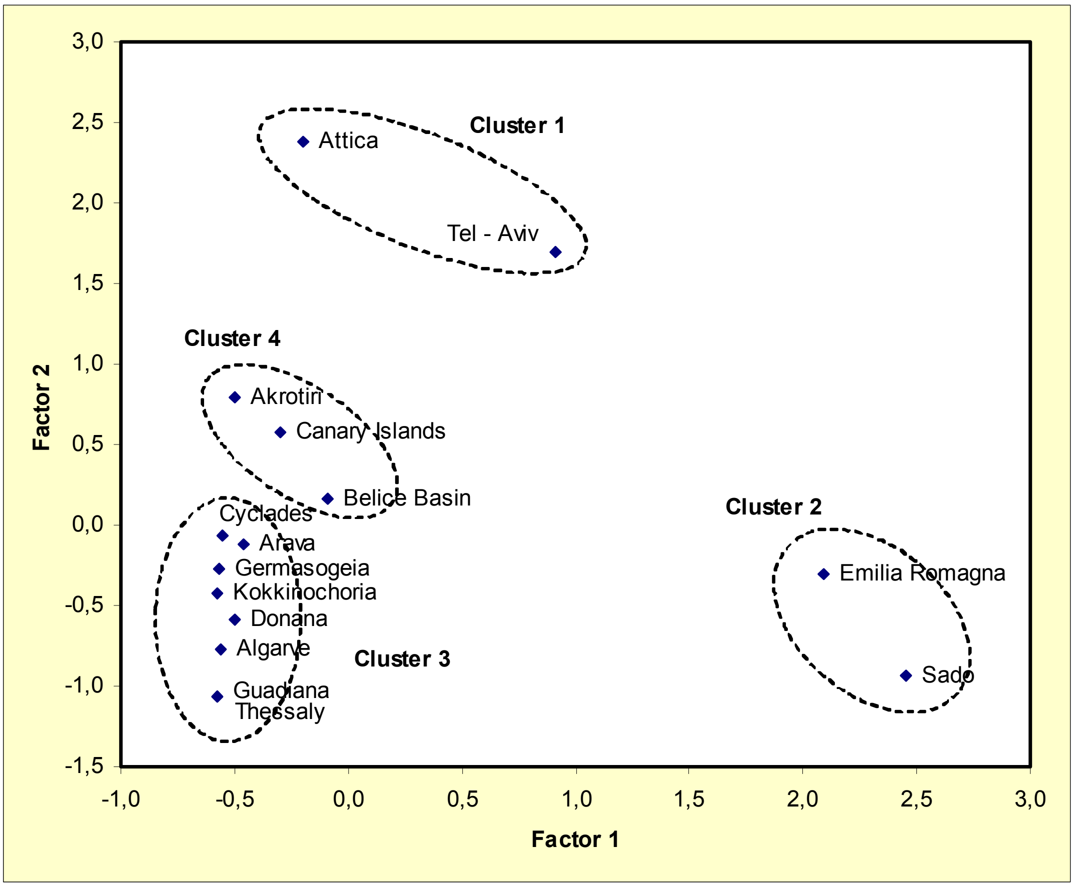

Figure 21 Plot of regions on the first two axes extracted by principal components analysis

According to the factor loadings, presented in Table 20, Factor 1 is highly correlated with the indicators representing the percentage of water consumption in irrigation (negative correlation) and industry-energy (positive correlation) sectors, while Factor 2 is highly correlated with the indicator representing the percentage of water consumption in domestic-toutism (positive correlation) and irrigation sectors (negative correlation). According to these remarks, the interpretation of clusters shown in Figure 21 is in agreement with the conclusions conducted by the cluster analysis.

3.4. A classification based on Responses to the Drivers and Pressures

The term "Responses" in the context of the DPSIR framework applies mostly to long-term management actions. These generally aim at adjusting or mitigating the pressures and impacts caused by the human environment, but are rarely able to make an impact on the driving forces. These actions form parts of different Policy Options (Table 22).

The regions can therefore be classified according to the actions selected within each policy option (see Tables 23 to 26 that follow). It is also possible to see the policy options selected in each region.

Table 22 Responses to water deficiency – Policy Options and Actions

Policy options	Actions
Supply Enhancement	Exploitation of unconventional/untapped resources Exploitation of existing resources Water production Importing
Demand Management	Quotas Irrigation improvements Conservation measures Recycling Improve infrastructure Water Reuse Raw material substitution and process changes
Social – Developmental Policy	Change in agricultural practices Change in regional development policy
Institutional Policies and other	Institutional Capacity Building Economic Policies Environmental Policies

Regarding Supply Enhancement actions, it is obvious that all regions do utilize such actions. Also, it should be noted that Water Production as an action is only utilized in four out of the 15 regions.

Table 23 Responses involving supply enhancement

Type	Response	Regions
I	Water transfers	Attica Cyclades Thessaly Belice Tel Aviv Kokkinochoria Sado Algarve Canary Islands
II	Exploiting existing resources	Cyclades Thessaly Germasogeia Emilia-Romagna Belice Sado Guadiana Doñana
III	Water production	Cyclades Tel Aviv Arava Akrotiri

Similarly, for Demand Management options, it is obvious that only two of the regions use Quotas as a tool for demand management, whereas none of the three Greek Regions or the Canary Islands applies such actions.

Table 24 Responses involving Demand management

Type	Response	Regions
I	Irrigation improvements	Emilia-Romagna Belice Sado Guadiana Algarve Doñana
II	Quotas	Akrotiri Germasogeia
III	Water reuse	Kokkinochoria Tel Aviv Arava Emilia-Romagna Belice Sado Algarve

Few of the Regions analyzed utilize Social and Developmental policies in water resources management. Of those, only in Germasogeia is there the option of a change in the Regional Developmental Policy. Agricultural practices changes are only employed in the other two Cypriot Regions, in Emilia-Romagna, Arava and Doñana.

Table 25 Responses involving social and developmental policies

Type	Response	Regions
I	Change in regional development policy	Germasogeia
II	Change in agricultural practices	Emilia-Romagna Arava Akrotiri Kokkinochoria Doñana

Finally, Institutional Policies are not used in the Cyclades, Belice and the Canary Islands, whereas all other Regions, with the exception of Doñana, utilize Economic policy actions.

Table 26 Responses involving Institutional policies

Type	Response	Regions
I	Economic Policies	Attica Thessaly Emilia-Romagna Tel Aviv Arava Akrotiri Germasogeia Kokkinochoria Sado Guadiana Algarve
II	Environmental Policy	Thessaly Tel Aviv Germasogeia Akrotiri Kokkinochoria Doñana Emilia-Romagna
III	Institutional Capacity Building	Kokkinochoria Doñana

3.5. Conclusions - a proposal for Paradigm building

The present research effort aims in ultimately developing and evaluating strategies and guidelines for an integrated water resources management that takes into account:

- **economic,**
- **technical,**
- **social,**
- **institutional/political and**
- **environmental** implications.

This is attempted through the determination of the distinguishing parameters that affect water deficiency and their interactions; the evaluation and formulation of strategies suited for water deficient regions will be attempted through the understanding of these processes.

To that effect, the approach for the formulation of the Typology of the regions, indices and indicators were analyzed that address those specific issues; taking into account:

- The nature of the water deficiency,
- The water supply sources
- The population, as they interact with, and shape, the natural environment,
- The economic activities in the area, and how they relate to water consumption,
- The social conditions in the area, and
- The current management of the water sector and the resource.

The ultimate aims of the formulation of this Typology approach can be summarized as follows:

- To enhance the understanding of the range of circumstances that occur in the analyzed regions,
- To enhance the understanding of differences in types of water scarcity that are faced in different regions,
- To highlight the critical variables of vulnerability of the surrounding environments that affect water availability and water management,
- To develop a classification scheme of types of scarcity and responses using critical variables and important interrelationships of these variables, and
- To generate a typology of regions, in order to reduce the excessive number of individual cases and allow for generalizing across meaningful categories.

In the aim to develop policies more sensitive to those particular ecosystems, an issue that is of major importance is the creation of **conflicts** among uses under the conditions of water scarcity. The nature of these conflicts is shaped by the interactions of economic activities of the area; these directly influence the **allocation** of water among uses, which at the present state is determined by each country's water policy.

Furthermore such conflicts contrast an existing or "real" management framework in the various areas with a proposed "ideal" or more comprehensive management approaches. The "ideal" may also be considered as the new "paradigm" for changing circumstances in a complex, demanding and fast evolving social and economic environment. By comparing the "ideal" with the real water resources management situation, it may be deduced that in all the cases the existing framework should deviate from the ideal one. Such a divergence may question the efficiency and effectiveness of the existing applied policy actions. Thus, the primary task of a holistic water resources management policy would be to bridge the gap between the ideal and the real conditions. Policy options should concentrate on minimizing such a gap before it becomes chasmic through time Therefore, while the above arguments summarize, more or less, the character of water resources management policy options, such options may focus on the following:- towards the development of an water resources policy with a long-range time horizon for complex spatial and organizational systems such as the presented ones; -and the application of effective water resources management schemes as a result of the above action.

More specifically, the formulation of policies for the integrated management of water resources should take into account the **opportunity costs** incurred by the water deficit to each use, and produce rationalistic allocation alternatives that minimize those costs.

Under this light, the social and economic conditions that occur in the regions analyzed become increasingly important, as it is those that will shape the conflicts that will invariably arise under shortage conditions.

In a synthesis of the classification approaches followed, three main types within the 15 regions can be distinguished based on Social and Economic criteria, summarized in Table 27 that follows. These three types concentrate the few characteristics that appear to be consistent throughout similar Regions.

This classification may be used for the selection of representative regions for Case Studies, for which Water management strategies will be developed and evaluated.

Table 27 Generalized Typology of Regions

Type	Distinguishing Characteristic	Description	Representative Regions

I	**Predominantly Urban**	• Regions including metropolitan/large urban centers.
		• Main economic activities largely belong in the tertiary sector, although secondary sector activities are also present.
		• Water deficiency is either:
		  o permanent, due to insufficiency of resources for the existing population, or
		  o seasonal due to meteorological / hydrological fluctuations.
		• Some price elasticity in water supply.
			Attica
			Tel-Aviv
			Emilia -Romagna

II	**Predominantly Tourist**	• Regions dependent on tourism, with small to medium sized urban centers and large seasonal population fluctuation. • Dependence on agriculture as well but the main source of income is tourist activities. • Seasonal water deficiency as a result of the population fluctuations due to the tourist industry's peak in the summer months. • Price elasticity is variable, depending on the local conditions.	Cyclades Canary Islands Algarve Akrotiri Doñana
III	**Predominantly Agricultural**	• Regions dependent on agriculture, with small to medium sized urban centers and limited population fluctuation. • Dependence on secondary and tertiary sector activities is often limited compared to agriculture, which is the main source of income. • Usually seasonal water deficiency as a result of increased crop requirements of water in the summer time. • Price elasticity is variable, depending on the local conditions.	Germasogeia Kokkinochoria Arava Belice Basin Sado Guadiana Thessaly

Closing comments

The objectives of this document, the Deliverable on the **"Systematic typology of comprehensive problematique"**, were, as stated in the Summary:

- To **present the regions** selected and analyzed in each country. The regions were presented in Annex I, where there are descriptions of each region selected.
- To illustrate the **commonalities**, **similarities**, **differences** and **gaps** among them. The comparative presentation of the region characteristics is effected in Sections 3 and 4 of the document.
- To develop a **classification scheme**. The classification scheme is presented in the Introduction of this document, as it is used towards the typology formulation.
- To formulate a **typology of regions** in terms of Drivers and Pressures leading to water deficiency, and Responses to these. The Typology should determine the interactions of the Natural Environment and the Human Interventions. The Typology is presented in the Conclusions of the Deliverable, where a final classification scheme is proposed and the regions are assigned to the emerging groups.

Following the identification of the existing Paradigms in water resources management, the Typology will be used for the selection of regions representative of each group, which will be analyzed in the Case Studies.

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Annex I - Regional Reports

Table of contents

I.1. Regional reports for Greece

I.1.1. Selecting the Regions

For the process of selection of regions, the aridity and socioeconomic characteristics of the Greek regions were investigated. Figure 1 illustrates the aridity indices in the different Hydrological basins in Greece. Three particular regions emerged as the most arid:

- Attica,
- Thessaly, and
- The Aegean islands and the southern part of Crete.

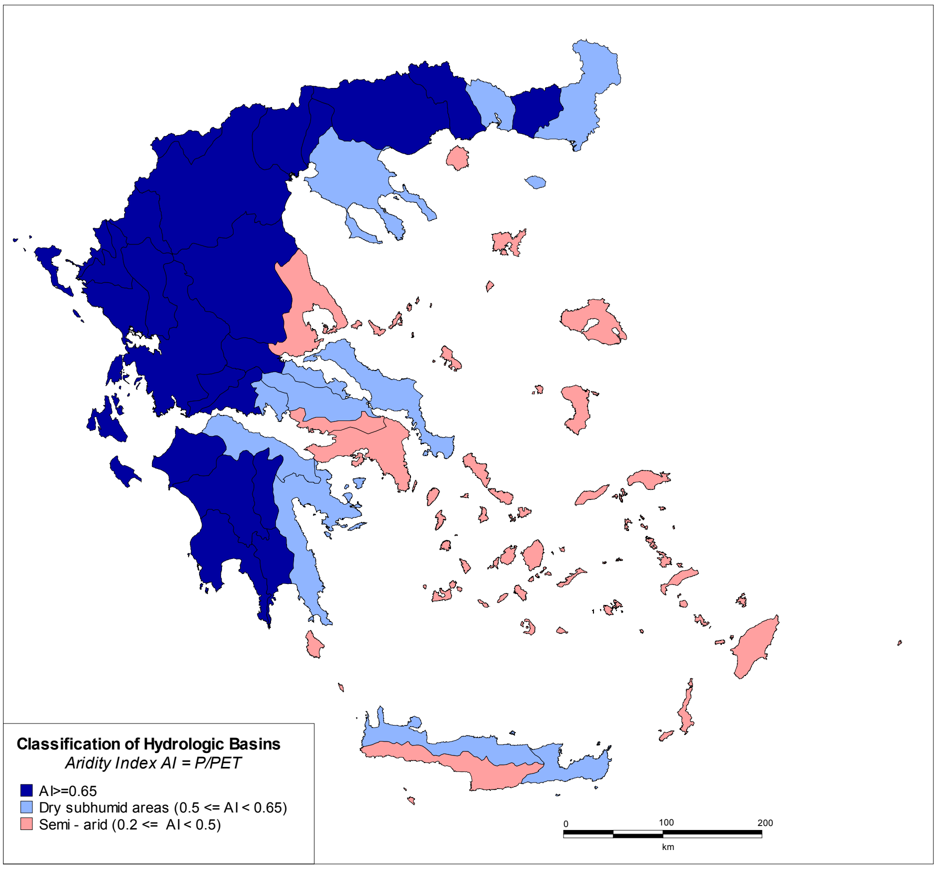

Figure 1. Aridity Index in Greek Hydrological basins

Figure 2 shows the regions selected. The selection of these candidate regions was based on the water deficiency and aridity of the area, as mentioned above, but also on its social and economic characteristics. Each one of these three regions suffers water deficits for a different reason, which makes them good candidates for study:

Attica, the area that hosts over half of the country's population in the Capital city and the surrounding areas, suffers water deficits because of the permanent population size, which is too big for the available local water resources to cover. Water for the supply of the capital city originates mostly in other Water Regions, as the underground aquifers of Attica – not adequate since ancient times – are overall polluted and eutrophic. The water deficit in this case is permanent and caused by increased domestic demand.

The Thessaly plains are intensively cultivated, requiring large amounts of irrigation water. As has already been mentioned, large amounts of water are used for irrigation in Thessaly that could be drastically reduced by the introduction of more efficient irrigation networks and a more organized approach to the selection of crops. The water deficit in this case is seasonal, and caused by demand for irrigation.

The Cyclades islands attract large numbers of tourists in the summer months, which steeply increase the water demand to the point that it cannot be covered by the existing infrastructure and water resources. During the summer months, water demand reaches its peak both for irrigation, and for domestic supply; in some islands the summer peak may reach up to thirty times the permanent population, while water resources are very limited. The water deficit in this case is seasonal, and caused by an influx of tourist population, while there are severe conflicts with use of water for irrigation purposes.

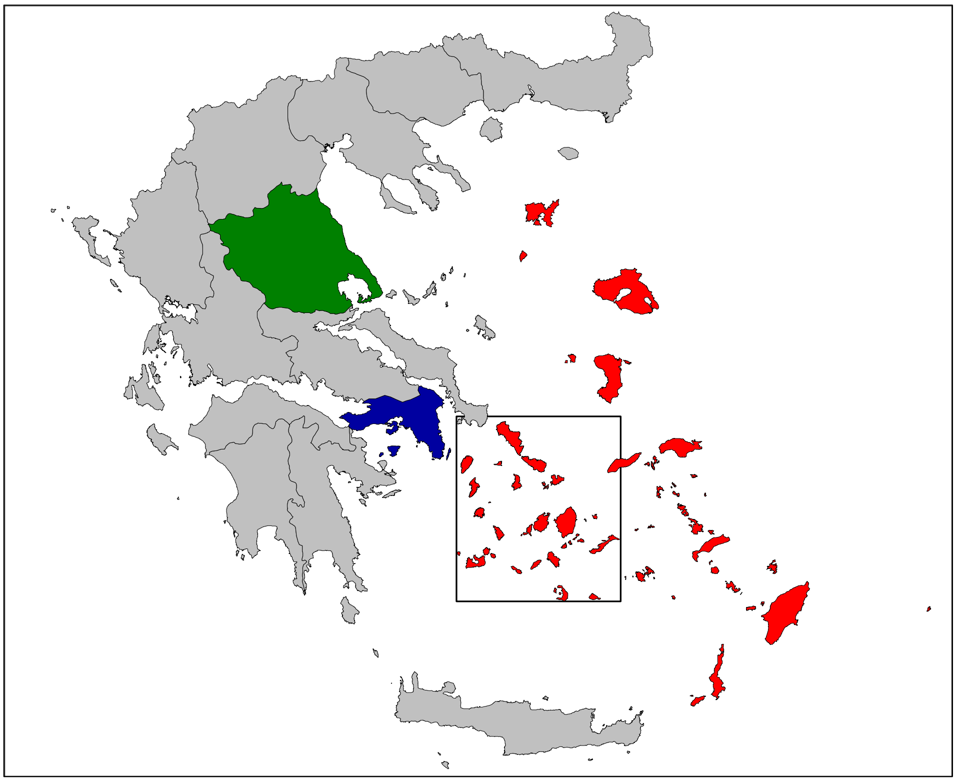

Figure 2. The Candidate Regions selected

I.1.2. Attica

The Water Region of Attica covers an area of 3,207 km^2. The region has several mountains (Parnitha, Kitheronas, Penteli, Imitos, Egaleo, Pateras) and plains on the coastal zone. The mean elevation is 115 m. It also includes a few islands, major ones being Egina, Salamis and the uninhabited Makronissos and a small part of Sterea Ellada (Voiotia) and Peloponnesus.

Attica borders Sterea Ellada to the north, Peloponnesus to the south, its eastern shoreline is on the south Evoikos Gulf and the Aegean and its western shoreline is on the Saronikos Gulf.

The two main rivers are Illissos and Kifissos, which in the urbanized areas have been transformed into covered stormwater conduits and drain into Saronikos Gulf. Their drainage basin covers 320 km^2. There are two small natural lakes, Vouliagmene and Koumoundourou. None of the drainage basins in Attica is larger than 600 km^2. The reservoir of Marathon, which is used for the water supply of the metropolitan Athens area, is located in the drainage basin of the Charadros River (185 km^2). The capacity of the reservoir is 41 hm^3.

Table 1. Surface of the drainage basins in Attica

Drainage Basin	Surface (km^2)
Attica's Kiffisos River – Illissos River	320
Sarantapotamos River	310
Charadros River	185

The climate is Mediterranean continental. The average temperature is 16 – 18°C. The average annual rain height is 400 mm, ranging from less than 400 mm in the south coastal areas, to 600 mm at the mainland and 1,000 mm on the mountains. Rain occurs 50 to 100 days per year. The precipitation is 1,698 hm^3/yr and the total runoff 259 hm^3/yr. Snowfall is very rare at the coastal areas but occurs on the mountains from October to April.

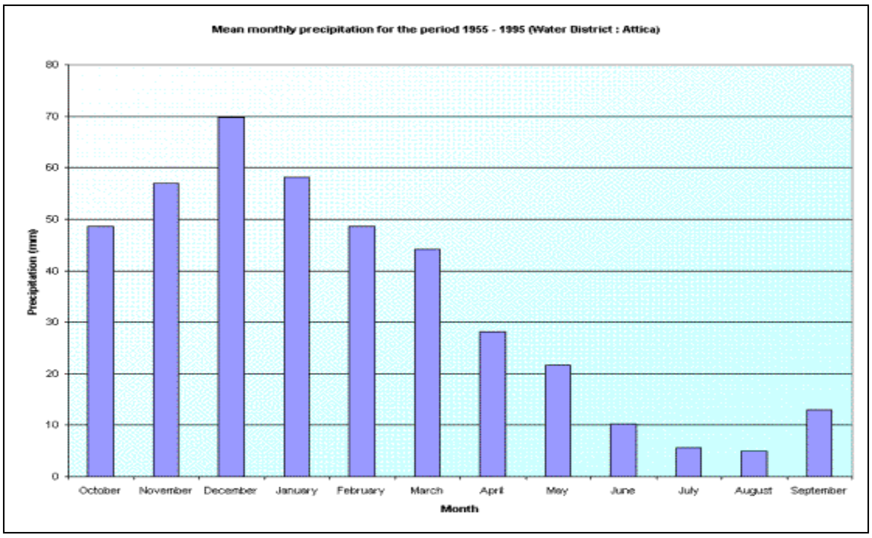

Figure 3. Mean monthly precipitation for the period 1955-1995 in Attica

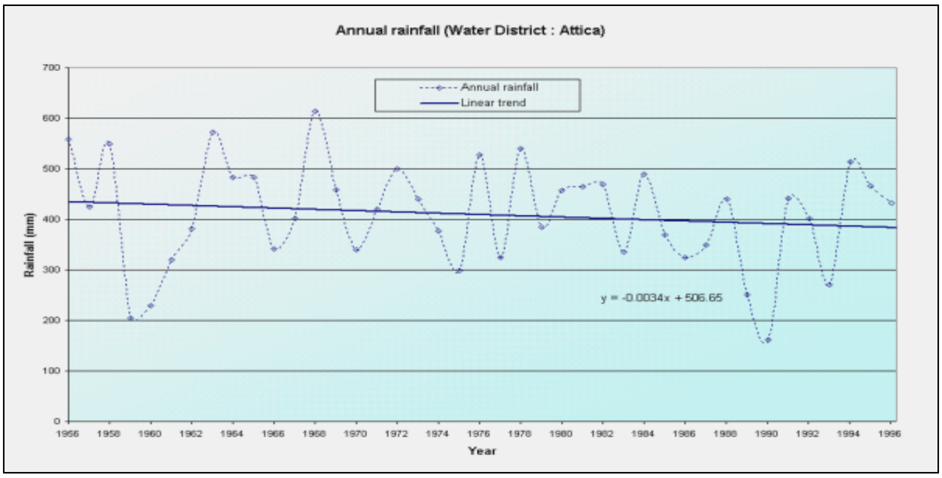

Figure 4. Annual rainfall in Attica

Permeable geological formations cover a significant amount of the total area. Karstic limestone formations cover the east and west part of the region. The total water availability is about 449 hm^3. This amount consists of 259 hm^3 surface water and 190 hm^3 potential groundwater. The groundwater can be found in the karstic and alluvial aquifers of the Region.

Table 2. Hydrological Entities of Attica

Hydrological Entities	Surface (km^2)	Total Runoff (hm^3/yr)	Potential Groundwater (hm^3/yr)
Karstic entities in limestone formations			
South Parnitha – East Pateras - Egaleo	510	157	120
Kitheronas	260	75	50 - 70
Gerania	250	42	20
Penteli	250	55	30
Ymitos	110	15	30
Northeastern Parnitha	300	95	60
Total		439	250 - 270[1]
Alluvial aquifers			
Athens	440	30	5
Mesogeia	820	50	15
Megara	260	15	3
Loutraki	320	20	4
Total		115	27

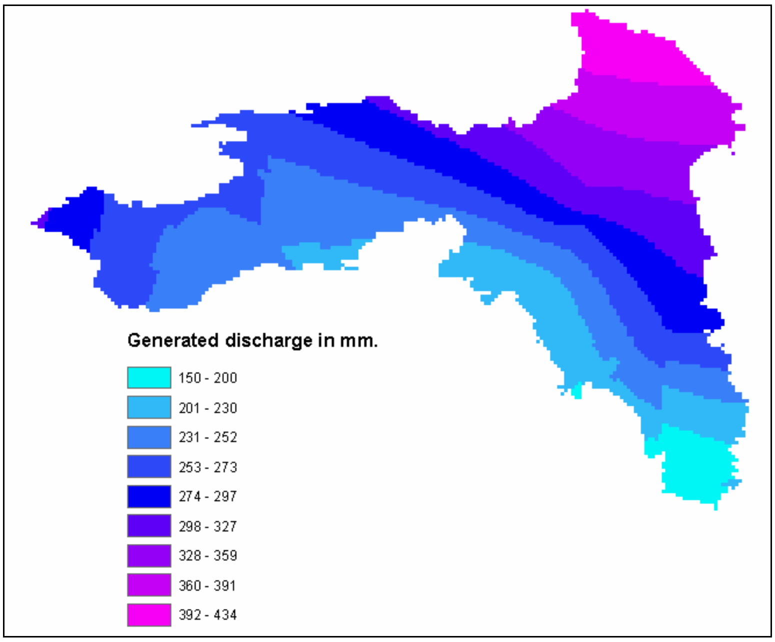

Figure 5. Generated discharge in Attica

[1] Northeastern Parnitha not included as it discharges in the Water Region of Eastern Sterea Ellada

There is no systematic monitoring of surface water quality in Attica, but as rivers are the recipients of unprocessed wastewater, they are generally in poor condition and their exploitation is unattainable. The treatment plant of Psytalleia treats 80-90% of the produced domestic wastewater. Many of the industries use the sewage system as well, but some others, through illegal connections, throw their waste directly into rivers and torrents or into the sea, which results the diminution of the quality of surface and ground water.

Results for ground water show that nitrates exceed the critical load for drinking water. In certain areas with significant industrial activity, high concentrations of heavy metals occur.

The main pollutant loads produced in Attica for the year 1996 were estimated as:

- BOD5: 120,000 ton/year
- TSS: 420,000 ton/year
- Total nitrogen: 20,000 ton/year
- Total phosphorus: 8,000 ton/year

Attica has 3,761,810 inhabitants (2001). It includes the capital district, and small parts of Sterea Ellada and Peloponnesus Region. The main economic activities are commerce, industry, agriculture and tourism. The region produces 36% of the GNP, while the per capita product is €12,560, and the mean declared income per inhabitant was €6930 in 2000. The unemployment rate in the region is 10.4%. The total annual water demand is 408 hm^3, consisting of 289 hm^3 for domestic use, 101.5 hm^3 for agricultural use and 17.5 hm^3 for industrial use. The consumption index is estimated to be equal to 69% and the population to water resources index is equal to 4494. The exploitation index is 49%.

In order to satisfy the demand, a significant amount of water is imported from the Hydrological Department of West Sterea Ellada (Rivers Mornos and Evinos), and from the Hydrological Department of East Sterea Ellada (Lakes Iliki and Paralimni).

Desalination plants are used to cover industrial demand.

The supply of water and wastewater services is effected by EYDAP S.A., the biggest water company in Greece, and hence the cost recovery for water services in this region is good, and the pricing of water is done on the basis of the services provided and is not subject to political pressures. Attica is the only part of Greece where demand management through pricing control has been effective, in the drought periods in the 1990's. As a consequence, public education on water conservation issues is on average better than in most other regions of the country, although there is little to no public participation on water-related decisions. Decision making regarding water issues in Attica is effected on the national level, as the region is under the direct control of the Ministry of the Environment.

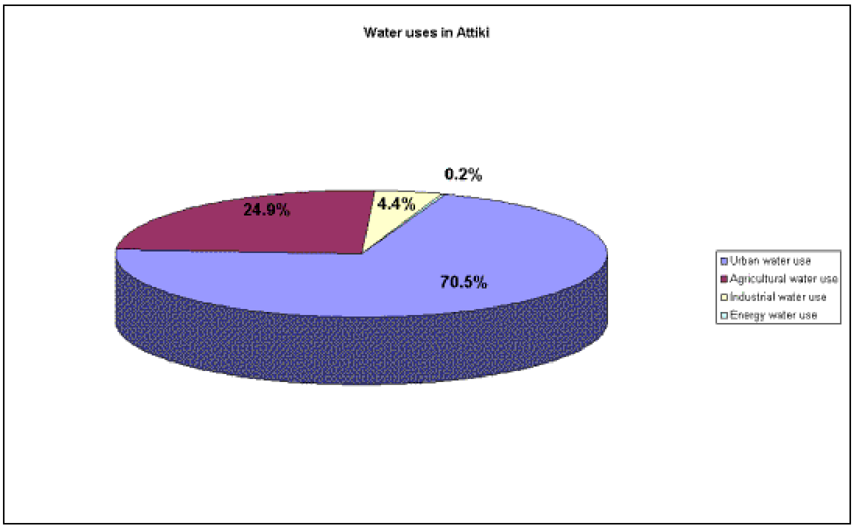

Figure 6. Water uses in Attica

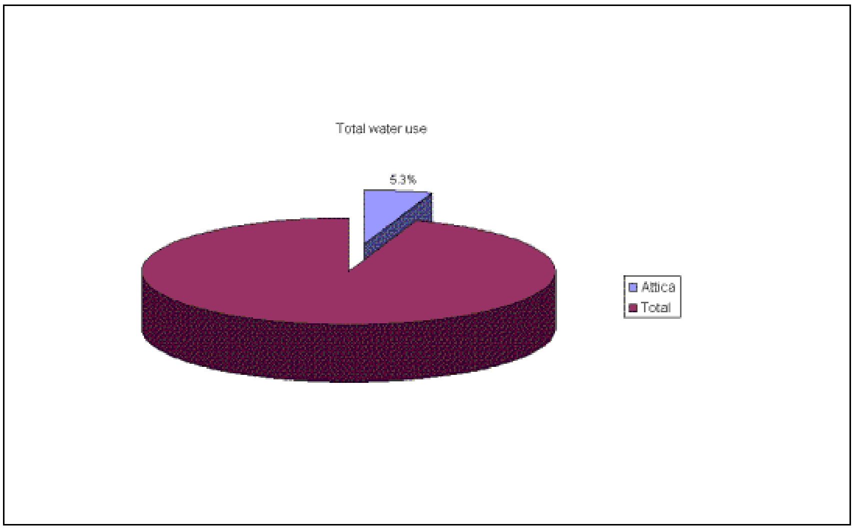

Figure 7. Percentage of the total water use in Attica in proportion with the water use in the country

I.1.3. Thessaly

The fertile plain of Thessaly water region covers an area of 13,377 km^2 that occupies the central section of mainland Greece. It is surrounded by high mountain ranges with altitudes more than 2000 m (Pindus, Olympus, Pelion, Othrys, Ossa and Agrapha), encircling a low plain. The River Pinios, coming down from the western slopes of Pindus, cuts Thessaly in two, passes through the valley of Tempi and meets the sea. Thessaly borders Macedonia to the north, Sterea Ellada to the south, Epirus to the west, and its eastern shoreline is on the Aegean. It has the highest percentage of flat land in Greece and the mean elevation of the area is 285 m.

Among the mountains flows the Pinios River which drains into the Aegean, after passing through the Thessalic Tempi. The drainage basin of Pinios River is 9,500 km^2 and the main tributaries are the rivers Titarisios, Enipeas, Kalentzis, Litheos and Asmaki. Thessaly District consists also of two more hydrologic basins: the drainage basin of Lake Karla (1,050 km^2), rising at the eastern side of the District and Lake Plastira at the western side. Lake Plastira is a part of the watershed area of Achelloos River which belongs to the West Sterea Ellada Water Region.

Table 3. Surface of the drainage basins in Thessaly

Drainage Basin	Surface (km2)
Pinios River	9,500
Lake Karla	1,050
Other Basins	2,812
Total	13,362

The climate is Mediterranean continental. Winters are cold, summers are hot, with a large temperature difference between the two seasons. The average temperature is 16-17oC. The average annual rain height is 700 mm, ranging from 400 - 600 mm at the central plains, to 600-1000 mm on the eastern part and over 1,200 mm on the mountains. Rain occurs 100-130 days per year. The precipitation is 10,426 hm^3/yr and the mean annual relative humidity is 67% - 72%. Snowfall is very frequent on the mountains.

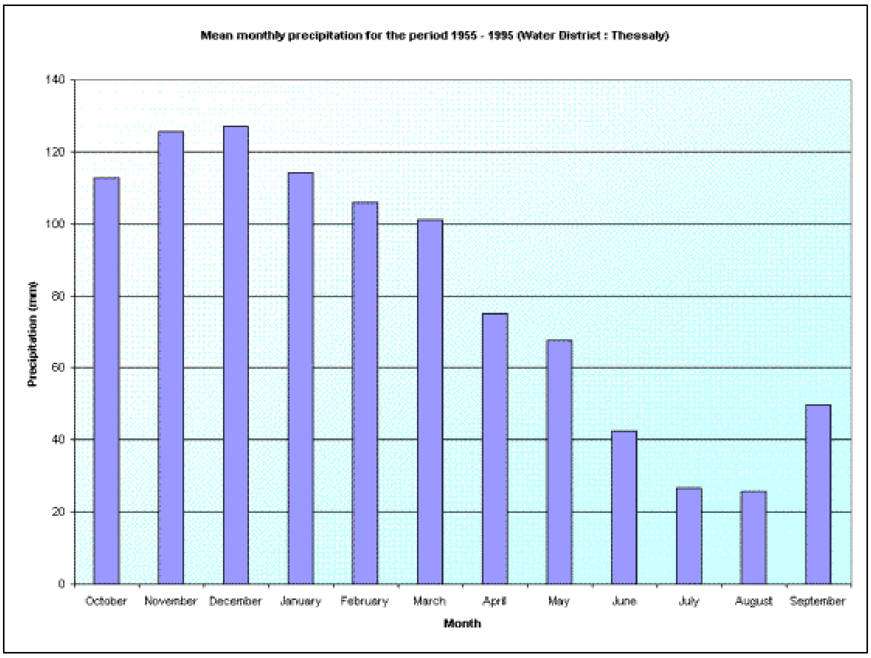

Figure 8. Mean monthly precipitation for the period 1955-1995 in Thessaly

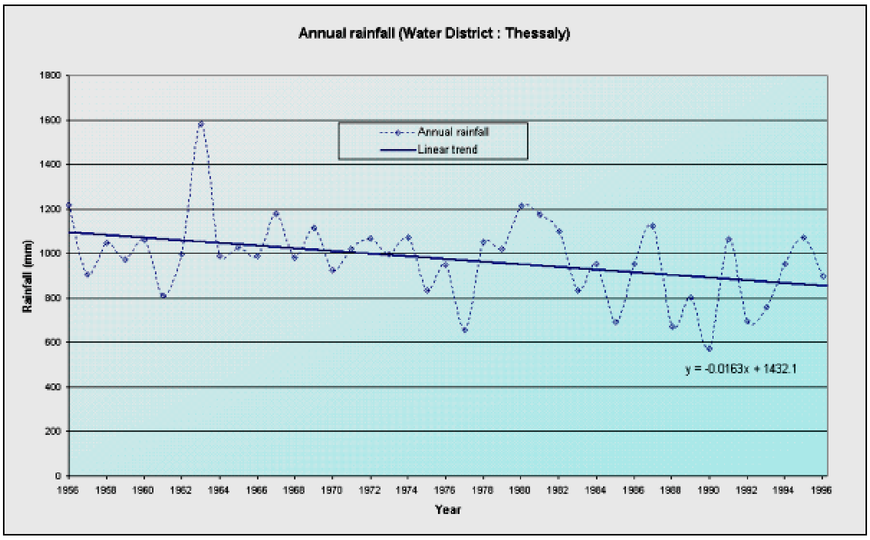

Figure 9. Annual rainfall in Thessaly

Impermeable geological structures cover 39.4% of the total area; karstic aquifers cover 16.2% and permeable structures which occur mainly on the plain cover 44.4%. The total water availability is about 3,094 hm^3. This amount consists of 2,558 hm^3 surface water and 506 hm^3 groundwater. The groundwater, which can be found in the karstic and alluvial aquifers of the District and the entire plain, consisting mainly of Neogene sediments, is fed from Pinios River and the tributaries, as well as from direct rainfall infiltration.

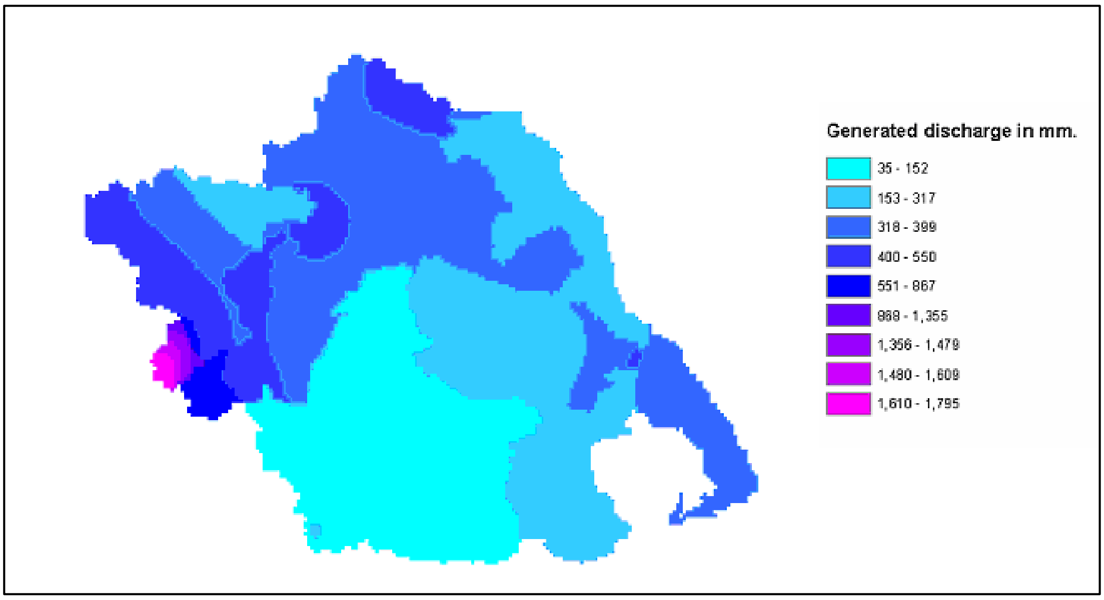

Figure 10. Generated discharge in Thessaly

According to monitoring results, surface water quality in Thessaly is generally in a good condition. The nitrites concentrations in a few sampling points exceed the limit values for drinking water, due to the cultivation carried out to serve agriculture in the specific areas of the drainage basin. In few of the sampling points, results for pesticides show elevated levels. Although urban waste loads in the water are significant, urban waste water treatment plants in the major cities of Thessaly ensure that the water quality remains good. The treatment plants constructed in all the major cities of the area are efficient enough and 45% of the population of the area (80% of the urban population) were connected to the public sewer network in 1998.

Results for ground water show that in many cases nitrates and in some cases ammonia exceed the critical load for drinking water. Because of this, the Thessaly plain is designated as a vulnerable zone (Joint Ministerial Decision 19652/1906/99), in order to take the appropriate measures for the protection of the area. The elevated nitrate and ammonia levels are attributed to agriculture and animal husbandry practices.

The main anthropogenic pressures observed in Thessaly are caused by loads coming from agricultural and breeding activities and from the urban wastewater. Non-point source loading from agriculture and animal husbandry in the area is significant. Cultivated areas are spread all over the plain areas and the land-application of all nitrogen-containing fertilizers enriches the watercourses causing significant pollution trends.

Pollution trends caused by industrial activities are not significant because of the limited industrial production. Pollution loads from industry are most abundant in Larissa and Volos where industrial units concentrate, and are particularly visible in the coastal waters of the region.

The main pollutant loads produced in Thessaly in 1996 were:

- BOD5: 51,740 ton/yr
- TSS: 66,670 ton/yr
- Total nitrogen: 37,920 ton/yr
- Total phosphorus: 3,750 ton/yr

Thessaly has 753,848 inhabitants. The biggest cities in the area are Larissa and Volos (total population for both cities 300,000). The main economic activities are agriculture, industry and tourism. The region produces 6.3% of the GNP, while the per capita product is €10,950, and the mean declared income per inhabitant was €3550 in 2000. The unemployment rate in the region is 12.2%. Total annual water consumption is 1,171 hm^3, consisting of 65 hm^3 for domestic use, 1.060 hm^3 for agricultural use and 46 hm^3 for industrial use. The consumption index is estimated to be equal to 38% and the population to water resources index is equal to 204. The exploitation index is 31%.

Irrigated agricultural land occupies 1,894 km^2. Water shortage problems occur during the irrigation period, while in the winter floods occur in large areas. Other significant uses for the watercourse are for animal breeding and aquaculture.

The coastal zone in the area is a favourite destination for many tourists during the summer, and so water supply requirements increase during the summer tourist period. The annual water demands for domestic use and for tourism are about 53.7 hm^3, and the areas with the higher water supply requirements are the municipalities of Larissa and Volos.

Lake Plastira, with a storage capacity of 400 hm^3, is regulated for hydropower production. The installed hydropower capacity is 141 MW and the power plant produces a total of 250 GWh. Industrial activities are limited in the cities of Volos and Larissa, and they are related mainly to food processing, textile works and iron and steel production. As mentioned above, water demands for industry are not remarkable. Thessaly has a dense network of motorways and a harbour in Volos that serves the entire area.

Water supply in the region is not regulated by a single authority. The larger cities each have their own water and wastewater services providers, but there is a number of independent local services, where the services are mostly affected through the municipalities. Thus, the pricing of water is a subject of political pressures. Public education for water conservation is limited, and cost recovery is, on average, with the exception of the larger cities, poor.

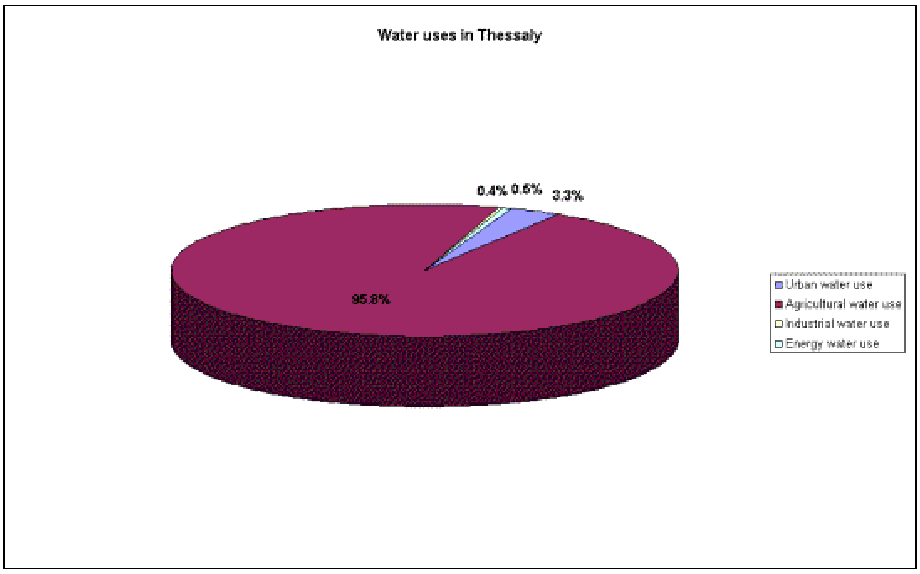

Figure 11. Water uses in Thessaly

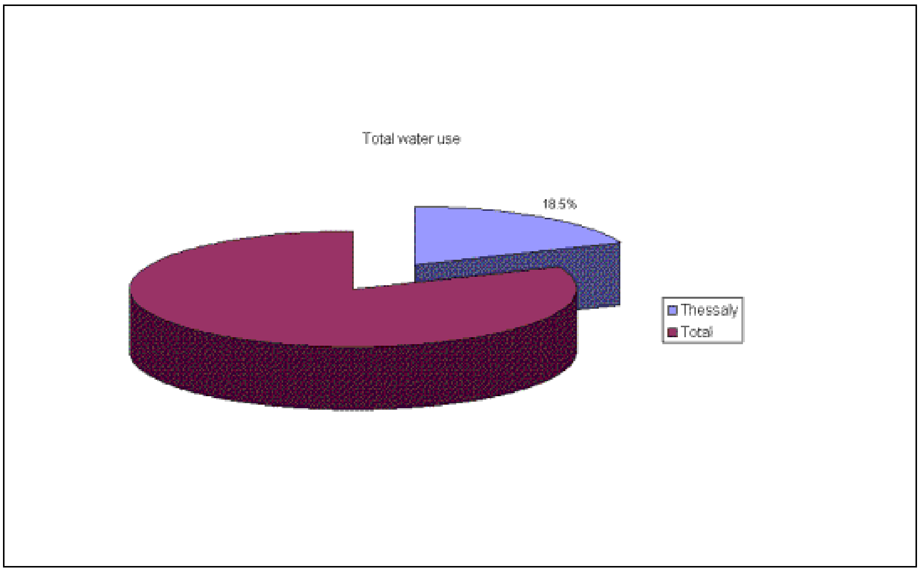

Figure 12. Percentage of the total water use in Thessaly in proportion with the water use in the country

I.1.4. Cyclades Islands

The Water Region of Cyclades covers an area of 2,553 km^2. The region consists of 24 inhabited islands, and is characterised the fragmentation in several smaller units with different climatological, hydrological and geomorphological parameters. The islands are semi-mountainous with plains and the mean elevation level is 160 m. There are no important rivers due to the small size of the islands, except for some torrential ones. Surface water is very limited on this area.

The climate in general is temperate Mediterranean but it varies on each island according to the geographical position, the size and the distance from the mainland. The average temperature is 16.5 – 19.5 °C. The average annual rain height is 379 mm for the central and southern islands (Naxos meteorological station) and 349 for the northern islands (Athens meteorological station). The precipitation is 902 hm^3/yr. The total estimated runoff is 156 hm^3/yr. The amount of evapotranspiration is estimated to be equal to 667 hm^3.

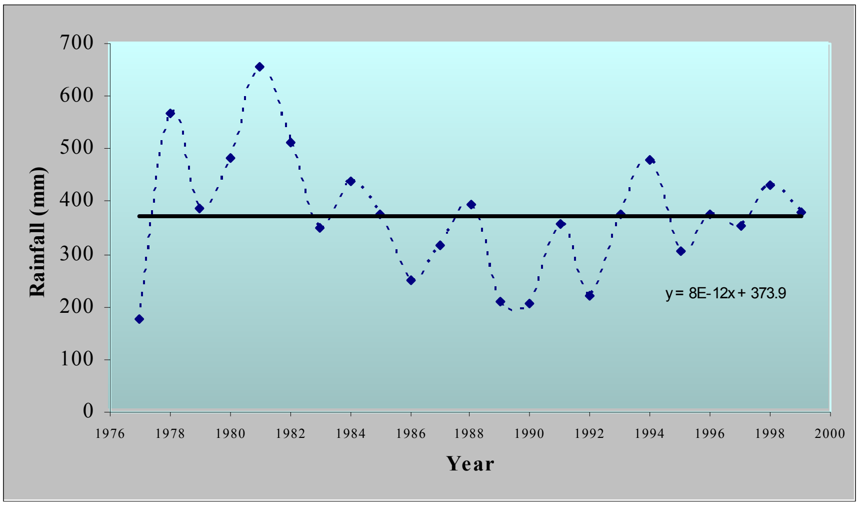

Figure 13. Annual rainfall in Naxos Meteorological Station

The geological formations that appear on the islands vary significantly. Metamorphic rocks cover large part of the complex. Limestone formations are very limited, whereas volcanic rocks appear on the islands Thira, Milos and Kimolos. The total water availability is about 212 hm^3. This amount consists of 156 hm^3 surface water and 55 hm^3 potential groundwater. The groundwater can be found in the karstic and grainy aquifers of the District. Due to the small size of the islands, springs are accordingly small and in many cases problems of brackish water occur.

There are no monitoring results for surface water quality in Cyclades. The most important sources of pollution are agriculture and animal husbandry and domestic wastewater. Similarly, results for groundwater quality are scarce as well. The underground aquifers are often subject to saline intrusion due to their overabstraction.

The main pollution loads produced in Aegean Islands in 1996 were:

- BOD5: 8,000 ton/year
- TSS: 9,500 ton/year
- Total nitrogen: 3,400 ton/year
- Total phosphorus: 500 ton/year

The Cyclades have 112,615 inhabitants. The main economic activities are tourism and agriculture. The total annual water demand is 30.95 hm^3, consisting of 7.15 hm^3 for domestic use, 21.5 hm^3 for agricultural use and 2.3 hm^3 for animal husbandry. The region produces 1% of the GNP, while the per capita product is €12,330 and the mean declared income per inhabitant was €4600 in 2000. The unemployment rate in the region is 12%. The consumption index is estimated to be equal to 50% and the population to water resources index is equal to 531. The exploitation index is 15%.

Table 4. Hydrological Data for the Cyclades Islands

Island	Surface (km^2)	Precipitation (hm^3/yr)	Evapotraspiration (hm^3/yr)	Total Runoff (hm^3/yr)	Ground Water (hm^3/yr)
Amorgos	121	45.9	33.89	3.81	8.10
Anafi	38	14.4	10.66	3.64	0.10
Andros	380	144.0	104.75	25.05	2.80
Antiparos	35	13.3	9.77	2.43	1.00
Folegandros	32	12.1	8.88	1.62	1.50
Ios	108	40.9	30.27	10.39	0.24
Kea	131	49.6	36.10	9.50	0.10
Kimolos	36	13.6	10.06	2.24	1.30
Kythnos	99	37.5	27.25	7.15	0.10
Milos	151	57.2	42.33	12.47	2.40
Mykonos	85	32.2	23.83	8.12	0.25
Naxos	428	162.2	120.03	21.72	20.45
Paros	195	73.9	57.76	8.34	7.90
Serifos	73	27.7	20.50	7.10	0.10
Sifnos	73	27.7	20.50	3.00	4.20
Sikinos	41	15.5	11.47	3.23	0.80
Syros	84	31.8	23.53	7.47	0.80
Thira	76	28.8	21.31	5.69	1.80
Tinos	194	73.5	53.48	13.12	1.10

In some islands desalination plants are used to cover water demand and in some others water is transferred with tankers from other water sufficient regions. Several small dams and water tanks have already been constructed and are mainly used for irrigation purposes, while others have been planed and approved to be constructed in the near future.

Water supply in the region is not regulated by a single authority. The larger islands each have their own water and wastewater services providers, but there are a great number of independent local services, where the services are mostly effected through the municipalities. Thus, the pricing of water is a subject of political pressures. Public education for water conservation is limited, and cost recovery is overall poor.

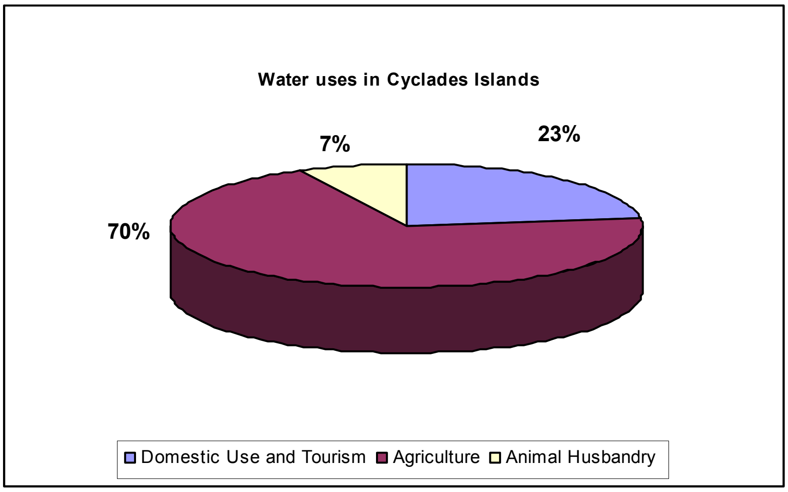

Figure 14. Water uses in Cyclades Islands

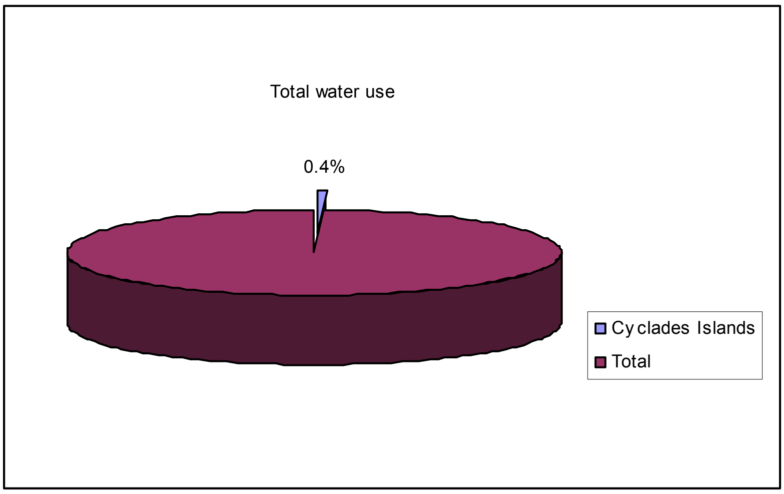

Figure 15. Percentage of the total water use in Cyclades Islands in proportion with the water use in the country

I.2. Regional reports for Italy

I.2.1. Selecting the Regions

Of the Italian Regions examined, the following two emerged as potential candidates for investigation:

Emilia Romagna is one of the largest Italian regions, which hosts several large cities on the plain part, whereas on the mountainous part is thinly populated. The main economic activities are gathered on the plain. Except the urban and industrial development, it has significant agricultural activity. The region also attracts great number of tourists. These parallel activities lead to conflicts between the users over water allocation, environmental degradation and water resources overexploitation.

Belice Basin is located on the island of Sicily. It is an area with intensive agriculture, where low rainfall as well as the inadequate infrastructure and the lack of even water distribution create water shortage problems. Agriculture is the main sector that is affected by this shortage as irrigation demands are not fully covered.

I.2.2. Emilia-Romagna

Emilia-Romagna is one of the largest Italian regions (the sixth), linking the north with the centre of the country. Stretching as far as the Adriatic sea to the east, Emilia-Romagna borders with Veneto to the north-east, with Lombardia to the north and north-west, with Piemonte and Liguria to the west, with Tuscany to the south and with the Marche and the Republic of San Marino to the south-east, and there is close coincidence of administrative and physical boundaries, delineated by easily distinguishable natural features: the Po river to the north, the Apennine ridge separating the Po Valley slopes from the Tuscany-Marche to the south, and the Adriatic coast to the east.

The region is divided into two main portions: Romagna stays at the south-east with the provinces of Forlì-Cesena and Rimini while Emilia consists of the administrative provinces at the west and middle. Almost the half of the territory stays in the Pianura Padana plain, which the Via Emilia separates from the Apennine from the watershed, a series of nearly parallel ridges thrusts outwards towards the plain, progressively decreasing in height, sharply separated from the transverse river valleys. Beyond the extreme outlying hills lie the undulations of the stony upper plain, formed by the fusion of fluvial detritus, beyond which extends the wide fertile alluvial plain. Of the great swamps, which at one time characterised the lower Emilia and Romagna plain before systematic regulation of the waterways, remain only the Valleys of Comacchio and the stretches of water belonging to the Po Delta. Except for the Po River, which flows along the northern boundary of the region, all the water courses flow from the Apennine watershed, cutting parallel down hill before reaching the plain and flowing into the Po (Tidone, Trebbia, Nure, Arda, Taro, Parma, Enza, Secchia, Panaro), or directly into the Adriatic Sea (Reno, Lamone, Savio).

The climate of Emilia-Romagna has sub-continental characteristics, with cold winters and hot summers, moderated, however, by sea breezes along the Adriatic, while the temperatures are closely affected by altitude in the Apennine region. The rainfall is about 800 mm/year and while the evapo-transpiration is around 500 mm.

With regards to population distribution, two zones are easily distinguished: the hills and mountains, thinly populated, and less suitable for economic exploitation, and the plains, characterised by an excellent communication network, the possibility of intensive farming and ideal conditions for industrial development.

Table 5. Water Withdrawals in Emilia-Romagna in 2001 (hm^3)

	CIVIL MUN.	INDUSTRIES	AGRICULTURE	TOTAL
Ground Water	279	169	212	660
Surface Water	205	52	997	1254
Total	484	221	1209	1914

The daily consume of water for domestic uses at a regional level is estimated in 158 l/hab with a value of 150 l/hab*day for the western provinces and of a value over 160 l/hab*day for the eastern ones.

One of the problems in water resource supply regards the agricultural use. Part of the surface water used for field irrigation, about 260 hm^3, is currently uptaken from the Apennine's rivers and torrents but this amount is going to be dramatically reduced with the future application of the DVM, Minimum Vital Discharge. This water discharge has to be assured in order to reach and keep a certain environmental quality level of the fluvial ecosystem, in terms of river basin morphology, interactions with aquifers, water quality, hydrology. At the time being the Basin Authority of the Po River is studying and testing some methods to compute the DVM and it is not so far to be applied. As a consequence, some hypothesis in the usage of water at the regional level have been made, revealing that the less water availability from hill and mountain basins, about 70 hm^3 per year, will be probably covered by further 30 hm^3 per year abstracted from the aquifers, a water resource already overexploited.

The greatest problems will concern the Emilia region, in particular the provinces of Parma and Piacenza where the use of Apennine basin water is greater.

The exploitation of the groundwater resources in Emilia-Romagna is presently not sustainable in that the yield produces a water deficit.

In general the aquifer is overexploited and this exacerbates the subsidence phenomenon and the intrusion of brackish and marine water along the coasts. The deficit in groundwater use represents the amount of water that exceeds the recharging capacity of the aquifer.

The shallow groundwater under Emilia-Romagna present extremely small deficits (fractions on Mm^3/year) as far as the abstraction of Ferrara, Forlì-Cesena and Rimini provinces is concerned, this also because the main water source in Romagna is given as surface water by the Ridracoli Reservoir managed by Consortium Romagna Acque. The deficit is limited to 1-2 Mm^3/year for the provinces of Ravenna and Modena and relevant for Bologna and Parma with 10-15 Mm^3/year. Total regional deficit in underground water at a annual level is about 30-35 Mm^3/year.

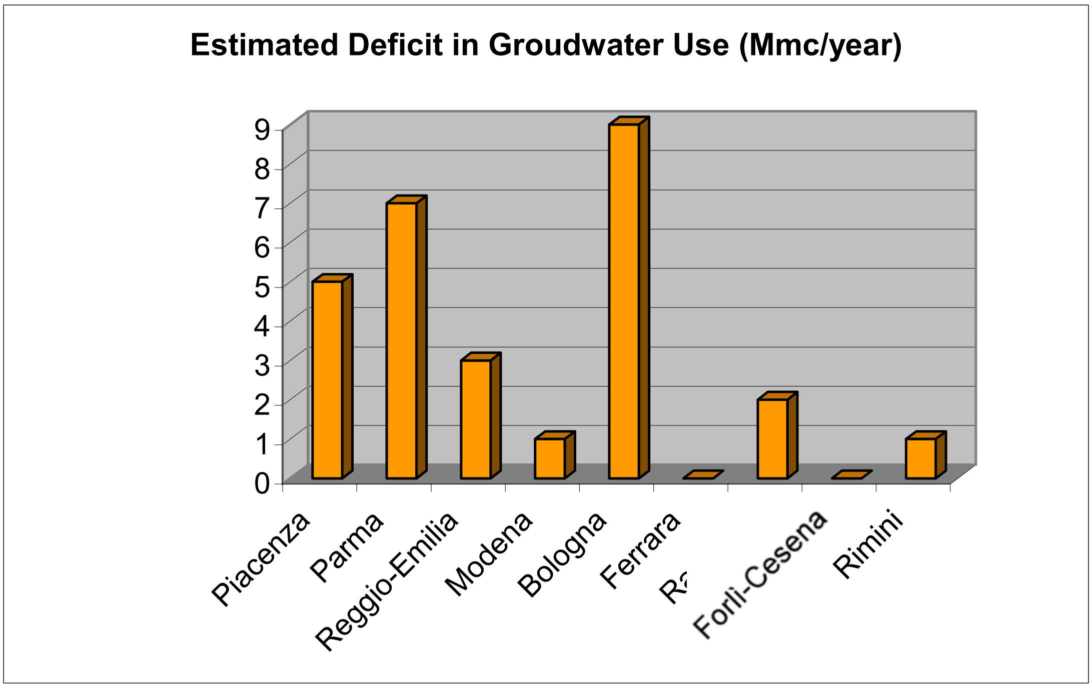

Figure 16. Estimated Deficit in Groundwater Use in Emilia - Romagna

Quality of water courses is pretty good at least for the stretches in the Apennine, where drinking use is usually possible without treatment. The use for irrigation is almost always permitted even if the stretches serving the provinces of Ferrara and Rimini have a relevant concentration of chlorides, so requiring a good drainage of the cultivated soil. Generally the river stretches in the plains present qualitative characteristics insufficient to direct drinking use and also to the aquatic life of plants and animals.

The main problem in groundwater quality consists in the presence of nitrates, mostly in the areas under alluvial cones where their concentration is greater than 50 mg/l, which is the limit for the drinking use. Therefore expensive treatment or mixing with water of better characteristics is needed.

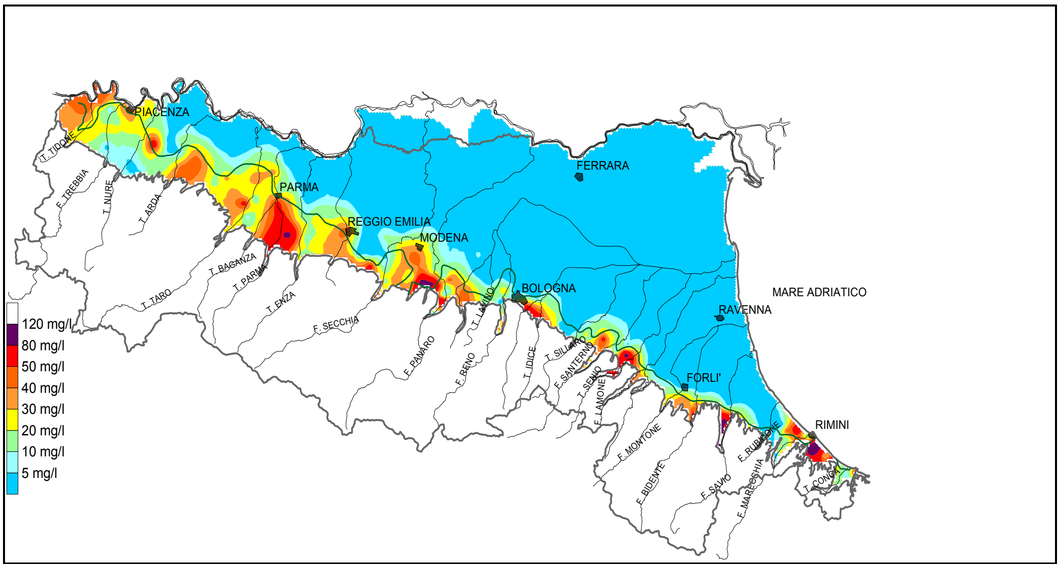

Figure 17. Areal distribution of nitrates concentration in the aquifers of Pianura Padana in 2001

However, the Groundwater Quality Status Index, which is used to study the antropogenic pollutant and natural chemical parameters distribution, shows that Emilia-Romagna groundwater belong to the "class 0" of the Index Range of values, denoting null or insignificant anthropical impact with medium-good natural hydro-chemical parameters.

Table 6. Qualitative Chemical Classes of Groundwater

Class	Anthropical Impact	Natural Hydro-chemical parameters
1	Null or insignificant	Optimum
2	Small and sustainable over the long period	Good
3	Significant	Medium
4	Remarkable	Bad
0	Null or insignificant	Medium-Good

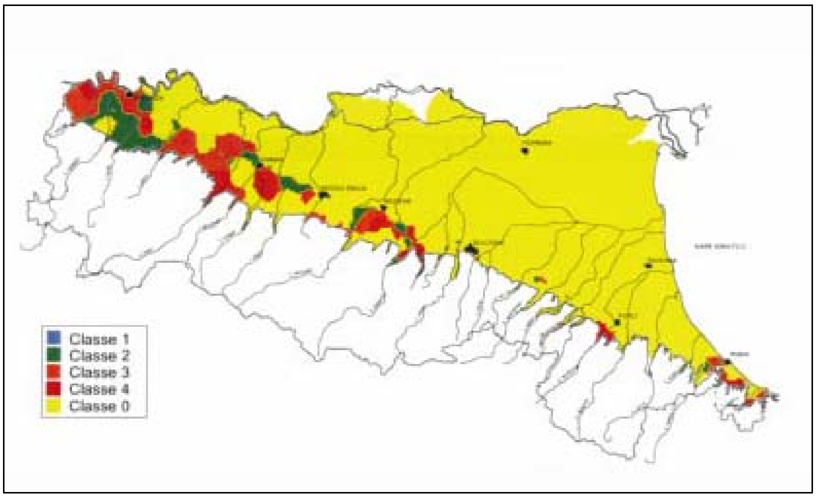

Figure 18. Qualitative chemical Status of Emilia-Romagna groundwater in 1999

As far as the coastal water quality is concerned, it can be given a "medium" rate. The eutrophication level denotes presence of nutrients and algal biomass associated to low transparent waters and suffering benthic life ecosystem. On the other hand, a study conducted in 1999 on the coastal zones says that bathing and swimming are allowed in the 99.7% of the controlled coasts so denoting a low presence of urban wasting pollutants.

The problem of eutrophication is not exclusive to the Adriatic coast but relevant to the entire Po River Basin, as declared by the European Commission within the Urban Waste Water Treatment Directive 91/271/EEC. The commission gives two alternatives: a) to assure the standard concentration of nitrates and phosphorus of treated water in areas with more than 10000 equivalent habitants b) to reduce by the 75% the nitrates and phosphorus loads produced by the civil municipalities.

The role of agriculture in Emilia Romagna will be determinant as the regional and local authorities are studying plans to re-use the treated waste water in irrigation: this would have the two advantages of nullifying the drainage of treated waste water into the Po River and of reducing the withdrawals of water from aquifers.

Figure 19. Areas with saline intrusion phenomenon in Italy (source: Enea 1998)

As regards the water price, it is established by the local authority with respect of general guidelines. In Bologna District for example, the water service is managed by the public firm Seabo and a typical household with civil consumption of 130 m^3/year can pay something like 132 Euro. The total cost of water per cubic metre considers a part for treatment service, about 0.276 euro/m^3, a part for water supply, 0.77 euro/m^3 (for annual consumes between 80 and 150 m3) and a part for the sewerage service, 0.096 euro/m^3.

Apart from Bologna and the other major urban centres, tourism in Emilia-Romagna is principally directed to the Adriatic coast, where from the Comacchio Valleys to the Marches boundary lie some thirty famous and busy seaside resorts. The beaches of Romagna such as Milano Marittima, Cervia, Cesenatico, Bellaria, Rimini, Riccione, Cattolica have, in fact, always attracted tourists from home and abroad.

Table 7. Regional Tourist Presence in Emilia-Romagna in 2001

AREA	2000	2001	TREND% (2001-2000)	DIFF.
Adriatic Coast	39.475.000	40.690.000	+3,1%	+1.125.000
Apennine	2.812.000	2.835.000	+0,8%	+23.000
Cities	3.403.000	3.480.000	+2,3%	+77.000
Watering places	1.994.000	2.025.000	+1,6%	+31.000
Total	47.684.000	49.030.000	+2,8%	+1.346.000

Table 8. Tourist Presence in Adriatic Coast in 2001

NATION	2000	2001	TREND% (2001-2000)	DIFF.
Italy	31.642.000	32.480.000	+2,6%	+838.000
Germany	3.505.000	3.724.000	+6,2%	+219.000
Switzerland	662.000	687.000	+3,8%	+25.000
Austria	316.000	333.000	+5,4%	+17.000
Others	4.483.000	4.744.000	+5,8%	+261.000
Total	39.475.000	40.690.000	+3,1%	+1.215.000

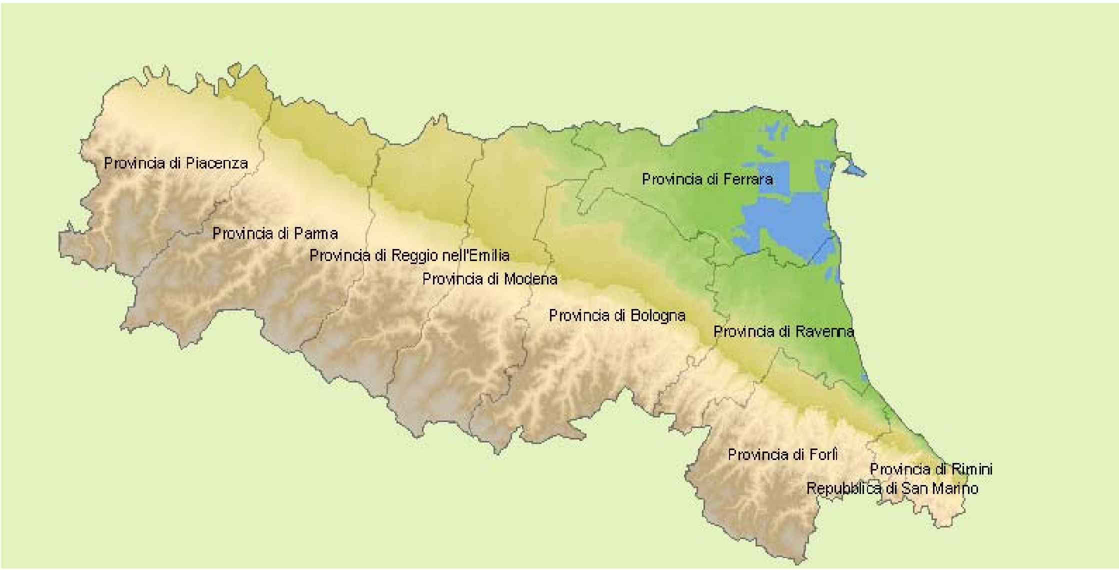

Figure 20. Administrative Provinces' Division in Emilia-Romagna

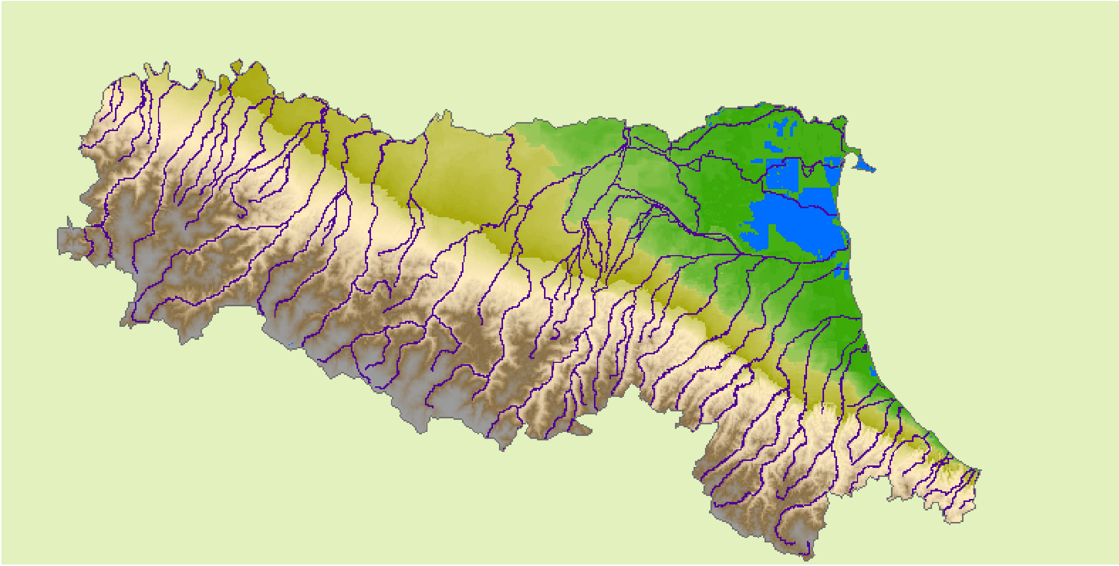

Figure 21 The Rivers Network in Emilia-Romagna

I.2.3. Belice Basin - Sicily

Sicily is the largest and most important island in the Mediterranean, and until the fourteenth century Sicily was the most important island in Europe. Though the Mediterranean is usually considered a single body of water, Sicily's shores are washed by two of its smaller seas: the Ionian and the Tyrrhenian. Most of the island's surface, covering more than 25,000 square kilometres, is mountainous and hilly, with some level coastal areas and a large plain near Catania. At 3342 meters, Mount Etna is the highest peak, and Europe's largest active volcano. A number of small islands located around Sicily are popular tourist resorts, the volcanic Aeolian (or Lipari) archipelago being the largest group.

Figure 22. Sicily

The extensive coastline ranges from rocky cliffs to sandy beaches, but Sicily also offers other fascinating natural sights such as Alcantara Gorge (near Taormina), various caverns (Carburangeli near Carini and others around Sicily and on the surrounding islands), and the grey mud flows formed by sporadic geysers that give Maccalube, near Aragona, its moonlike appearance.

While its mountains and coastline are Sicily's best known natural features, its low hills and flat valleys are quite scenic, too, though the rivers and streams that flow through them are usually dry by July.

The rivers are fast flowing with an irregular volume of water, flash flooding in winter and long periods of drought. The principal rivers are the Simeto (which channels the waters of the Dittaino, Gornalunga and Caltagirone), the Alcantara, Anapo, Cassibile and Tellaro, on the Ionian side; the Torto and San Leonardo, flowing into the Tyrrhenian Sea, and the Belice, Platani and Salso which empty into the Sicilian Sea.

The climate is in prevalence warm-temperate with annual mean temperatures of 14.5-16.9 °C, and annual fluctuation of 15 - 17 °C.

The water availability is a very strategic element in the agricultural sector of Sicily, as the water scarcity have always been the main constraint to the agricultural development.

In Sicily region there are 11 Public Consortiums whose main tasks are the management of irrigation networks, the analysis of the water quality and the land reclamation.

The Consortiums have built the majority of the present catchment, supply and distribution systems all over Sicily. At the time being, the reality of irrigation water supplied by Private Consortiums or by the land owners themselves is very limited, there are just some areas in The Eastern Sicily. The private supply comes from the aquifers while the public consortiums take water from the artificial reservoirs and small lakes.

C. n° 1: TRAPANI
C. n° 2: PALERMO
C. n° 3: AGRIGENTO
C. n° 4: CALTANISSETTA
C. n° 5: GELA
C. n° 6: ENNA
C. n° 7: CALTAGIRONE
C. n° 8: RAGUSA
C. n° 9: CATANIA
C. n° 10: SIRACUSA
C. n° 11: MESSINA

Figure 23. The Regions of Sicily

The Sicily agriculture can count on 16 irrigation systems with a total length of 7000 km serving an area of 140000 ha. In spite of the rather full network coverage, the present really irrigated area is about the 50% of the potential equipped one and this is due to the effective lack of water: year 2001, for instance, has been so critical to agriculture that the entire water volume supplied for irrigation over the whole region, about 160 hm^3, has not been sufficient to cover the needs of The only Eastern Sicily. One of the reasons is the lower precipitation of the last few years and in particular of 2001 with about 200-250 mm less than the mean value of the past thirty years, but there are other remarkable factors among which the lack of a regular activity of maintenance both of the water distribution networks, where it would avoid pipe-bursts, and of the artificial reservoirs of which the region is rich, where it would help keeping the actual storage capacity near to the nominal value. There are also some reservoirs whose water is more than sufficient to cover the seasonal demand of the territory they serve, so they could give water to the neighbour poorer ones but unfortunately the necessary pipelines to connect them have never been built.

Table 9. Available water volumes per single reservoir (Mm^3)

Reservoirs	Storage Capacity	Available volumes on 15/04/02	Available volumes on 15/04/01	Differential 2002-2001	Var. 2002-2001 (%)
Rubino	11,50	1,49	6,11	-4,62	-75,6
Zafferana	1,00	0,00	0,49	-0,49	-100,0
Paceco	15,00	4,10	5,03	-0,93	-18,5
Trinità	18,00	2,88	8,64	-5,76	-66,7
Garcia (1)	60,00	26,97	47,30	-20,33	-43,0
Poma (2)	68,00	7,69	38,47	-30,78	-80,0
Rosamarina	80,00	40,49	49,43	-8,94	-18,1
Arancio	38,80	10,70	21,13	-10,43	-49,4
Prizzi	9,20	3,02	n.d.	n.d.	
Gorgo	3,41	0,56	1,18	-0,62	-52,5
Castello	26,00	5,20	12,21	-7,01	-57,4
San Giovanni	16,30	5,71	9,31	-3,60	-38,7
Comunelli	8,00	0,00	1,20	-1,20	-100,0
Disueri	14,00	1,00	2,30	-1,30	-56,5
Cimia	11,30	0,40	4,20	-3,80	-90,5
Biviere	4,80	0,30	1,45	-1,15	-79,3
Nicoletti	19,30	5,96	10,03	-4,07	-40,6
Pozzillo	141,00	3,00	n.d.	n.d.	
Ancipa (3)	30,40				
Olivo	10,00	1,69	3,63	-1,94	-53,4
Don Sturzo	110,00	8,20	n.d.	n.d.	n.d.
Ragoleto	20,00	1,60	n.d.	n.d.	n.d.
Santa Rosalia	20,70	13,38	20,01	-6,63	-33,1
Lentini (4)	127,00	32,00	37,00	-5,00	-13,5
TOTAL	863,71	176,34	279,12	-102,78	-36,8

Sicily's Precipitation in 2001

The wet season in 2002 proves to be even more crucial than in 2001. Water availability of Sicilian reservoirs is so decreased that even in case of rainfalls, problems can not be solved. According to the last INEA report on water emergency, the water quantity of Sicilian reservoirs has reduced by about 37% in comparison with that in the same period of the last year.

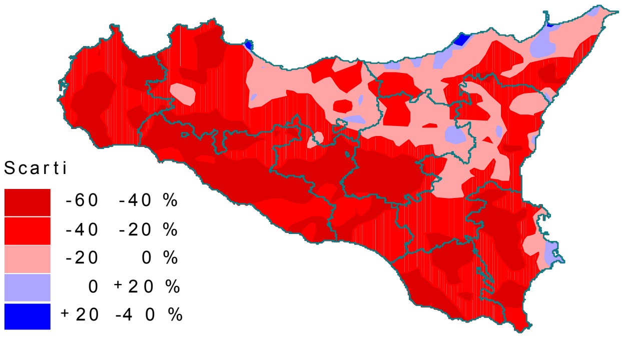

Figure 24. Per cent deviations of rainfall rates during the period August 2001 – April 2002 from the mean rates of the same period of the past 30 years

According to the data collected and processed by "Servizio Informativo Agrometeorologico Siciliano" (SIAS, i.e. Sicilian Agro-metereologic Information Center) the rainfall rates during the solar year 2001 have been considerably lower than the climatic mean rates of the last 30 years, the negative deviation being about 30 - 50% in the yearly average. This percentage has been higher in the middle-southern areas of the isle, with peaks of 50 - 70%. In general, the average negative deviation resulted to be about 150-250 mm in comparison with the climatic mean values. The most serious period came after summertime - which usually is a dry period in the areas with mediterranean climate - and lasted up to the end of March. Later, more details on the recent period of drought will be given.

In the following paragraph we will show mapping calculations carried out focussing on the period August 2001-April 2002 in Sicily, by comparing the current rainfall rates with the climatic mean ones of the last thirty years (we always consider the "mean rainfall rates" as median rates, and even in this analysis we will consider them like that).

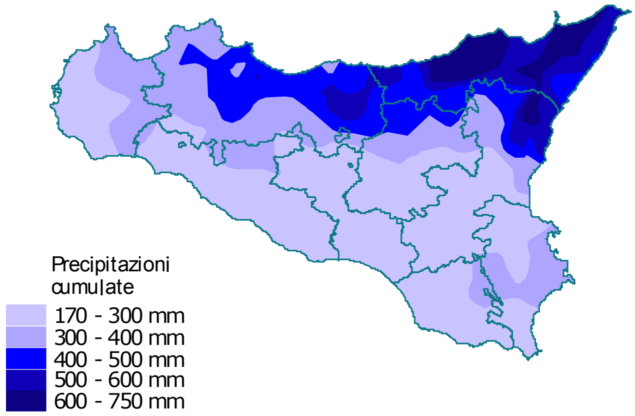

Figure 25. Cumulated rainfall (August 2001 – April 2002)

Comparisons have been made by per cent deviations, this being one of the possible ways to perform drought. By such a method the deviation (that is to say, the difference) between the current rainfall rates (meteorological data) and the reference rates (climate rates, that is to say, the mean rates of the last thirty years) are related to a value of 100. In other words, by considering 100 as the mean rainfall rate of a place, the difference in rainfall rate between the current period and the climate will be related to 100.

In the case of Sicily, our study starts with the data referred to August 2001, because in our climate from the month of August on, after the usual summer aridity, Autumn precipitation allow the storage capacity of water reservoirs to increase. Autumn rainfalls usually are among the most plentiful - and often "the" most plentiful - of the year.

Last year, 2001, it was not like that. In fact, in August in many areas the rainfall rate was higher than the mean one, but from September on the general situation has been very critical, particularly in many inland and south - west areas. But let's proceed methodically to more detailed considerations.

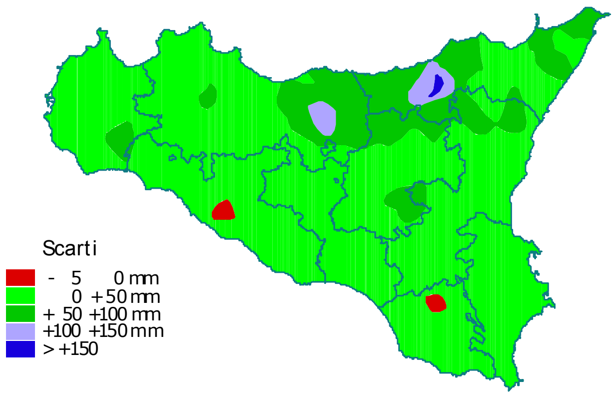

Figure 26. Mean rainfall in May for the past 30 years

The first map acts as a synthesis and shows the per cent deviations of rainfall rates during the period August - April. The map evidently shows that almost everywhere in the region the rainfall rate has strongly decreased, the overall situation being particularly crucial in north - west, south - east and middle - south areas.

The map is the result of the comparison between the map of the meteorological values concerning rainfalls during the period August 2001 - April 2002, and the map of climate values referred to the same period in the last 30 years (according to the above mentioned method).

In both mapping calculations the pluviometric deficit of the areas where the recent drought was most serious, can be quantified in about 200 - 250 mm, with peaks of 300 mm. It is to be considered that in many of these areas the rainfall rate of the same period is usually 400 - 500 mm, but this year it has drastically diminished to only 200 - 250 mm or less.

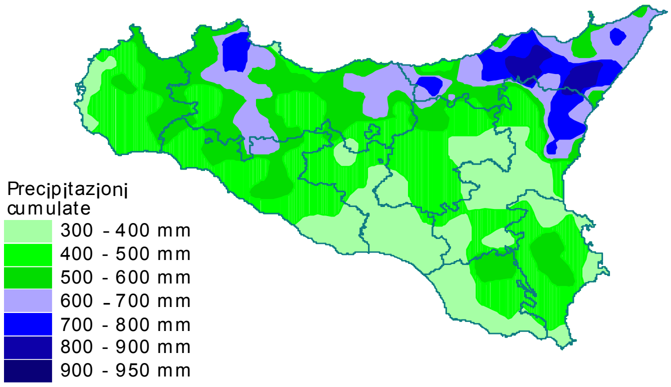

Figure 27. Mean rainfall rates of the past 30 years (Cumulated values of period August 2001 – April 2002)

Considering the monthly rainfall rate, data prove that in August it was higher than the average one, and that the rainfall shortage began from September on, worsening in the month of October, when the negative deviation has been as high as 100% - that is to say, there have been no rainfalls at all.

This situation has caused serious consequences, in particular to the zootechnic sector, that usually benefits a lot by rainfalls in September and October. In fact in that period, in Sicily forage species usually benefit their typical Autumn renewal.

Furthermore, rainfalls during November and December concentrated mainly in the northern area of the isle, the remaining area of the region keeping to suffer the current rainfall shortage. The crisis became even worse in the first three months of this year, from January on, and particularly in February and March, concentrating in the western and southern areas.

Luckily, the month of April has been definitely different, because almost everywhere in the isle rainfall rates resulted quite higher than the mean rates of the period, bringing some relief - even if just a little - to the very serious and evident water shortage.

Precipitation increased even more in May 2002, so that rainfalls rates were much higher than the average almost everywhere in the isle. In many cases rainfall rates were five times as high as the mean rates of the period.

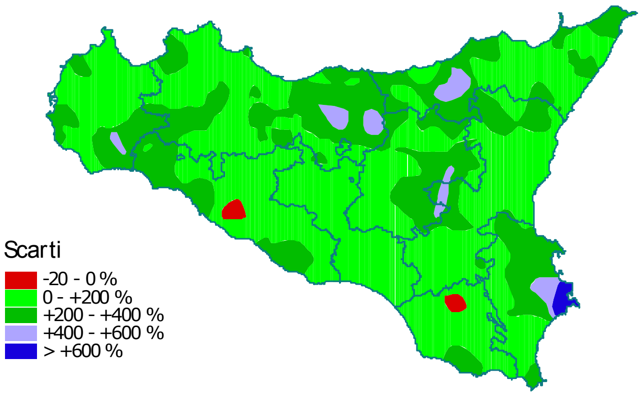

Figure 28. Deviations of rainfall rates in May 2002 – April 2002 from the median rates of the past 30 years

The increase of rainfall rate has helped improve the general situation of the region, above all the overall water supply, so like it happened in April, too. In agriculture, instead, together with positive effects, also some negative aspects are to be stressed out, above all those concerning the harvest of forage rich in hay, which in many cases has suffered the abundant and persisting rains, affecting the final quality of the product.

Furthermore, one of the most serious consequences of the rainfall deficit of last Spring - notwithstanding rains in April and May - was the big damage to cereal production, above all in inland and southern areas of the region, where strong reduction of the product quantity can already be calculated.

I.2.4. The Belice Basin

The Belice Basin is placed in the south-west of Sicily. It covers an area of about 967 km^2, in the administrative territory of Palermo, Trapani and Agrigento provinces. It borders with the Modione and Freddo River Basins at the west, with those of Jato and Oreto at the north and with those of Verdura and Carboj at the east. The Belice River is divided into three branches, the Right Branch, the Left Branch and the stretch after the confluence near the town of

Poggioreale, each one defining a sub-basins. The Right Branch has a length of 55 km and comes from The Northern part of the Basin. His basin covers an area of 227 km^2. The Left Branch has a length of 57 km and comes from Mount Leardo and Mount Rocca Busambra and is supplied by torrents Fosso and Bicchinello. Some of his tributaries are Corleone River and the torrents of Batticano and Realbate. The sub-basin has an area of 407 m^2. After the confluence the river extends for 50 km up to the Sicily Canal.

Figure 29. The Belice Basin

In The Belice Basin there are many aquifers which are deeply exploited for irrigation and municipal supplies.

The mean daily precipitation and evapotranspiration are respectively about 1.256 mm and 3.23 mm, consequently the Aridity Index is 0.39 (semi-arid conditions).

The total water resource availability is 80 hm^3 of which 24.8 are groundwater. The water sources are the aquifers, 19% of supply, and Belice River together with artificial lakes, 81% of supply. Corleone city takes trans-boundary water from Prizzi Lake in the amount of 18 l/sec which corresponds to about 0.56 hm^3/year. About 21.9 hm^3/year are transferred towards near basins.

Groundwater is used mainly as drinking water for civil municipalities with the 45% of the total, while the 30% is used for irrigation and the 25% for industrial use.

Water consumed for irrigation is the 64% of the total, this reflects the fact that agriculture is at the basis of the local economy, while water consumed for domestic use, which includes the tourists' consumes, is about 27%, and the industrial and energy production one is 9%.

The water quality of the Belice River, of groundwater and of coastal water is good.

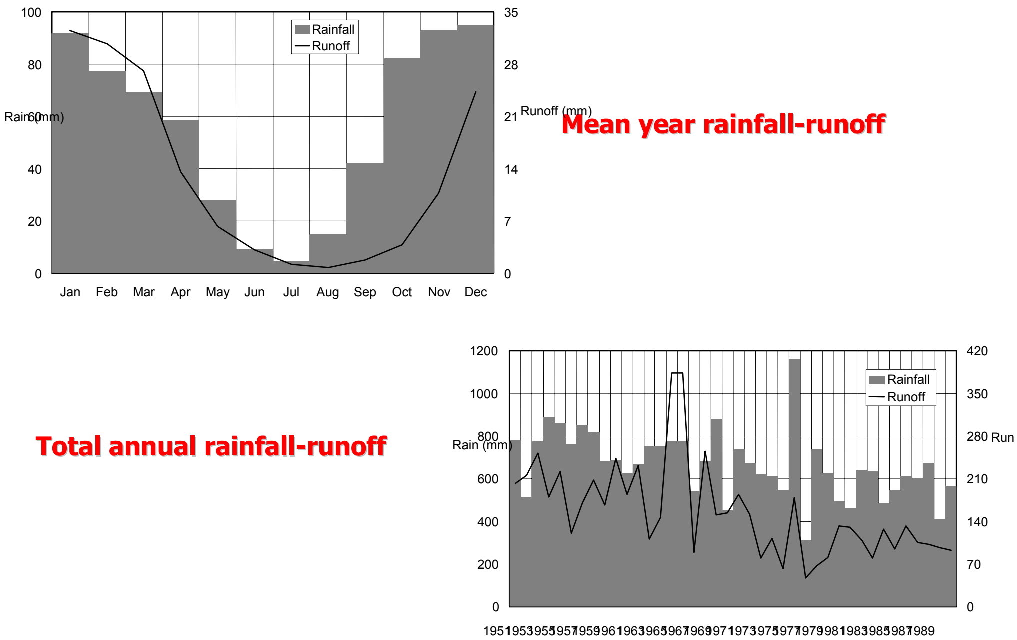

Figure 30. Rainfall and runoff in the Belice Basin

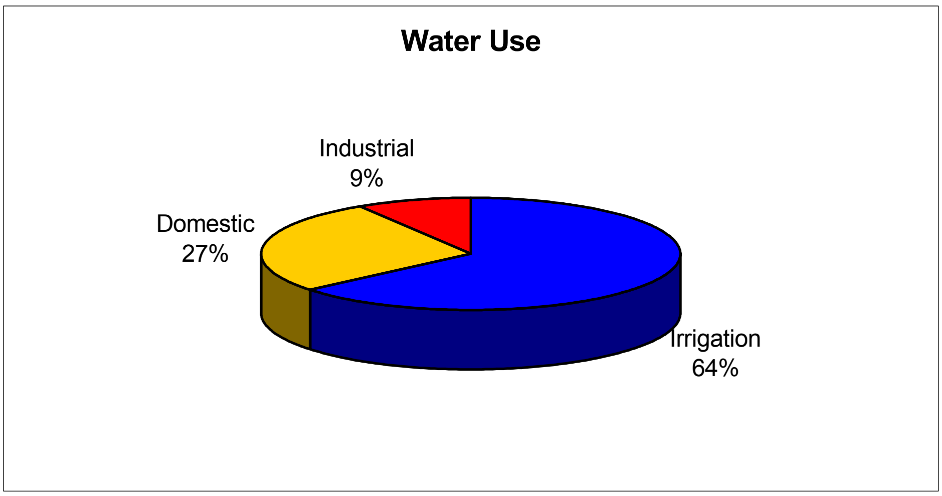

Figure 31. Water Use

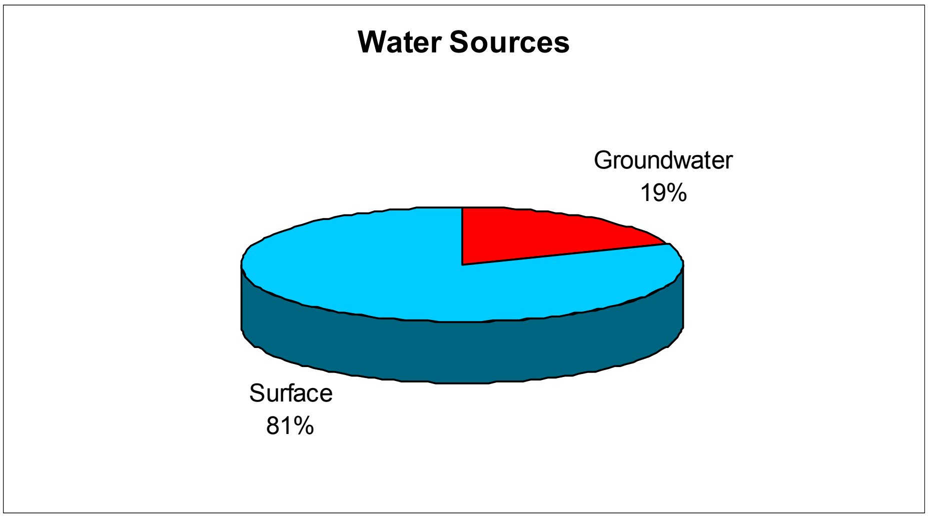

Figure 32. Water Sources

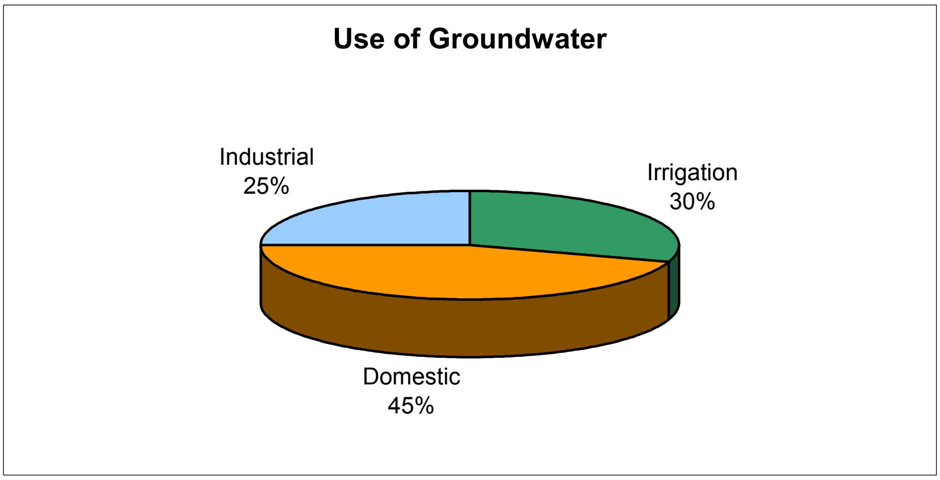

Figure 33. Use of Groundwater

The Belice Basin extends under the administrative competence of Consortium n°3 Agrigento. In his territory the lack of water for irrigation in 2001, mainly due to the lower precipitation, caused an heavy delay of the irrigation season from the usual and official starting month of April to the month of June. Besides, the fields' requirements of the entire region haven't been completely covered due to the uneven water availability conditions of the different water reservoirs and consequently some districts the irrigation season has terminated one month earlier.

Natural conditions are not the only problem affecting the fields water needs: in some districts the absence of the necessary activity of maintenance of the pipelines bringing water from the reservoirs has been the first cause of pipe bursts.

I.3. Regional reports for Israel

I.3.1. Selecting the Regions

The Israeli National Water Carrier (NWC) connects all major sources of freshwater into a single network which serves most of the regions of the country. Thus, in principal, the management of water resources and the design of water policies can treat most of the country as a single economic entity. The region of Tel Aviv is an example of a region which served by the national water system. It is very important and interesting region for a few reasons. In terms of population it is the largest in the country with 30% of total population and it has 16,000 ha of irrigated land. Thus its water economy is characterized by (high) domestic and industrial water consumption as well as consumption of agricultural water. The region's large population creates the potential for large supply of recycled water for agricultural use as well as for rivers rehabilitation. Since the cultivated land in the region is overlying the coastal aquifer, the environmental consequences of irrigation with recycled effluents should receive a special attention. The climate in the region is semi-arid (Mediterranean climate) with annual precipitation of 450 mm. The Arava region is one of the very few regions in the country that is not connected to the national water system, and receives its water only from local system. The climate in the region is arid with very law precipitation (up to only 10 mm per year) and aridity index of 0.65.

In contrast to the region of Tel Aviv, it is sparsely populated and includes only one small tourist city (Eilat) and many rural villages. Currently, the city of Eilat is the only municipality in Israel that its water consumption is supplied via desalination of sea water (from the Red Sea). Water for the villages are supplied via local small ground water aquifers, some of them are saline. In addition, recycled effluent for irrigation is obtained from Eilat and the agricultural settlements. In contrast to the situation in Tel Aviv's region, land prices in the Arava region are low and there is no demand for additional urbanization in the expense of agricultural land.

I.3.2. Tel Aviv

The region is located in the coastal plain on the eastern shore of the Mediterreanean Sea and it lies above the coastal aquifer. In terms of population, the Tel Aviv region is the largest in Israel with two million people, 30% of the total population (Table 11).2 The region has 160,000 dunam of cultivated agricultural land, 5% of the total cultivated land in the country. The region's water economy is therefore characterized by relatively high domestic and industrial consumption, and relatively low agricultural consumption (see Table 12 to Table 14 and Table 16).

Natural water sources in the area are:

[2] Data in all tables refers to the year 2000

- Supply from the national water system (via the national water network of the Mekorot company):
- Production from the coastal aquifer, above which the region lies
- Water supply from the Sea of Galilee via the National Water Carrier (NWC).

In addition, part of the fresh water is provided by private producers from the coastal aquifer (some 35% of the fresh water).

In the future, this region is slated to receive a significant amount of the desalinated sea water.

Aggregate supply is summarized in Table 18.

Domestic consumption is similar to the national average (100 m^3 per capita per annum). This consumption is expected to increase by 20% with the development of metropolitan parks and the improvement in quality of life.

The quality of the fresh water is good, with a salinity level of 150-250 mg chlorine per liter. In the future, the use of desalinated water will lead to an improvement in the water quality.

The region's large population creates the potential for a large supply of recycled water for agriculture. In addition, high quality treated waste water can be used for irrigation of metropolitan parks and for rehabilitation of streams like the Yarkon River (Table 15).

Climatic conditions in the region:

- Mediterranean climate, semi-arid.
- Annual precipitation 450 mm.
- Aridity index 0.05-0.2.

Water prices are determined within the national framework. Private producers are subjected to a production levy.

Land prices in this area are among the highest in the country. Therefore the region is subject to further urbanization and a reduction in agricultural area. Agriculture in this region has value as a public good in conserving open areas and "green lungs".

I.3.3. Arava

The region is located at the south-eastern tip of Israel, between the Dead Sea and the Red Sea.

The region is sparsely populated, based mainly on the tourist city of Eilat, at the southern tip. The remaining population is scattered in rural villages (Table 11).

Domestic consumption per capita in this region is particularly high (Table 12), for two reasons:

- Dry climatic conditions lead to heavy evaporation and a greater demand for garden irrigation and drinking water.
- A large part of the population lives in rural settlements, where large amounts of water are needed for private and public gardens.

Sources of fresh water in the region

- The Arava is not part of the national water system, but receives water from local sources only, via the national water company Mekorot:
- Drillings in the center of the region (Faran drillings) yield water of reasonable quality: up to 350 mg chlorine per liter.
- Drillings in the southern Arava yield low-quality water: 600-1,100 mg chlorine per liter.
- The desalination plant of Red Sea water provides water for the local population in Eilat.

In addition, waste water for agriculture is obtained from Eilat and the agricultural settlements. It is important to note that the Red Sea is a unique coral reserve of great ecological value, and it is therefore essential that waste water be recycled for agriculture and not be disposed of in the sea.

The prices for all the water supplied by Mekorot, fresh and saline, are determined within the national framework. Saline water is cheaper than fresh water, in accordance with the salinity level. The price for recycled water for agriculture covers the operational and the capital costs, after discounting state grants.

The water development plans for the region are mainly in the area of pooling and transferring waste water. In the more distant future there is a possibility that the desalination plant in Eilat will be enlarged.

Climatic conditions in the region:

- Arid climate, very low precipitation (up to 10 mm rain per annum).
- Aridity index 0.65.

The climatic conditions favor intensive cultivation of vegetables, flowers and date palms. Some 40% of the greenhouses in Israel are located in this region.

Some additional comments: This region borders with Jordan. The water production balance – drillings and water production from the local aquifer – is affected by the peace treaty with Jordan. Land prices are low and there is no demand for additional urbanization.

Table 10. Distribution of population by type of settlement

Type of Settlement	Tel - Aviv		Arava	
	thousands	%	thousands	%
Metropolitan areas (Pop. exceeding 200,000)	349	19	-	0
Big cities (Pop. 100,000-200,000)	887	47	-	0
Mid-sized cities (Pop. 20,000-100,000)	469	25	40	88
Small towns and cities (Pop. 2,000-20,000)	154	8	-	0
Villages and communities	25	1	5	12
TOTAL	1,884	100%	45	100%

Table 11. Domestic Consumption (MCM/year)

Year	m^3 / capita	Consumption from National System	Consumption from Local System	Total Demand
Tel - Aviv	100	75	113	188
Arava	200	-	9	9

Table 12. Industrial Consumption (MCM/year)

	Freshwater			Saline Water	Recycled Water	Tota l
	Consumption from National System	Consumption from Local System	Total Demand			
Tel - Aviv	23	35	58	0	0	58
Arava	0	1	1	0	0	1

Table 13. Agricultural Consumption (MCM/year) Sources

		Tel - Aviv	Arava
National System	Fresh	34	-
	Recycled	5	-
	Saline	-	-
	Total	39	-
Local System	Fresh	51	12
	Recycled	-	5
	Saline	-	14
	Total	51	31
TOTAL	Fresh	85	12
	Recycled	5	5
	Saline	-	14
	TOTAL	90	31

Table 14. Environmental Consumption (MCM/year) Sources

		Tel - Aviv	Arava
Local System	Fresh		
	Recycled	2	
	Saline		
	Total	2	

Table 15. Summary of Water Consumption by Water Type (MCM/year)

		Tel - Aviv	Arava
National system	Fresh	133	-
	Recycled	5	-
	Saline	-	-
	Total	138	-
Local System	Fresh	198	22
	Recycled	-	5
	Saline	-	14
	Total	198	41
Total	Fresh	331	22
	Recycled	5	5
	Saline	-	14
	TOTAL	336	41

Table 16. Salinity Levels and Long-Term Average Recharge by Water Resource

Basin	Salination Level (mgchlorine/liter)	AverageAnnual-Recharge (MCM)
Coastal Aquifer – National System and Local Producers	-	250
Sea of Galilee Basin - National System	-	180
Arava – Local Sources	400	-
TOTAL	400	222

Table 17. General Water Balance (MCM/year) + estimates

	Arava	Tel - Aviv
Demand by sector:		
Domestic	9	188
Industrial	1	58
Agricultural	31	90
Jordan & PA	-	-
Environment	-	2
Total	41	338
Demand by water type:		
Freshwater	22	331
Reclaimed	5	7
Saline	14	-
Total	41	338
Supply:		
Aquifers (including saline)	27	333
Desalination	9	-
Recycled	5	5
Total	41	338

I.4. Regional reports for Cyprus

I.4.1. Selecting the Regions

The selection of the three candidate regions in Cyprus was made based on the basis of water scarcity/ shortage or deficiency and aridity of the area, as mentioned above, but also on its social and economic characteristics and the complexity of the water system. Each one of these three regions suffers water deficits for a different reason, which makes them good candidates for study. These are:

The Akrotiri aquifer area

This was the most dynamic aquifer in the island with the annual recharge being about 32 Mm^3 and the extraction amounting to 10 to 15 Mm^3. The balance was being lost to the sea and the nearby Salt Lake through the subsurface. The completion of the Kouris dam of 115 Mm^3 capacity, in 1987 changed the hydrologic regime and cut off the main source of replenishment through infiltration within the Kouris riverbed. Presently the estimated annual recharge from local rainfall and return flow from irrigation is of the order of 6 to 8 Mm^3 while the extraction remains near the pre dam-construction levels. A major part of the balancing replenishment is made up by artificial groundwater recharge through releases from surface reservoirs into ponds and the dry streambed.

The groundwater levels are presently below mean sea level throughout most of the area of the aquifer. Sea intrusion has propagated up to 2 km and an important part of the aquifer has been rendered useless. The reduction of replenishment (leaching effect) and the increased agricultural activity using surface water from the Kouris dam has caused a trend of nitrate and other elements built up in the groundwater. The drop of the groundwater levels also affects the Salt Lake and marshland in the southern part of this area, which is of unique environmental importance. At the eastern fringe of the area lies Limassol the second largest city in Cyprus with a population of 100,000.

Until recently a large part of the domestic water supply of this city relied upon groundwater from this aquifer. At present, a number of communities as well as the British Bases still pump groundwater for their needs. The local demand for the irrigation of the citrus orchards and seasonal crops relies on surface water from Kouris dam, Polemidhia dam and Germasogeia dam, local groundwater, groundwater from within the Limassol city (high in nitrates) and tertiary treated effluent from the Limassol sewage treatment plant. Currently a sea water desalination plant is planned to start operating by 2004 and a major artificial recharge project using the tertiary treated effluent (up to 6 Mm^3) is being set up through recharge ponds and re-pumping for irrigation purposes.

The aquifer has excellent information for more than 30 years. It has quite a complicated water resources management system and serious management problems to address such as environmental, quality, quantity, social and economic. This area has permanent water shortage problems and it presents a unique situation for integrated management application.

The Germasogeia aquifer

The Germasogeia catchment is in the southern coast of Cyprus. It is about 141 square kilometres up to the Germasogeia dam, which is of 13.1 million cubic meters capacity. The average annual runoff is about 20 million cubic meters. A major part of the catchment is covered by natural forest but considerable agricultural activity is present in riparian land.

Downstream the dam a riverbed aquifer develops. This aquifer that is 5 km east of Limassol town has a length of 5.5 km and an average width of about 350 m. with an active storage of fresh water of the order of 3.5 Mm^3 increasing to 5.0 Mm^3 at high water table.

This small aquifer has been relied upon to meet the major portion of the increasing demand for the water supply of the town of Limassol and the neighbouring villages that have high seasonal water demand due to tourism.

The complete cut-off of the natural replenishment by the construction of the dam and the proximity to the sea, coupled with the increasing extraction from the aquifer, requires a coordinated programme of releases from the dam for artificial recharge to cope with the extraction. With such action the sea intrusion is controlled and at the same time an efficient use of the scarce water resources is made.

The catchment area has extensive hydro-meteorological, geological and hydrogeological data as well sufficient surface and groundwater quality data. It constitutes an excellent case study for conjunctive use of surface and groundwater and for evaluating drought conditions and their repercussion to the hydrologic regime and the socio-economic environment of the area.

The Kokkinochoria aquifer

The Kokkinochoria area is in the South-eastern part of the island, the coastal area of which has developed to an important tourist location. It is one of the most dynamic agricultural regions in the country with high-income farmers. The aquifer is made up of Miocene and Plio-Pleistocene sediments gravel, sand, silts and calcareous matrix and blocks of reef limestone. It has an areal extent of 170 km^2. The replenishment of about 12-14 Mm^3 per year was exceeded for many years by an annual extraction of 25 Mm^3. The aquifer after 35 years of extensive development and mining presently holds some 10 to 15 % of its original reserves. This has resulted to excessive drawdown of the water levels, reduction in yield per well and sea intrusion.

At present, some 2500 boreholes are in operation irrigating about 6000 hectares of mainly seasonal crops, potatoes being the main crop with an estimated annual extraction of 10 Mm^3. The yield of these boreholes being very low at present, 1 to 7 m^3/h, is supplemented by surface water imported to the area by the Southern Conveyor project. Under normal years some 17 Mm^3 per year are envisaged to be transferred in the area from the Kouris dam, some 70 km to the west. In the last 10 years though due to a prolonged drought the quantity of water imported to the area annually has been less than 5 Mm^3.

With a drop of the water-table averaging to 1.5 m/y for the last 30 years, the water-table in many areas especially near the coast is located down to 40-50 m below mean sea level. The thickest and most productive part of the aquifer, being within 3 km from the coast has practically been sea-intruded and rendered useless.

The water deficiency problems of this area need to be addressed and alternative sources of supply, water demand management practices, change of cropping pattern and other similar issues need to be considered.

I.4.2. Akrotiri

The Akrotiri area covers the Akrotiri peninsula and it is the southernmost part of the island. It covers an area of 142 sq. km. Its eastern part is taken over by the urban area of Limassol with some 125000 inhabitants. There are 10 other village communities with a total population of 16000 within the same area that basically may be considered as suburbs to Limassol with their inhabitants commuting to the city and also working as farmers within the general area.

At the southern tip of the peninsula there is a major British military base with an airfield and an estimated force of the order of 15000 soldiers with their families. This is separated from the agricultural land and aquifer further to the north, by a Salt Lake and marshland that is of unique environmental importance.

The aquifer, the third largest in the island, essentially is a gently dipping coastal deltaic alluvial aquifer of a 40- km^2 extent. Its western half coincides with the alluvial fan deposits of the Kouris River that drains a catchment of 338 sq. km., whilst the Garyllis River draining a watershed of 100 sq.km takes up the eastern half. Groundwater is pumped through some 500 wells and boreholes mainly for irrigation (9 to 12 Mm^3/y) and for domestic purposes (1.5 to 3 Mm^3/y). About 90% of the annual extraction is metered and recorded at monthly intervals. Pumping permits are issued annually on the basis of the current groundwater conditions and the water content in the surface reservoirs.

The main source of the natural recharge of the aquifer, after the construction of Polemidia dam in 1965 on Garyllis river and the construction of the Kouris dam in 1987 on Kouris river changed dramatically. It now depends entirely on local rainfall of about 380 to 430 mm, return flow from imported water for irrigation and on artificial groundwater recharge.

Sea intrusion was originally confined at the eastern part but more recently, and after the construction of the Kouris dam of 115 Mm^3, a large part of the Kouris delta area has also been sea-intruded. Ongoing artificial groundwater recharge with water from the surface reservoirs, and planned with treated effluent, together with further control of pumping is expected to reverse the situation. Furthermore, with the reduction of the flashing effect of the annual recharge together with the increased agricultural activity, a gradual built up of nitrate and other elements has been noted in the groundwater of the area.

Presently the irrigation requirements of the area are met by local groundwater, tertiary treated effluent, surface water from the Kouris, Germasogeia and Polemidhia dams and from reclaimed groundwater pumped from within the Limassol urban area. The area irrigated at present is 2200 ha with a demand of 15 Mm^3, out of a planned area of 3775 ha. The Limassol domestic supply is mainly provided from the Kouris dam and partly from groundwater from the Germasogeia aquifer.

A major desalination plant of 20000-m^3/d capacity is planned for commissioning by 2004 to be built at the western part of the area.

The aquifer is very well controlled. The groundwater levels are observed monthly from a network of 150 since 1960, 85 to 100 of which are regularly sampled. The groundwater pumping is quite well monitored through water meters that are observed every month. The area is well surveyed and studied. A good database exists and numerous studies have been performed including groundwater modeling.

Low rainfall and reduction of the surface reservoir water content resulted to diminished recharge, both natural and artificial, of the aquifer. This together with the continued extraction pattern of pre-dam construction has caused a serious drop of the groundwater levels (Figures 34, 35 and 36) and sea intrusion (Figure 37).

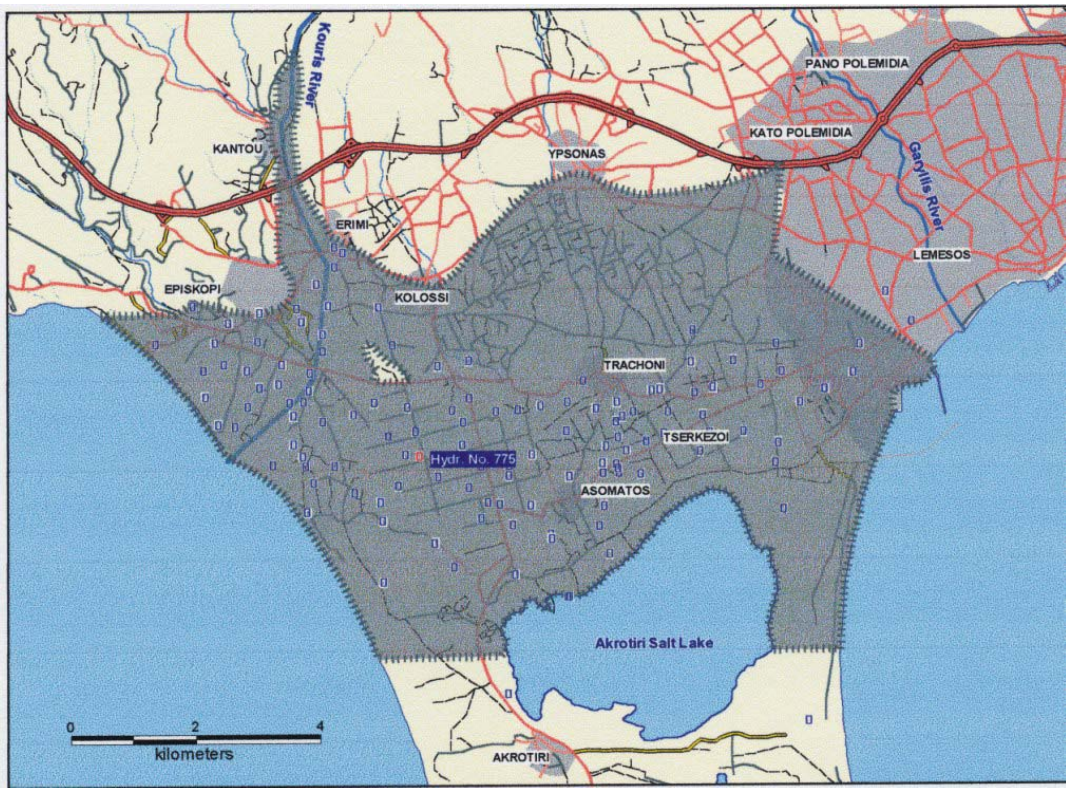

Figure 34. Akrotiri Aquifer showing inhabited areas and well observation network

The intensive use of fertilizers in agriculture together with the reduction of the flashing effect by natural recharge resulted to a nitrate built-up in the aquifer. The concentration of nitrate ion in the eastern part of the aquifer is in excess of 200 mg/l.

At the same time the diminished flows of Kouris River and the drop of groundwater levels are threatening the ecosystem of the marshlands and of the Salt Lake. Urbanization at the eastern and northern parts of the aquifer and increased storm runoff from these areas presents also a problem to the Salt Lake being the lowland and the natural receiving area.

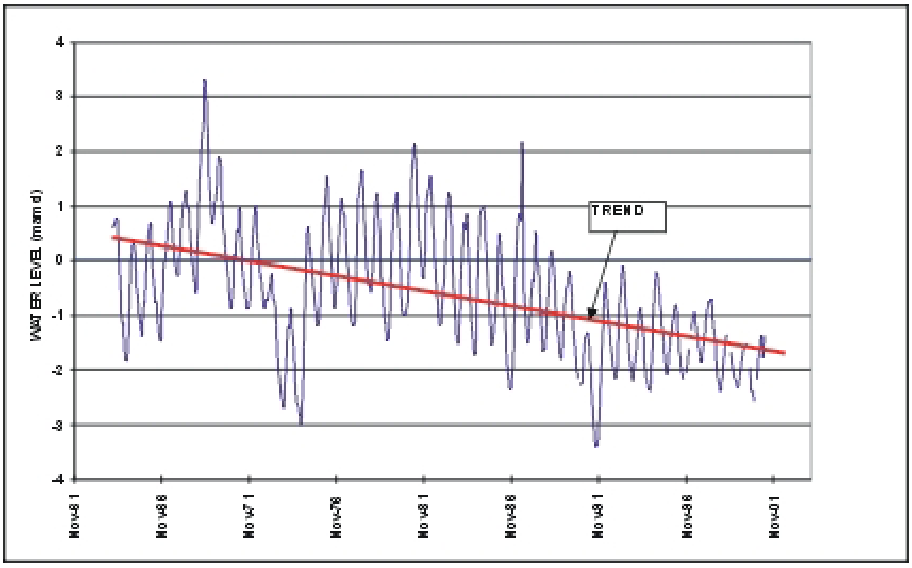

Figure 35. Hydrograph of borehole Akrotiri 775 (Elev. 15.63 m amsl)

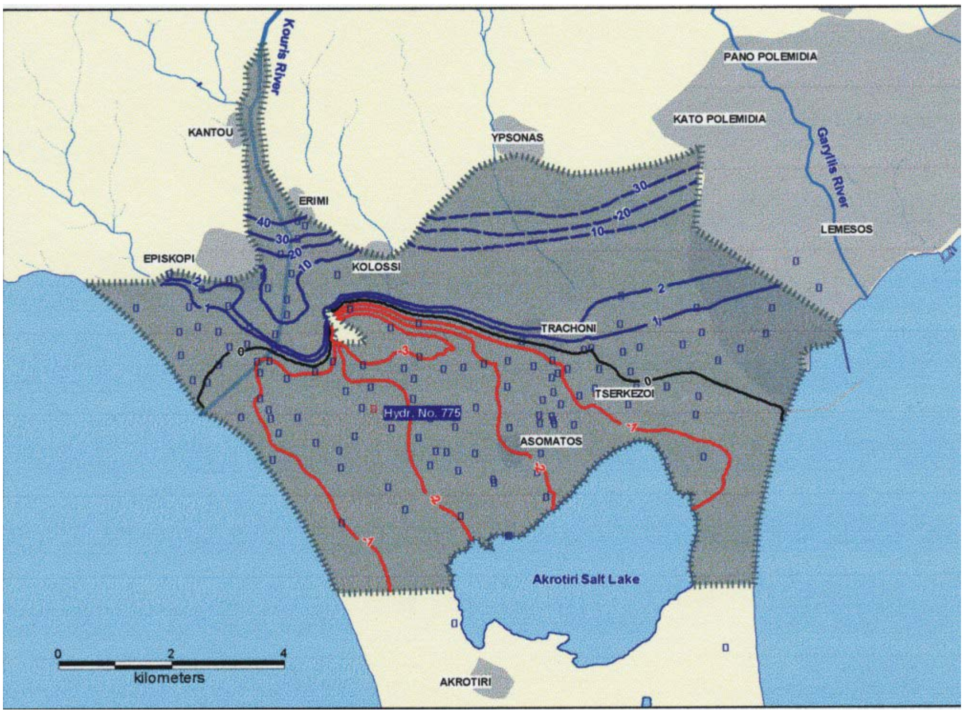

Figure 36. Akrotiri Aquifer - Water Level (m amsl) Contour Map March 2001

Anthropogenic intervention has changed dramatically the hydrologic regime in the area especially after the construction of the Kouris dam. The average water balance over the period of 1967/68 – 1976/77 compared to present conditions is shown on the Table below (All in Mm^3/yr).

Table 18. Recharge

Kouris dam was constructed in 1987	Rainfall	Riverbed Recharge	Subsurface Inflow	Sea	Return from irrigation	Return imported / Diversions	Artificial Recharge	Total	Remarks
Before (1968-1978)	5.9	15.4	4.2	0.7	4.5	3.5		34.2	Average rainfall 395 mm
At present	4.2	0.5	0.2	3.0	1.1	0.7	3.3	13.0	Average rainfall 380 mm

Table 19. Outflow

	Abstraction for irrigation and domestic	Evapotranspiration	Rising water	Sea/ Lake Outflow	Total	Remarks
Before (1968-1978)	14.5	2.5	2.2	16.0	35.2	
At present	10.8	2.4	0.3	0.5	14.0	

From the balance above one should note the very small quantity of groundwater that outflows from the system at present and which does not provide the required leaching effect, the reduction of rising water that affects the marshland, and the increase in sea intrusion quantities which although they are considered as part of the "recharge", the resulting true balance is in effect negative and of the order of 4 Mm^3 per year.

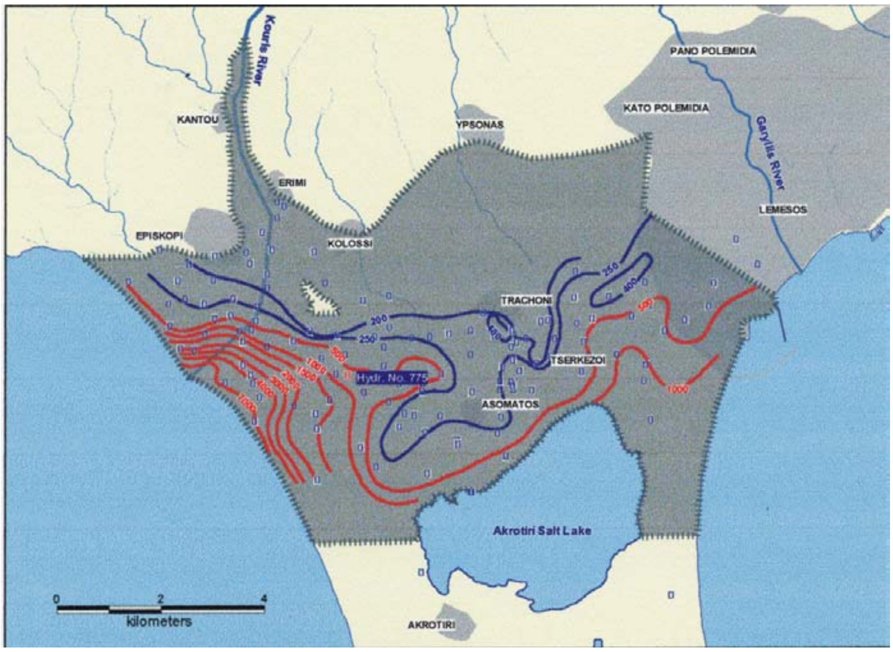

Figure 37. Akrotiri Aquifer - Isochloride (ppm) Contour Map April 2001

I.4.3. Germasogeia

The Germasogeia catchment is in the southern coast of Cyprus. It is about 141 square kilometres up to the Germasogeia dam of 13.1 million cubic meters capacity. Its average annual flow is about 20 million cubic meters. A major part of the catchment is covered by natural forest but considerable agricultural activity is present in riparian land. The annual and seasonal crops irrigated from the various sources of water are shown on Table 21 that follows.

Table 20. Annually and Seasonally Irrigated Crops (in hectares and Mm^3)

Germasogeia Watershed (in relation to Dam)	RIVER		SPRINGS		WELLS/BH		TOTAL	
	Area	Water Use	Area	Water Use	Area	Water Use	Area	Water Use
Upstream	295	2.5	78	0.8	16	0.2	386	3.5
Downstream	304	3.0					304	3.0

There are 14 village communities within the watershed with a total permanent population of just over 10000 and water demand of 0.5 to 0.7 Mm^3 per year, of which 12 villages are upstream the dam with a population of about 4000. There is considerable tourist development at the coastal area with an estimated 0.5 million-guest nights and a water demand of 0.9 Mm^3 during the tourist season.

Downstream the dam a riverbed aquifer develops. This is a typical river alluvial aquifer.

This aquifer, which is 5 km east of Limassol town (Figure 38), has a length of 5.5 km and an average width of about 350 m. This phreatic aquifer consists of sandy gravels with low silt content except towards the coast where an increase of finer material is noted. The thickness in the deepest part varies from 35 meters near the dam to 50 meters near the coast. The permeability in the upstream part of the aquifer is as high as 300 m/d reducing to 100 near the Delta. The specific yield varies from 13 to 22%. The active storage of fresh water is of the order of 3.5 MCM increasing to 5.0 MCM at high water table.

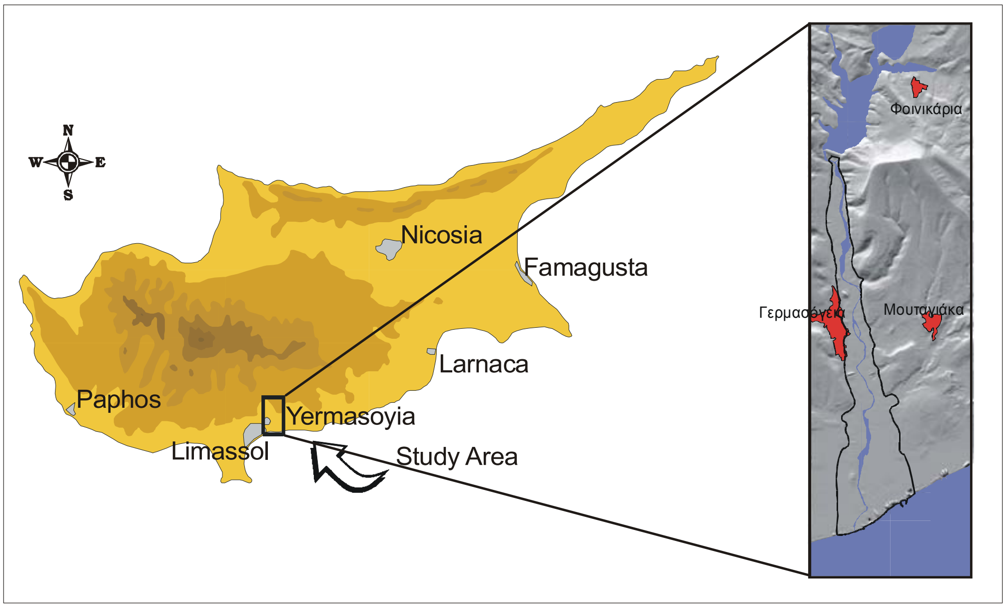

Figure 38. Location of the Germasogeia watershed (the part downstream the dam)

The small aquifer between the surface reservoir and up to 4 km downstream, before the development of the Delta area, has been relied upon to meet the major portion of the increasing demand for the water supply of the town of Limassol and neighbouring villages with high seasonal demand due to tourism.

Since the construction of the dam in 1968 the recharge of the aquifer depends on controlled releases from the dam and its spills. During the last ten years the dam spilled only twice, in 1993 and 1995.

The complete cut-off of natural replenishment by the construction of the dam and the proximity to the sea, coupled with the increasing extraction from the aquifer, requires a coordinated programme of releases from the dam for artificial recharge to cope with the extraction. With such action the sea intrusion is controlled and at the same time an efficient use of the scarce water resources is made.

The need for controlled releases from the dam to artificially recharge this aquifer through flooding in the active channel became a necessity by 1982 due to the increasing demand for domestic supply and the rather dry conditions experienced at the time. This conjunctive use of the surface and groundwater reservoirs enabled a dramatic increase in the extraction from this aquifer deferring the need for an expensive treatment plant for many years.

The extraction was doubled due to an equivalent increase of recharge. It is important to note that with the regulated releases of water and the resulting recharge the annual extraction in many years was about three times the active storage of the riverbed aquifer.

In the early days of the recharge, large quantities were released at irregular time intervals. Gradually, the daily release quantities were being reduced and the length of the period of release was increased.

Since 1986, the release is practically continuous and at such rates that the losses to the sea through the subsurface are minimal.

The rates of release are of the order of 15 to 25 000 m^3/d whilst the total groundwater inflow to the main well-field serving Limassol is in the range of 18 to 30 000 m^3/hr.

Chemically the groundwater is similar to that of the water in the surface reservoir. Bacteriological analyses from all the boreholes show that the 10 to 20 meters of unsaturated thickness of alluvial sediments provides an efficient protection to bacteriological pollution.

In the Delta area and near the coast the interface has remained practically stable showing that the recharge-extraction regulation has been of the correct order without excessive pumping or serious subsurface loss of fresh water to the sea.

In effect the small Germasogeia riverbed aquifer has been turned into a natural treatment plant for domestic water supply without the need of complicated and expensive surface water treatment requiring chemicals, qualified technical and managerial personnel and the necessary civil engineering structures. Surface water from the Germasogeia and Kouris dams is being released in the riverbed since 1982 for recharge of the aquifer. Groundwater is pumped for the domestic water supply of the Limassol town, for the surrounding villages, and the tourist zone. This aquifer is the only source of domestic water supply of the local village communities and the tourist zone.

The catchment area has extensive hydrometeorological, geological and hydrogeological data as well sufficient surface and groundwater quality data. It constitutes an excellent case study for evaluating drought conditions and their repercussions on the hydrologic regime and to the socio-economic environment of the area. In the aquifer area some 46 boreholes are monitored every 15 days and conductivity logs are kept for 10 boreholes for monitoring the sea/fresh water interface. The extraction from all wells and boreholes is monitored monthly my water-meters. The releases for recharge are monitored on a daily basis. A good database and GIS as well as groundwater models exist for the area.

The Germasogeia water resources system (surface reservoir and aquifer) is the most intensively exploited one in the island. In 1996 up to 9 Mm^3 of groundwater were extracted from this small aquifer, whose area is only 3 km^2 and its total fresh water capacity at average groundwater level conditions, is in the order of only 3.5 Mm^3.

A fast growing urbanization within the aquifer area and tourist development is causing concern about the environmental impact and possible deterioration of the quality of groundwater in this highly susceptible aquifer.

The hydrogeological regime and the water balance of the aquifer are "regulated" by controlled releases from the dam into the river valley. The main targets are:

- To cover water demand with groundwater of acceptable quality,
- To protect the aquifer from sea intrusion,
- To minimize groundwater losses to the sea and to
- Maximize the water availability through conjunctive use of surface and groundwater.

Some 23 boreholes operate in the aquifer today for domestic water supply. The yields of these boreholes vary from 50 to 200 m^3/hour. Annually, the average extraction is about 6 Mm^3, whilst the average artificial recharge is about 5 Mm^3.

The water balance of the aquifer is quite good and no problems of sea intrusion are faced provided there is ample water in the surface reservoir for recharge and the groundwater extraction is contained within the capabilities of the system.

The sustainable extraction under natural conditions i.e. with no artificial recharge of the aquifer is estimated to be of the order of 1.4 Mm^3/year based mainly on the leakages from the dam.

Figure 39 shows the location of the surface reservoir and the aquifer whilst Figure 40 shows a typical groundwater level fluctuation. The cycles of increased recharge or extraction are quite obvious on this hydrograph. Figure 41 shows the groundwater contours in the area, especially as these develop around the main well-fields and near the coast.

Table 21. Recharge

Germasogeia dam (13Mm^3) was constructed in 1968	Rainfall and Return from irrigation /domestic	Riverbed Recharge	Leakage from dam	Sea intrusion	Artificial Recharge	Total	Remarks
(1982– 1987) average rainfall 430 mm	0.4	0.5	1.8	0.0	3.6	6.3	By A. Christodoulides
(1991-2000) average rainfall 400 mm	0.5		1.0	0.1	5.1	6.2	By A. Georgiou

Table 22. Outflow

	Abstraction for domestic	Sea Outflow	Total	Remarks
(1982– 1987) average rainfall 430 mm	5.6	0.7	6.3	By A. Christodoulides
(1991-2000) average rainfall 400 mm	6.4	0.3	6.7	By A. Georgiou

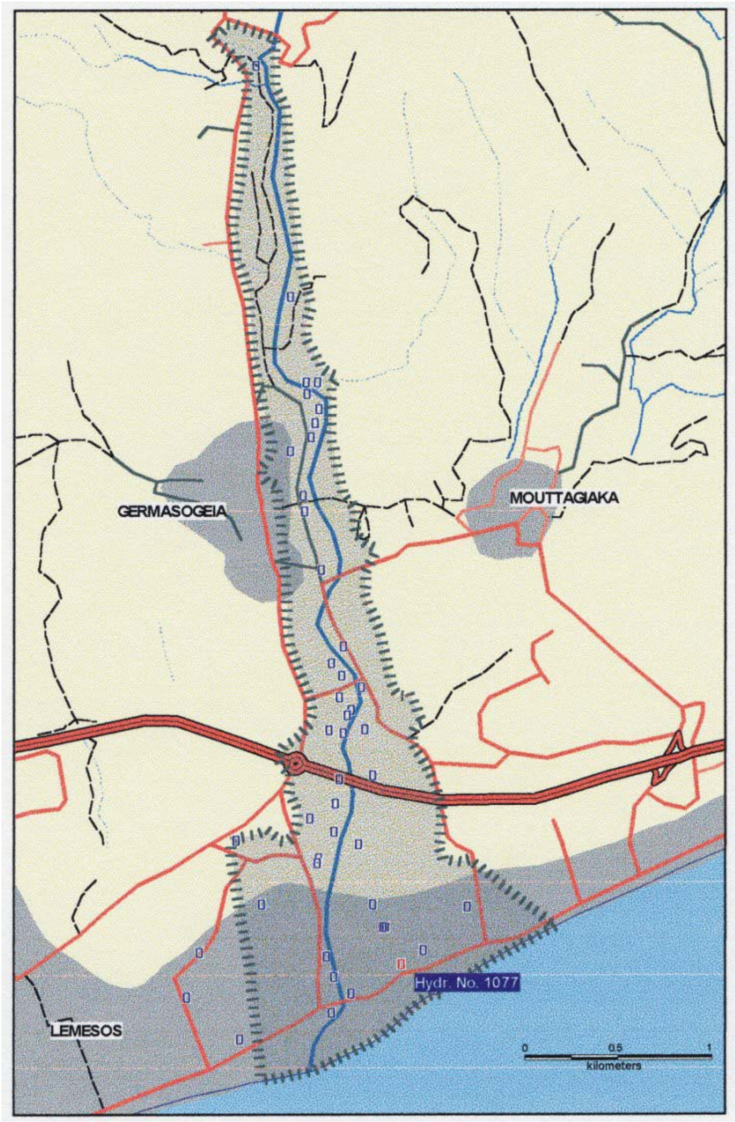

Figure 39. Germasogeia Riverbed Aquifer - Location Map

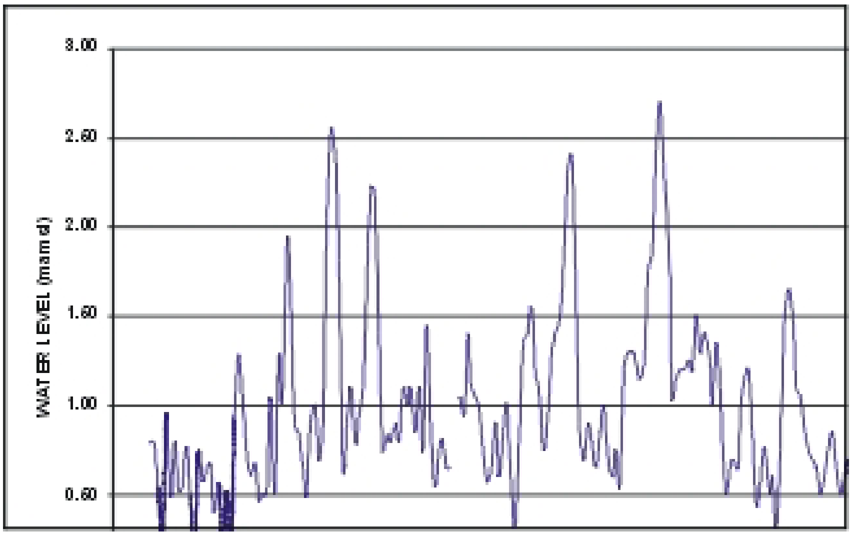

Figure 40. Hydrograph of borehole Germasogeia 1077 (Elev. 4.98 m amsl)

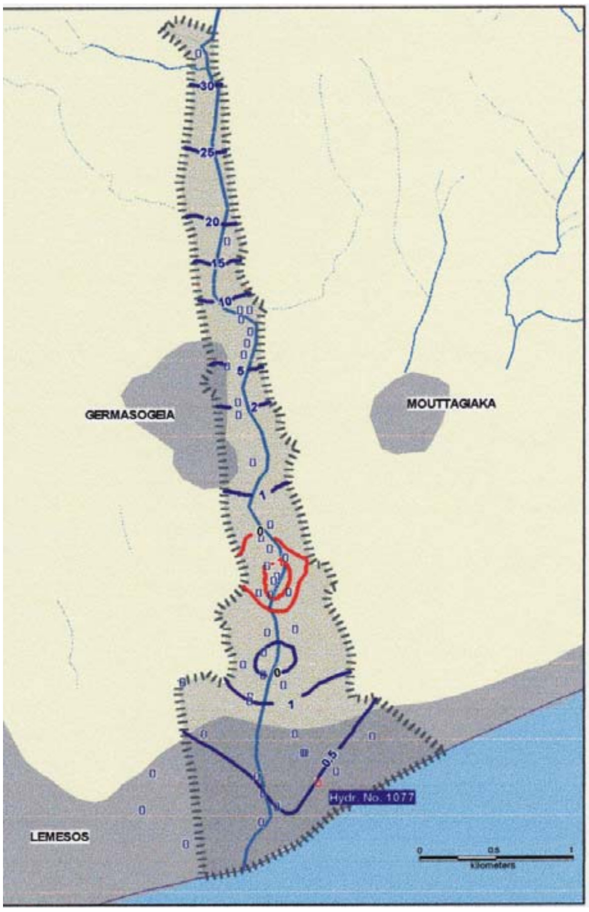

Figure 41. Germasogeia Riverbed Aquifer Water Level (m amsl). Contour Map November 2001

I.4.4. Kokkinochoria

The area includes five village communities and three municipalities with a total permanent population of 30000 and an annual water demand in excess of 1.7 Mm^3. Two areas near the coast (Paralimni and Agia Napa) have developed to a very attractive tourist resort with tourists exceeding 6 million-guest nights and a water demand of about 3 Mm^3.

The Kokkinochoria area being at the lee-side and far from the Troodos Mountains receives the lowest rainfall in the island, the long-term average being 330 mm per year. There is no stream crossing the area except during storm events in winter due to local storms.

The local aquifer has been overexploited since the early 1960s and the groundwater mined is in excess of 350 Mm^3. At present the groundwater reserves are only 15% of the original. Water levels in the aquifer within 2 km from the coast have dropped to 50 m below mean sea level.

The region is an early-potato producing area with most of the produce being exported to the UK and elsewhere. The past agricultural activity in the area has been maintained by importing water through the Southern Conveyor Project from the Kouris Dam some 70 km to the west. A total of an annual supply of 17 Mm^3 has been envisaged which together with the local safe yield of 8 Mm^3 would allow the continuation of the agricultural activity in the area. This has been accomplished, although the extended drought of the last decade did not allow the transfer of the quantities envisaged. This did not have devastating repercussions since a lot of the workforce shifted in the meantime from agriculture to other employment associated with the locally thriving tourist industry. Nonetheless, both the soils and farming experience in the area is a resource that should be exploited to its maximum and the conditions need to be established in the area to allow the continuation of potato production for the benefit of the economy of the island.

There exists good hydrogeological information for the area with some 164 wells being monitored for water levels since 1964 every three months (see Figure 43 and 44). Water quality surveys are carried out seasonally to check the propagation of the sea-intrusion (see Figure 45).

In the Table that follows an estimated water balance of the Kokkinochoria aquifer is presented for two periods: 1963-78 and for 1990 to present.

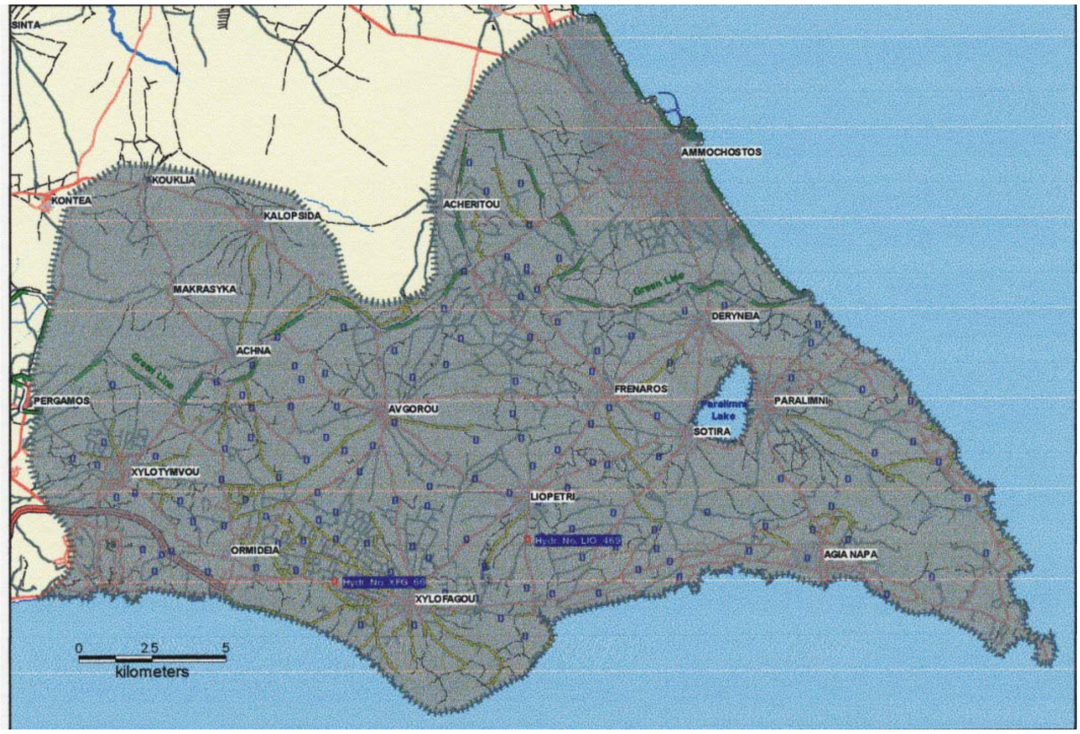

Figure 42. The general area and the Kokkinochoria aquifer

Table 23. Recharge

Southern Conveyor Project completed in 1987	Rainfall	Subsurface Inflow	Sea intrusion	Return from irrigation	Return imported / Diversions	Total	Remarks (aquifer area 172 sq. km)
1963-1978 (SCP study – Iacovides)	8.2	1.1	2.9	4.7		16.9	Average rainfall 330 mm
At present (FAO study – Georgiou)	8	0.1	5.5	0.5	1.6	15.7	Average rainfall 300 mm

Table 24. Outflow

	Abstraction for irrigation and domestic	Sea Outflow	Total	Balance
1963-1978 (SCP study – Iacovides)	27.1	0.4	27.5	–10.6
At present (FAO study – Georgiou)	14.0	1.5	15.5	+ 0.2 *3

The most productive parts of the aquifer (Ormidhia, Xylophagou, Liopetri, Phrenaros), have been sea intruded and abandoned since the early 1980s. The less productive parts are already depleted with dramatically reduced borehole yield.

It is estimated that over 5000 boreholes operate in the area today. Yields of these boreholes have reduced from an average of 10 m^3/hour in 1980 to 1 to 2 m^3/hour in 2000. Boreholes with yields of 2-3 m^3/day are still in operation. In effect the farmers are rapidly and inexorably drying out the aquifer. A rough estimate of the average annual extraction during the past 10 years is estimated to be around 12 to 14 Mm^3.

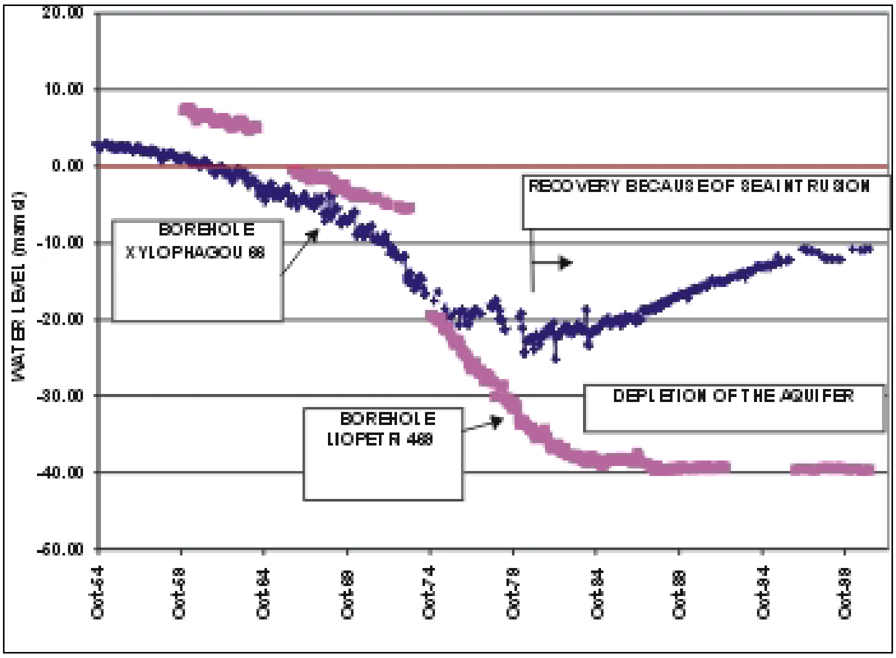

Figure 43. Hydrograph of boreholes Xylophagou 66 and Liopetri 469 (Elev. 52.61 and 30.74m amsl)

[3] The annual balance would be – 5.3 Mm^3 if the sea intrusion is considered.
The recommended annual pumping from this aquifer is only 8 Mm^3

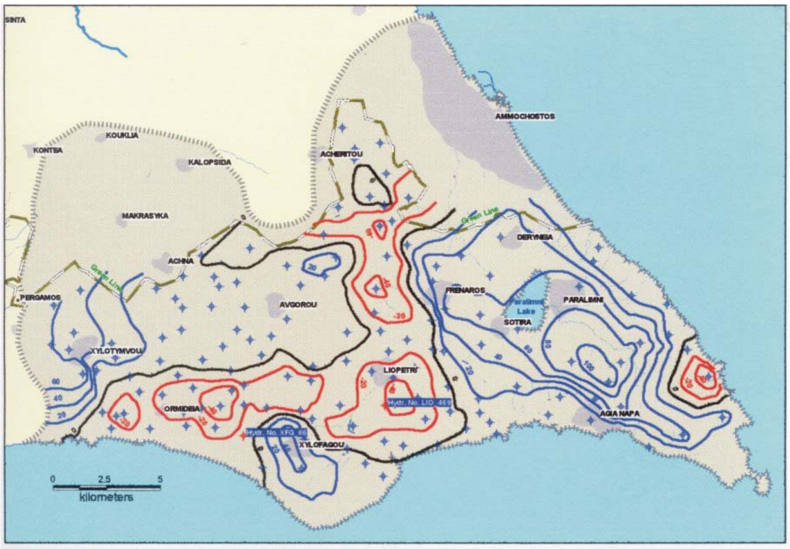

Figure 44. Kokkinochoria Aquifer - Water Level (m amsl) Contour Map Sept. 2000

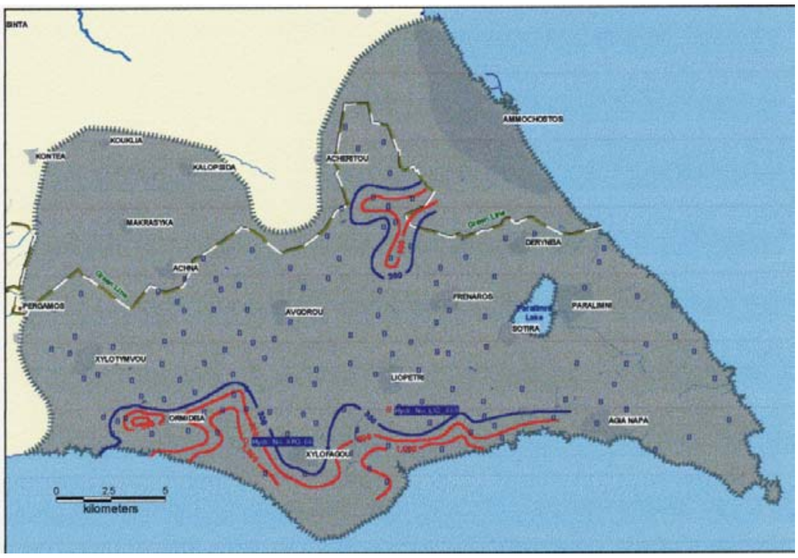

Figure 45. Kokkinochoria Aquifer Isochloride contours (ppm) for June 1994 (after Georgiou)

I.5. Regional reports for Spain

I.5.1. Selecting the Regions

Among the areas and regions affected by water resource deficiency, which fall within the arid and semiarid areas scope, two spaces have been selected, in view of their representative social, environmental and economic features.

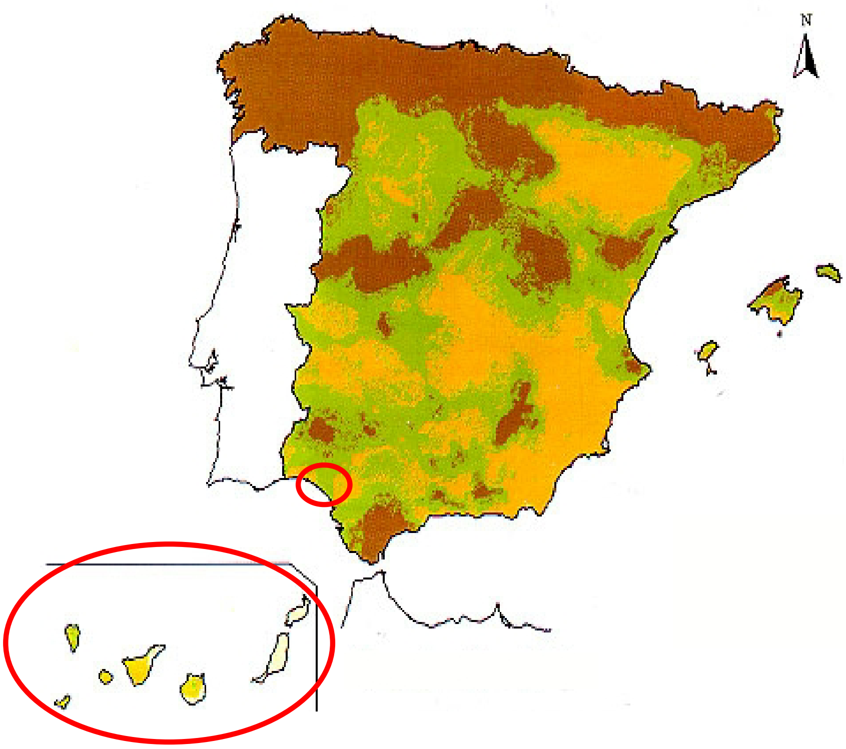

Figure 46. Selected regions

The Canary Islands. This region is made up by a group of volcanic islands with a land total area of 7,000 km^2 and a total population of 1,781,366 inhabitants (2001, INE). A large situation variability of water behaviour exists in the different islands. A large part of the archipelago's lands is subjected to drought conditions where disarrangements between resource availability and evolution of consumption progressively increase. The existence of intensive agriculture characterised by a high water consumption, the very rapid rise of population and the spectacular development of mass tourism create serious conflicts and risks with regard to water availability. Resorting to sea-water desalination, that was at a first beginning suggested as a complement and a security system to face supplying problems, is progressively turning to be the basis for water supply in the most arid islands.

Figure 47. Canary Islands

Doñana, region and connected hydrographic basins. The wide region of Doñana and its surroundings represents at present an authentic paradigm as regards water resource management, planning and assignment. It hosts the most important wetland of Europe, the Doñana National Park (Ramsar and World Heritage site), but at the same time its surroundings host a population of more than 100,000 inhabitants, whose activities (fundamentally recently introduced agriculture) progressively clashes with the requirements needed to maintain the seasonal water levels for the wetland conservation. The programme Doñana 2005 and the Sustainable Development Plans of the Doñana surroundings try to face the dilemma between conservation and development in a framework of water scarcity and progressive alteration of water tables in an area where quality of water, both for human consumption and for the conservation of basic ecosystems, is a serious problem.

Figure 48. Orthophoto of the Doñana region

I.5.2. Canary Islands

Due to their geographic localisation, close to the Tropic of Cancer, the Canary Islands are under the influence of the trade winds, originated by the circulation of air masses around the anticyclone of Azores. Air-layering caused by trade-winds generates a characteristic layer of stratocumulus clouds on the northern coast of the higher islands, which occur between 500 m and 1,500 m. Humidity condensation in these areas involves a complementary water contribution, saving the western Canary Islands (higher than 500 m) from extreme aridity conditions.

In spite of that, the Canaries are poor in freshwater resources. The extent of their own freshwater resources, 177 m^3 per inhabitant per year, place them in the last place within the Spain classification by hydrographical river basins, and this number is very far from the national average of 1,389 m^3/pers./year. With a population near to 1.5 million inhabitants, the islands host every year more than 10 million tourists whose average daily water consumption is of 350 l/pers./day (Insular Hydrologic Plans). This increasingly pronounced difference between resource availability and consumption is one of the present-day most relevant characteristics of the archipelago. Rainfall in the Canary archipelago is very scarce (an average of 310 l/m^2/year) and irregular, both in time and space.

Topographic difficulties and permeability of the existing geologic materials lead to the exploitation of only a minimum share of the surface water resources. It is explanatory enough that the volume of water retained by the some 100 dams built to this end (41 hm^3/year), only reaches the 33% of their total capacity.

A relevant feature of underground water management is the fact that they are private property, a singularity in Spain. This market is subjected and regulated by the Canary Islands' Water Law (12/1990).

Another important feature that affects especially the Eastern islands is the progressive dependence from desalinated water, which is greatly increasing every year. An extreme case is the island of Lanzarote, where 97% of water supply is from desalination (the maximum security forecast of the system is 5.4 days). The progressive energy conception of water in the Canaries is reflected by the fact that in the year 2000 almost 15% of available power in the grid was directed to this aim.

Agricultural consumption is a priority on islands like La Palma and El Hierro, reaching the 80% of total consumption. On the main islands (Tenerife and Gran Canaria), where the greatest part of population is concentrated, urban and tourist consumption have greater protagonism. In the minor islands of the archipelago with a strong tourist penetration, tourist water consumption is progressively approaching the urban one (Lanzarote and Fuerteventura).

One of the most distinctive features of water consumption for agriculture refers to the generalised presence of intensive crops characterised by a high demand. Banana plantations –representative crop and main consumer of water in the Canary archipelago- are characterised by water demands around 11,350 and 14,850 m^3/Ha/year. These crops receive subventions in the framework of the European Common Agricultural Policy and are important producers of landscapes that have progressively reached a crisis point, similarly to other productions, because of conflicts with tourist and urban water demand and the as a consequent rise in water price, since the private character o the canary water market.

The unforeseeable population growth of the last years causes strong uncertainty as regards water resource planning. In only five years the foreign population growth doubled the natural growth rate. A similar tendency is detected in the tourist sector, where the tourist lodging capacity has practically doubled itself in the period 1998-2001.

As regards sewerage, we also find important deficits, especially among the dense scattered settlements of the islands, which directly influence underground waters due to contamination of aquifers. Only the two main islands rely on acceptable grids although they also have significant deficiencies in specific settlements. The remaining ones have serious deficiencies regarding sewers or pour too large quantities of surface or underground wastewater.

With regard to water treatment, serious competency conflicts have also been detected in tuning and maintenance of the treatment systems that at present have a very low operational rate (close to 30%). Scattered treatment plants are a distinctive feature of the Canary situation. Price policy of treated water, public owned, is also characterised by its variability and inconsistence. In Tenerife, as an example, the price of treated water treated to a third stage is 0.36 €/m^3 while that treated to only a second stage is 0.31 €/m^3, while in Gran Canaria prices are around 0.12-0.15 €/m^3, clearly below cost.

Water quality for urban supply followed a descending curve in the last years. Following-up carried out by the different hydrological plans detects negative effects in the quality of underground waters, to which it must be added those derived from hydrogeologic situations that present specific aquifers characterised by a high fluor content.

Public management, especially the local one, faces serious difficulties for a sufficient and efficient implementation. Difficulties have to do with, from the one side, budget origin and destination, without forgetting financial collection; from the other side with the politic price of cost transfer to users, the progressive rise in price of the higher number of services required and, lastly, with the population to serve, characterised by a very high growth rate or by depopulation. All this has an influence on scale economies or diseconomies.

The studies: SPA-15, Canarias Agua 2000, Mac 21, advances of several Insular Hydrological Plans, Canary Islands Hydrological Plan, constitute the basic list of planning actions in the matter of water carried out in the Canary Islands in the last 25 years.

Within this context, the strategy of the Canary Islands Hydrological Plan is founded on the following principles:

- To promote a sustainable use of water resources on the basis of a medium-large term planning.
- To protect water ecosystems as an essential principle for a sustainable development.
- To guarantee a qualitatively and quantitatively appropriate water supply to achieve a sustainable development.
- To achieve the economic efficiency of water offer and use compatibly with social and environmental dimensions.
- Congruence between economic and environmental criteria and the design of an integrated management system, with a prudent use of regulatory and market processes.
- To advance in setting up innovatory and realistic policies on endowment and prices.
- To these criteria some considerations of the Infrastructure Director Plan within the section regarding water resources:
- To improve knowledge about natural resources, setting up an automatic control network within the whole region that allows the following-up of comparable data

and the establishment of a sound basis to achieve and maintain a sustainable use of the public water domain.

- To protect quality and guarantee renovation of the different sources of production.
- To optimise the implementation of systems for non-conventional resource production.
- To intervene in sewerage and supply infrastructures.

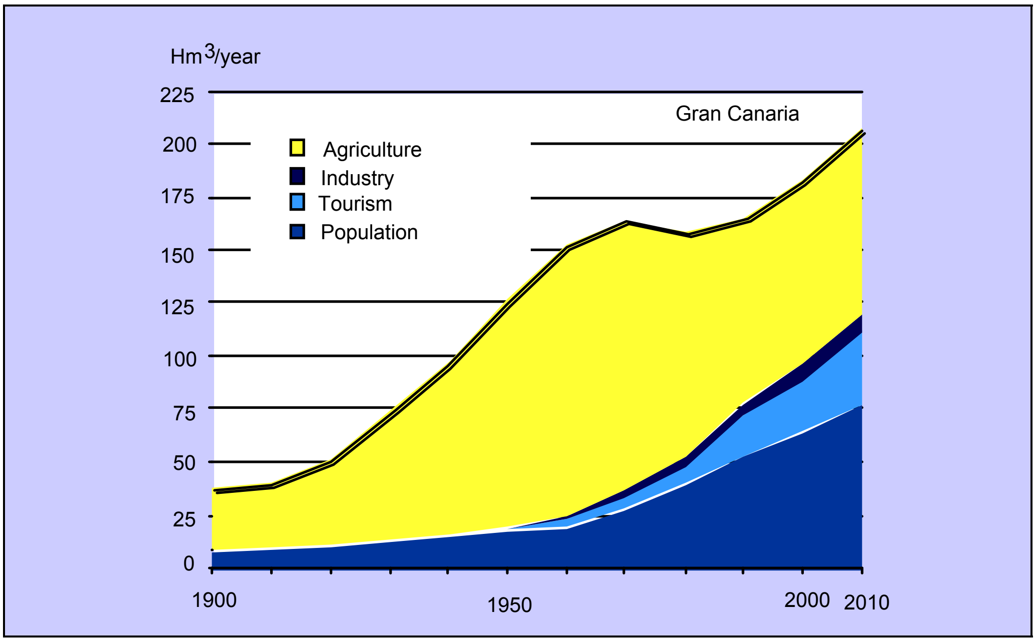

Figure 49. Evolution of water demand (perspective – year 2000) Source: Canary Island Water Centre

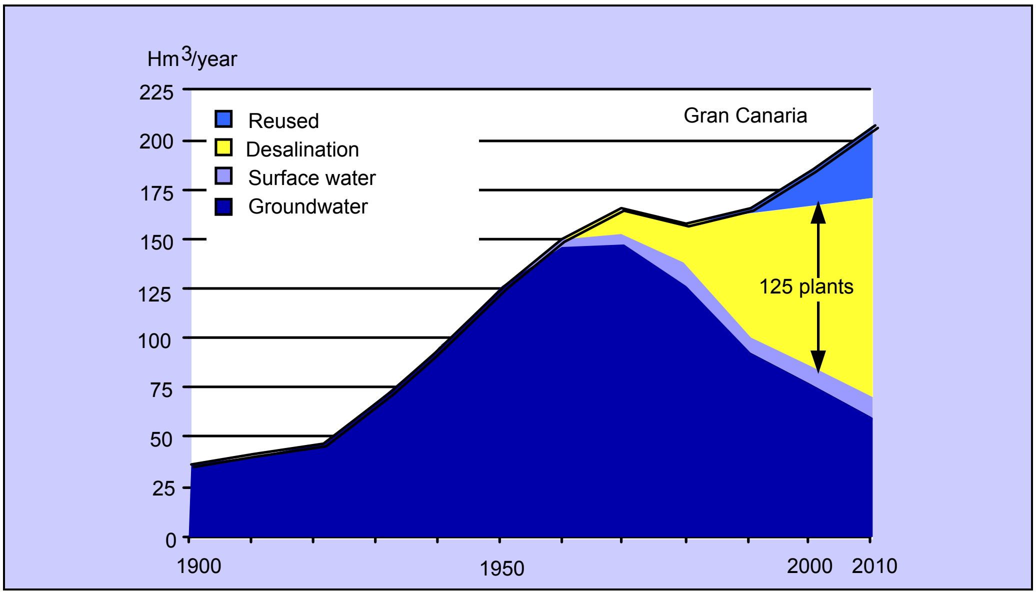

Figure 50. Evolution of water production (year 2000 perspective) Source: Canary Island Water Centre

Table 25. Water Balance

Concept/Island	FUERTEVEN (1)		LA GOMERA		GRAN CANARIA		EL HIERRO		LANZAROTE		LA PALMA		TENERIFE	
	hm^3	%	hm^3	%	hm^3	%	hm^3	%	hm^3	%	hm^3	%	hm^3	%
Precipitation	16	100	140	100	466	100	95,3	100	127	100	518	100	865	100
Evapotranspiration	s.d.	-	69	49,3	304	65	69	72,4	122,2	96	238	46	606	70
Surface water	4	25	11	7,8	75	16	0,3	0,3	1,3	1	15	3	20	2
Infiltration	12	75	60	42,9	87	19	26	27,3	3,3	3	265	51	239	28
Sources: Advance of island hydrological plans. 1. Island Plan of Fuerteventura s.d.- without data available														

Table 26. Water Balance

	FUERTEVENT		LA GOMERA		GRAN CANARIA		EL HIERRO		LANZAROTE		LA PALMA		TENERIFE	
PRODUCTION	hm^3	%	hm^3	%	hm^3	%	hm^3	%	hm^3	%	hm^3	%	hm^3	%
Surface water Small dams	2,6	21,3	3,4	24,3	11	8,5	-	-	0,07	0,7	5	7	1	0,5
Groundwater	5,3	43,5	10,6	75,7	98	75,4	1,45	100	0,2	2,3	68	93	211	99,5
Desalination	4,3	35,2	0	-	21	16,1	-	-	9,6	97	0	-	0	-
Re-use	-	-	0	-	0	-	-	-	s.d.	-	0	-	s.d.	-
TOTAL	12,2	100	14	100	130	100	1,4	100	9,9	100	73	100	212	100
Sources: PPHH of La Palma, La Gomera and El Hierro. Hydrological Plans of Tenerife and Lanzarote;" Las Aguas del 2000" - and PIO Fuerteventura. s.d.- without data available														

Table 27. Water consumption by category

	FUERTEVENT.		LA GOMERA		GRAN CANARIA		EL HIERRO		LANZAROTE		LA PALMA		TENERIFE	
CONSUMPTION	hm^3	%	hm^3	%	hm^3	%	hm^3	%	hm^3	%	hm^3	%	hm^3	%
Irrigation - Agriculture	8,4	61,8	6,1	43,3	75	58	1,2	85,7	0,3	6	58	79,5	109,2	52,7
Domestic and Services	2,7	19,8	6	42,6	38	29	0,2	14,3	2,4	52	6	8,2	62,7	30,2
Tourism	2,5	18,4	-	-	15	11	-	-	1,4	31	-	-	14,1	6,8
Industrial	-	-	2	14,1	2	2	0	-	0,5	11	2	2,8	5,3	2,6
Resources nonused	-	-	-	-	-	-	-	-	-	-	6,9	9,5	4,5	2,2
Distribution losses	-	-	-	-	-	-	-	-	-	-	-	-	11,5	5,5
TOTAL	13,6	100	14,1	100	130	100	1,4	100	4,6	100	72,9	100	207,3	100

Sources: PHH La Palma, La Gomera, El Hierro, Tenerife and Lanzarote; "Las Aguas del 2000".

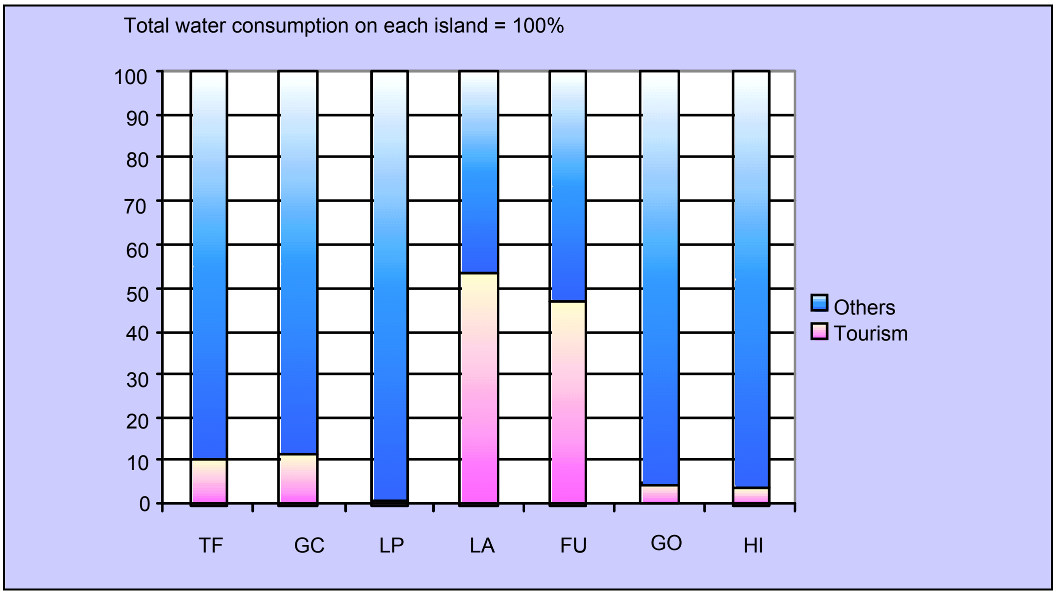

Figure 51. Percentage water consumption of the tourist sector on each island. Source: Canary Island Water Centre

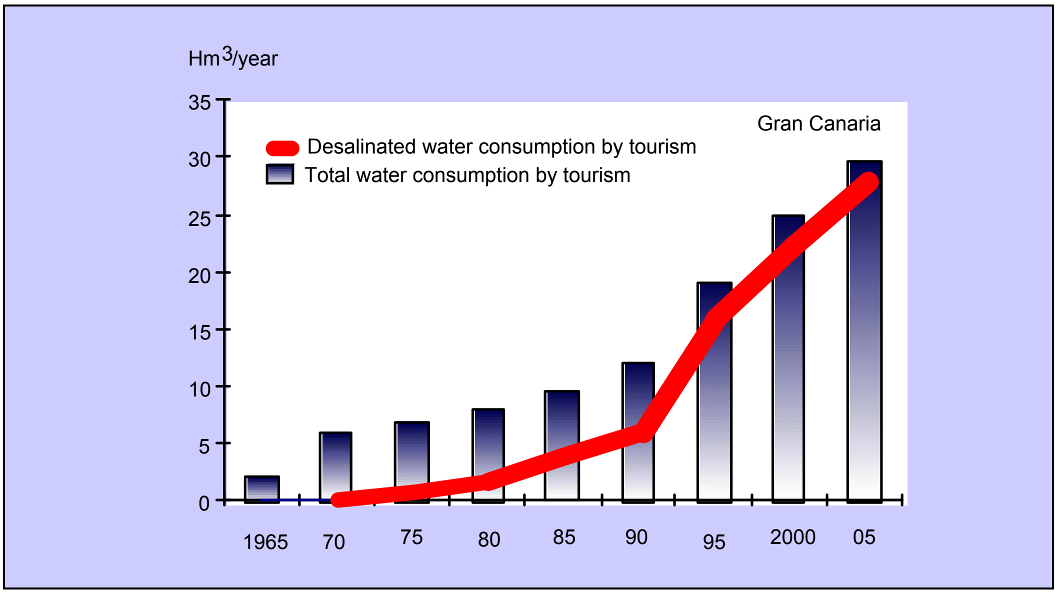

Figure 52. Tourism water supply and desalination. Source: Canary Island Water Centre

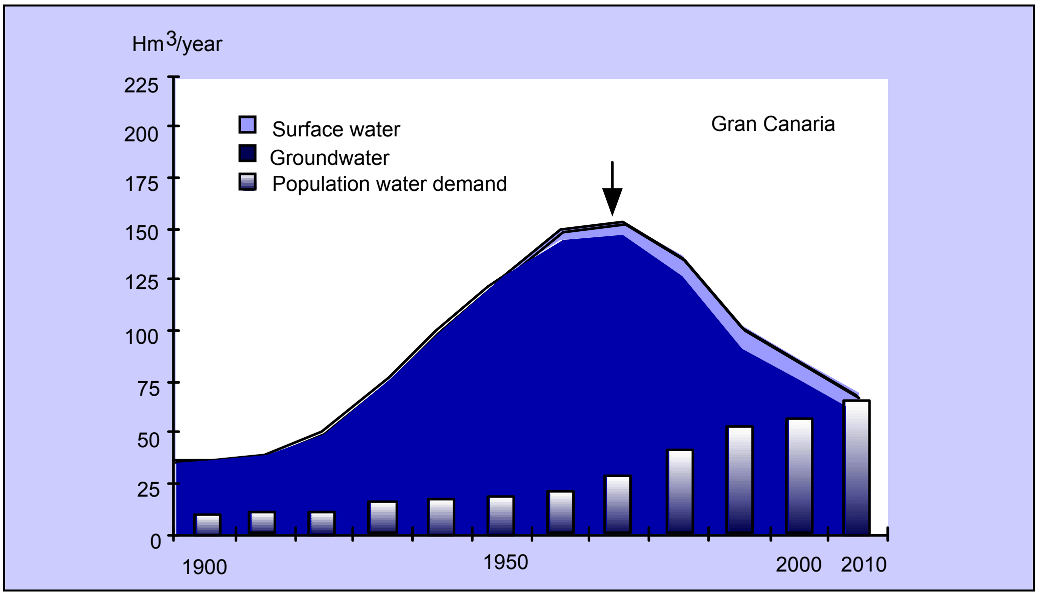

Figure 53. Evolution of water production and population demand (perspective). The case of Gran Canaria. Source: Canary Island Water Centre

Table 28. Growth in tourist accommodation. 1986-1996. Canary Islands. Source: White Paper on Canary Island Tourism. 1998

Year	Tourists	Rooms
1986	4,169,050	201,493
1987	5,068,242	251,067
1988	5,416,652	308,177
1989	5,352,205	343,559
1990	5,459,473	364,269
1991	6,136,990	375,995
1992	6,327,112	337,482
1993	7,551,065	337,975
1994	9,256,817	330,614
1995	9,693,086	324,124
1996	9,804,540	328,254

I.5.3. Doñana

Doñana and its surroundings constitute a natural space featuring the widest variety of pressures regarding the use and assignment of water resources. As a territory in which the most important European wetlands coexist, the National Park of Doñana includes areas of rice fields, intensive crops and a considerable tourist activity, mainly concentrated on the coastline.

Doñana could be considered to be an excellent laboratory for studying the management of water resources, a place where all the preservation and development strategies applied during the last decades share the difficulties of managing water resources.

Regarding the policies of preservation and management of water resources, the plans have entirely focused on the National Park of Doñana. With an area of more than 50 thousand hectares, Doñana is one of the world's most emblematic coastal wetlands. Apart from being a Ramsar site and a Special Protection Area for birds, the National Park of Doñana was declared a Biosphere Reserve in 1980, and was inscribed on the World Heritage List in 1994. The Biosphere Reserve includes a buffer zone of 26 thousand hectares, summing a total of 77,260 hectares. Doñana belongs to the small group of coastal wetlands within the three categories, together with San San-Pond Sak (Panama), Palawan (Philippines), Danube Delta (Romania-Ukraine), Ichkeul (Tunisia) and Everglades (USA).

Around this sanctuary of the European biodiversity is the Natural Park of Doñana and its Surroundings, located in the municipalities of Almonte, Hinojos, Lucena del Puerto, Moguer and Palos de la Frontera (province of Huelva), Sanlúcar de Barrameda (province of Cádiz), Puebla del Río, Aznalcázar, Villafranco del Guadalquivir and Villamanrique de la Condesa (province of Seville). This extended list is representative to the administrative and territorial complexity of the area.

The territory occupied by Doñana's basins, which also includes the National and Natural Parks, holds over 180,000 permanent inhabitants. The figures indicate a considerable increment compared to the 128,000 inhabitants registered in 1981. More than 60% of the employment is concentrated on the agricultural sector, and another 25% is devoted to the service sector, which is mainly focused on tourism.

The agricultural development in the area arrives at a later stage due to its hard conditions: the XIX century witnessed a series of failed efforts oriented to drying the salt marsh. By the end of the 1920's, the area devotes itself to massive rice crops, which nowadays occupy over 35,000 ha, thus becoming a factor of pressure for the National Park.

After this episode, in the 1970's, the FAO generates a report that results in the creation of a Plan for Agricultural Development in Almonte-Marismas (decree 1194/71), driven by a development-oriented mentality that resolves to declare it an Area of National Interest. This is the consolidation of 45,960 ha of crops; 30,000 of which correspond to irrigated land. This strategy is based on recognising the existence of an important water table in the area. Nowadays, the useful surface for irrigation sums up to approximately 14,000 ha.

Regarding the agricultural exploitation, we must highlight de importance of the strawberry trees, which occupy some 2500 ha, and constitutes a very concentrated source of employment. The exploitation of groundwater does not directly affect the water supply of the National Park, although it does affect the quality of underground waters, which sometimes feature nitrate concentrations of more than 50 mg/l.

The tourist activity, mainly concentrated on the area of Malascañas, located at the border of the National Park, is also a factor of pressure for water resources, especially during times of drought. Matalascañas offers a tourism capacity of 63,233 people, with a high level of concentration during the high season.

All these episodes resulted in an alteration of the water regimes, followed by a serious overexploitation of groundwater and manipulation of superficial water systems, which have seriously endangered the preservation of the National Park of Doñana.

This has lead to a progressive recognition of the fact that the preservation of the National Park is not only an obligation brought about by the need to preserve this important natural sanctuary, but also of the fact that Doñana is a patrimonial value which cannot be dissociated from the future economy of the area. This concern has resulted in the implementation of several strategies oriented to the sustainable management of water resources. In this sense, we must highlight the International Experts Commission's Report about the Development of Strategies for the Sustainable Development of Doñana in 1992. This report has inspired many of the principles for the alternative management of water resources during the last years.

But in 1998, Doñana faces one of its worst moments due to the breaking of a pyrite pond belonging to a mining exploitation, that caused the flooding of more than 2600 ha with high metal content muds. Although the muds did not reach the park itself, this accident caused red alert within all administrations and the whole society. After an impressive deployment of technical and human resources, the muds could be removed avoiding an ecological catastrophe with unforeseeable consequences.

What at the beginning appeared to be one more regrettable accident due to lack of planning and foresight in natural areas management turned to be the start of one of the most important wetland regeneration initiatives ever carried out in the whole planet. In reply to this situation, the big water regeneration programme named "Doñana 2005" was started, supported by the Spanish Ministry of Environment, whose immediate environmental actions were funded with some 140 million €. It is a project whose objectives are a lot more ambitious than providing the mere solution of the problems caused by the accident. It is also complemented by another important action called "the Green corridor of Doñana", supported by the "Junta de Andalucía" that will be carried out within the buffer zone.

Hydrological characteristics

The area is divided into two domains:

The salt marsh. Is a very plain area that combines periods of flood and drought. Its main sources of water are the rivers and tributaries and, in a smaller proportion, some few emergencies of underground water running through pipes.

The rest of the territory is basically made up of sand. This is the area where water precipitations overload the water table (called water table 27). It holds most of the water demanding activities.

On the overall system, the role and the alteration of underground waters is one of the fundamental problems for the management of this resource in the area. As in many other groundwater, overload is one the factors where estimations are more subject to error. The figures range from 50 to over 200 mm/year.

The challenges

The conflict between preservation and a balanced leverage of water resources in Doñana materializes with the solving and recognition of the following aspects:

The overexploitation of groundwater is seriously affecting natural areas of vital importance. The effects of overexploiting the underground waters in the ecosystems seem to be put off with the years. Nowadays, a great portion of the water table under the salt marsh has fallen from a 1-meter level over the ground to a 2-meter fall under its own level.

Overexploitation is starting to allow the entrance of the salty waters contained in the sediments of the salt marsh, with a considerable impact on the quality of waters.

The massive usage of fertilizers in the main agricultural activities has a devastating effect on the quality of the waters.

The organic contribution due to domestic tributaries also adds to the problem, since the network of cleansing stations is still to be completed.

The agricultural and industrial residues, especially the vegetable waters derived from olive manipulation, results in scattered episodes of contamination in large brooks.

The original water system of the salt marsh is deeply altered. For many years, a series of corrective actions have tried to balance the complex system of the salt marsh. A considerable part of the Doñana Programme 2005 is oriented to regenerating the hydrological systems for the basic functions of the salt marsh and its compatibilization with human needs.

I.6. Regional reports for Portugal

I.6.1. Selecting the Regions

Figure 54 presents Thornthwaite's aridity indices in the different river basins of mainland Portugal. According to it, three regions may be considered: a first one, north of Tejo, which can be considered humid, as precipitation exceeds evapotranspiration; a second one, sub-humid, in Douro's interior, and in some areas south of Tejo; and, a third one, arid, in Guadiana's basin, part of Sado's basin and Algarve region, where the ratio between precipitation and evapotranspiration is less than 0.5.

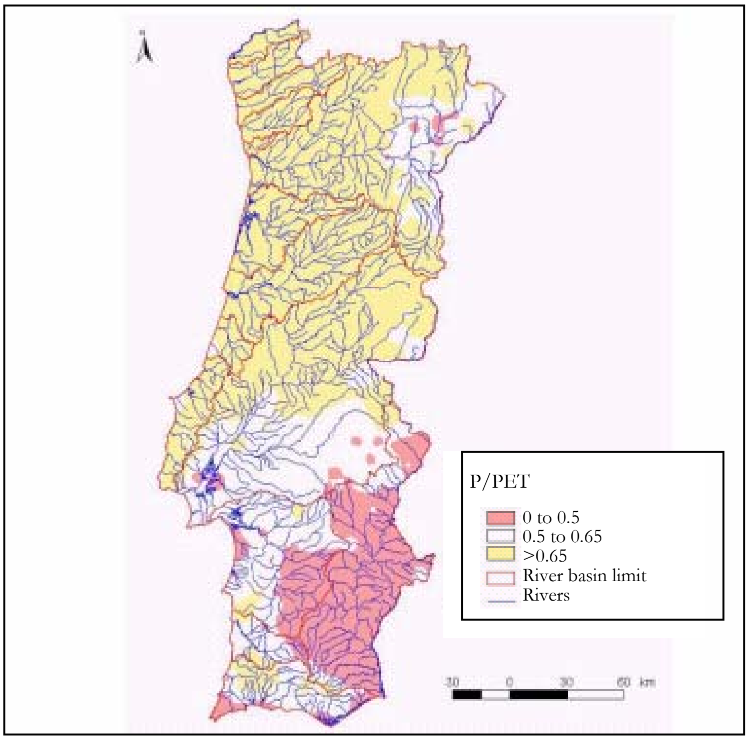

Figure 54. Thornthwaite's aridity index in mainland Portugal

The basins that are currently facing water scarcity problems, with the hydric balance not enabling to guarantee water supply for different sector uses, monthly and annually, are the ones located in the arid and sub-humid regions. That figure refers some of those basins coastal areas as having not been covered by the evaluation study. Nevertheless, that doesn't mean that those areas have no problems; on the contrary, those problems may be enhanced by that littoral position, not only because the population and/or industry is mainly located there as also due to tourism (mainly in Algarve regions).

Thus the three regions selected to be candidate regions are Sado, Guadiana and Ribeiras do Algarve basins, as shown in Figure 55. The main reasons for these three River Basins' water scarcity current situation are:

In the case of Sado, the main problems are related with the demands of water for irrigation (due to which Sado is the Portuguese river basin with the biggest storage capacity compared to annual mean flow) and for industry (mainly Sines' industry on the coast), and also with the demands of water for energy consumption (mainly due to cooling in thermo-electric power plants).

As to Guadiana's, the water deficit is due to the demands of water for irrigation, to the poor quality of the water available for the various uses and to Spanish flow regularization on summer/driest periods.

In the case of Ribeiras do Algarve, because all the region attracts a large number of tourists, especially in the dry semester and there is also a lot of pressure due to irrigation water uses. The increase in the water demand in the summer period leads to the point that the demand cannot be covered by existing infrastructure and water storage, although currently there is already an inter basin water transfer from Guadiana's basin (for irrigation and domestic water supply uses).

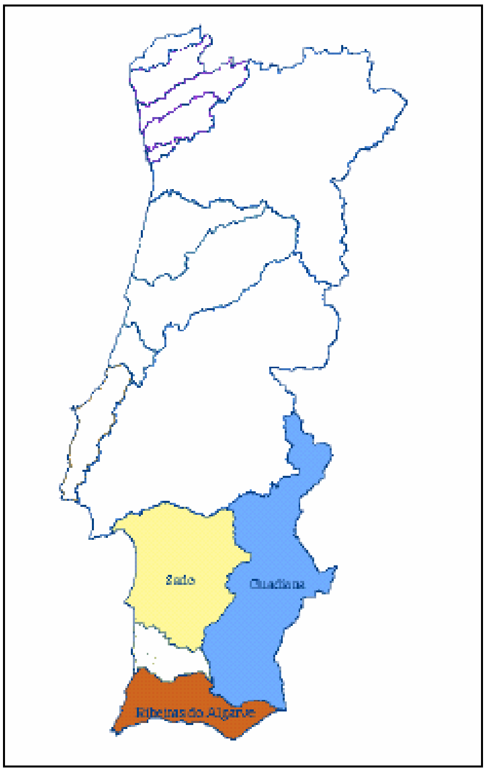

Figure 55. The Candidate Regions selected

These three regions will now be characterized as to their respective sets of circumstances, affecting water resources and management. The only available data in terms of average household income relates to 2000 and is made by great planning regions, thus joining namely Sado and Guadiana basins in the same area (Alentejo). The same correspondent value is then considered for those two basins (13562 €/year). Referring to the pricing system, the cost recovery and price elasticity will relate to the urban sector, looking for that main sector characterisation and also due to the lack of reliable data for the other sectors of activity.

Concerning to "Water Resources Management", the characterisation was done in "overall terms" and taking into account IRAR regulating (envisaged) authority and municipal responsibilities.

I.6.2. Sado

Sado's river basin has an area of 8,295 km^2 and its population is 292,960 inhabitants (1998), with a population density of about 35 inhabitants per km^2, a low value when compared to Portugal Continental territory value of 110 inhabitants per km^2. The region is mostly plain, except to some low mountains, with an overall average altitude of 127 m. In fact, the altitudes range from 50 m to 200 m in most of the area, with a maximum basin altitude of 501 m. Most of the area presents tertiary and quaternary deposits with formations mainly composed by limestone and sedimentary rocks.

The climate is Mediterranean temperate, with rainy winters and dry summers. The average temperature is of 16 ºC, and in the summer peak months (July and August), it varies from 19 ºC in the coastal areas to 24 ºC in the interior. In the coldest month (January) it varies from 9 ºC in the interior to 12 ºC in the coastal areas. The average annual sunshine duration is about 2900 hours. The average annual precipitation is 622 mm, ranging from less than 600 mm in the coastal areas to more than 900 mm on the mountains. About 78% of the precipitation is concentrated in the dry semester (between October and March) and occurs 75-100 days per year in the coastal areas and 50-75 days per year in the rest of the basin. As to potential evapotranspiration its yearly average is 1145 mm and it increases in the dry semester. Figure 56 presents the mean monthly precipitation and potential evapotranspiration in Sado's basin. The total runoff is 972 hm^3/year.

Sado has a storage capacity of 771 hm^3 which makes it the Portuguese river basin with the biggest storage capacity when compared to annual mean flow, and that reflects irrigation availability needs. The overall availability is currently, in average, of 1714 hm^3/year, consisting of 918 hm^3 of surface water (716 hm^3/year in dry years) and 796 hm^3 of exploitable groundwater. However there will be a big increase in the availability of surface water due to the foreseen inter basin water transfer of about 450 hm^3/year from Guadiana's basin when Alqueva new multi-purpose hydraulic plant (still in construction) will be operating.

Surface waters are considered inadequate to the various uses, according to the national legislation, due to its poor quality, with pollutants loads exceeding the recommended values. In terms of groundwater, in the monitored aquifers the quality is good. As to coastal waters the quality is also good, with the exception of one or two polluted spots.

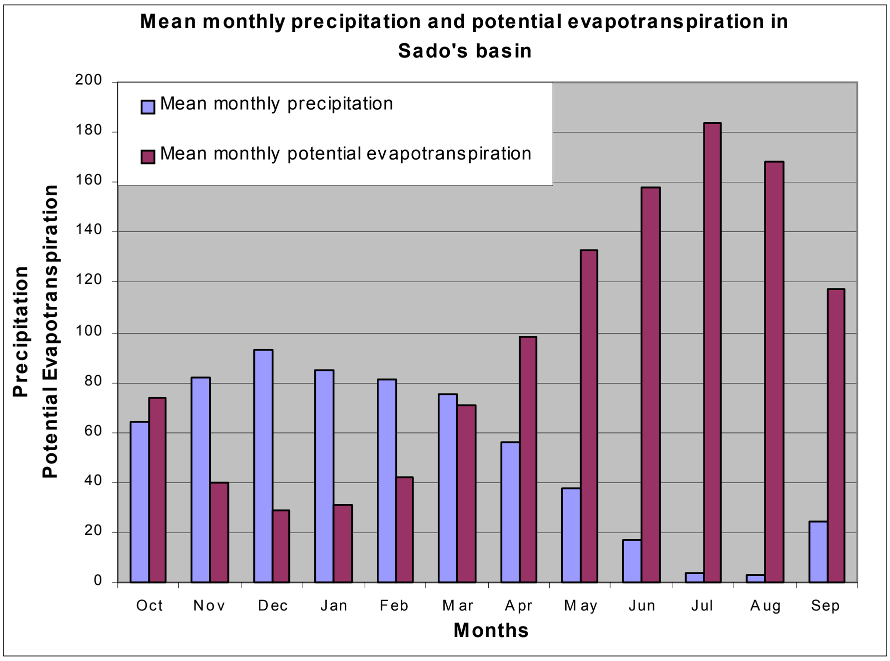

Figure 56. Mean monthly precipitation and potential evapotranspiration in Sado's basin

Industry, animal husbandry and non-point source loading from agriculture are the responsible for the majority of the pollutant loads verified in Sado. The main pollutant loads produced in Sado´s basin in 1998 were estimated as:

- BOD5 = 22461 ton/year
- TSS = 45281 ton/year
- COD = 42807 ton/year
- Total nitrogen = 3926 ton/year
- Total phosphorus = 2505 ton/year

The percentage of population served with water supply is currently of 97%, higher than the value correspondent to wastewater drainage (87%), with only 56% benefiting of treatment facilities. Urban water supply overall losses are currently high (average of 20%), and there is a low overall efficiency in agriculture water use (about 60%). The total annual water consumption is 1,195 hm^3 (600 hm^3 returning back to the hydric environment), distributed as follows: 672 hm^3 of water are used in energy production to the cooling in thermo-electric power plants, 441 hm^3 in agriculture, 58 hm^3 in industry (mainly Sines' industry on the coast), and about 24 hm^3 in domestic uses, with the water uses in tourism less than 1 hm^3. The percentage distribution of water uses per sector can be seen in Figure 57, whereas the percentage of the total water use in Sado's basin in proportion with the water use in Portugal Continental territory can be seen in Figure 58.

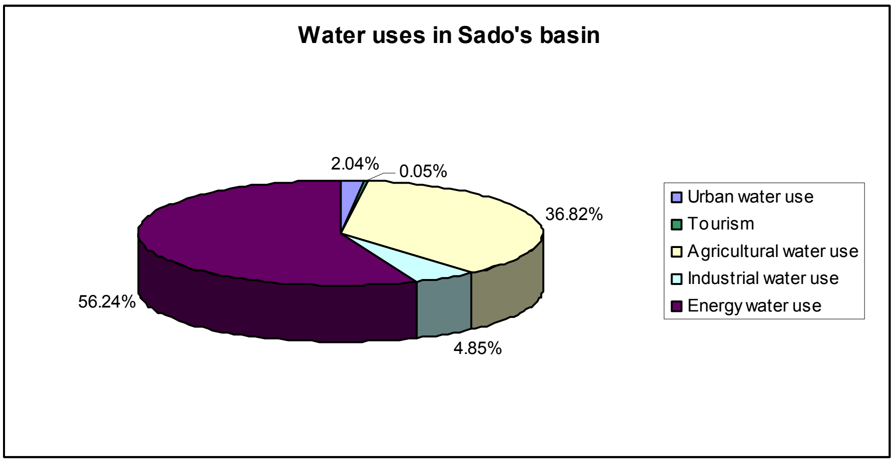

Figure 57. Water uses in Sado's basin

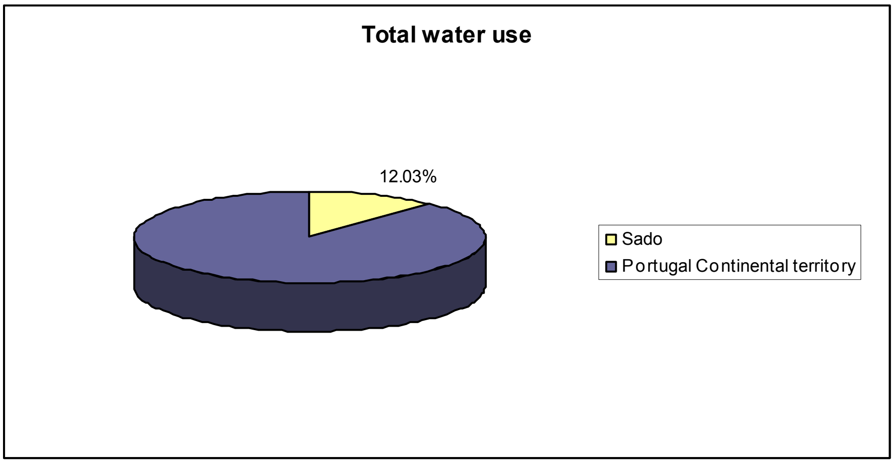

Figure 58. Percentage of the total water use in Sado's basin in proportion with the water use in Portugal Continental territory

The average household income in 2000 was 13562 €/year, with only 0.75% of this value allocated to domestic water supply, which indicates a low water pricing (0,57 €/m^3) and a low urban water sector cost recovery (37%). This situation is much aggravated in agricultural sector, with prices very low (0,06 €/m^3) and strongly subsidised.

There is no inter-municipal primary urban water supply system covering the basin. The (secondary) water supply distribution networks are mostly 100% (except one system, partly owned by Águas de Portugal group) of full municipal responsibility, and similar situation is due to wastewater drainage and treatment systems. Thus the pricing of water is mostly a political issue and not currently aiming cost recovery.

I.6.3. Guadiana[4]

Guadiana's river basin covers an area of 11,601 km^2 and its population is 182,580 inhabitants (1998), with a population density of about 16 inhabitants per km^2, almost the lowest value for all Portuguese river basins. The average altitude is 237 m, most of the region with altitudes that range from 100 m to 400 m, with a southern mountain chain (making the division between Alentejo and Algarve) where the maximum altitude occurs (1027 m). The slopes are mainly of 0% to 5% with 5% to 30% in the mountains. Most of the area presents formations mainly composed by metamorphic, eruptive and sedimentary rocks, with 2/3 of the basin composed by schistones.

The climate is temperate, with rainy winters and hot and dry summers. The average temperature is of 16 ºC, and in the summer peak months (July and August) it varies from 23 - 26ºC. In the coldest month (January) it varies from 8 ºC in the north of the basin to 11 ºC in the (south) coastal areas. In this river basin temperature reaches maxims of 41 to 44 ºC. The average annual sunshine duration is 2829 hours, with an average: maximum for July (370 hours) and minimum for December (147 hours). The average annual precipitation is 568 mm, spatially ranging from a minimum of 350 mm to little more than 1000 mm. Precipitation occurs 50-80 days per year and, in volume, more than 80% of it is concentrated in the dry semester (between October and March). As to potential evapotranspiration, the averaged yearly value is 1242 mm and it increases in the dry semester. Figure 59 presents the mean monthly precipitation and potential evapotranspiration in Portuguese Guadiana's basin territory. The total runoff due to that part of the basin is 1,887 hm^3/year, whereas in Spain the annual mean flow is 5,470 hm^3/year.

[4] All the referred data concerns, with exception if expressly referred, to the Portuguese river basin territory and internal resources.

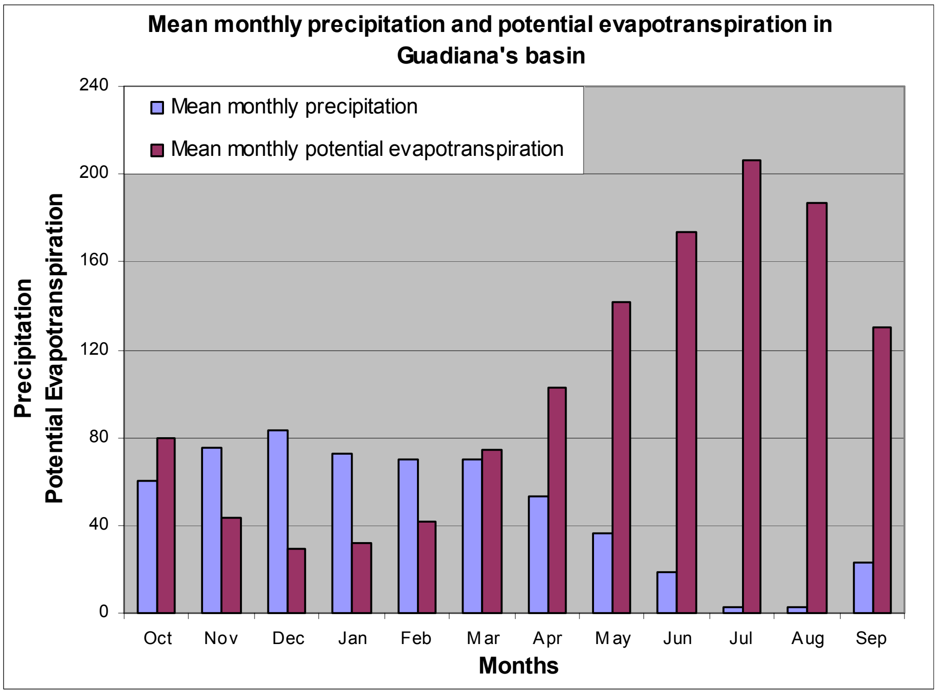

Figure 59. Mean monthly precipitation and potential evapotranspiration in Guadiana's basin

Portuguese Guadiana's water storage capacity is of 460 hm^3, but this figure will be highly increased due to Alqueva new multi-purpose hydraulic plant (still in construction), which will account for a (useful) storage capacity of 3,150 hm^3. Although currently a 30 hm^3 inter basin water transfer from this basin to Algarve occurs, Alqueva's storage capacity will enable a foreseen big inter basin water transfer of about 700 hm^3, mainly to Algarve (for irrigation and for public water supply, in support of tourism water needs) and also to Sado's basin (for domestic and industrial water supply).

In terms of water availability, in average, it is currently of 3585 hm^3/year, consisting of 3156 hm^3 of surface water (1476 hm^3/year in dry years) and 429 hm^3 of exploitable groundwater. It must be emphasised that Guadiana's basin is one of the regions of Portugal that has lastly been most affected by droughts, namely in the beginning of last decade (90-95), when periods with no affluences from Spain did occur. This way, the "resources to population index" was evaluated on a dual way, i.e., considering "total resources" as the natural mean flow (i) of all basin or (ii) of only the Portuguese basin area. On a similar way, this has been reflected also on the consumption index, with values of (i) 5% and (ii) 18%, respectively. Nevertheless, although those values are currently not high, it should be stressed that even if only the referred 700 hm^3 inter-basin transfer (to Sado and Ribeiras do Algarve) is taken into account, those values would increase to values of (i) 14% and of (ii) 49%, correspondent to the two different referred "total resources" definition.

Surface waters are considered inadequate to the various uses, according to the national legislation, due to its poor quality as they are the receptors of the pollution caused mostly by Spain and also by national agriculture. The same can be applied to some aquifers, with groundwater presenting parameters like magnesium, sodium and nitrates exceeding the maximum acceptable values for drinking water. As to coastal waters the quality is good.

The main pollutant loads produced in Guadiana´s basin in 1998 were estimated as:

- BOD5 = 17389 ton/year
- TSS = 17849 ton/year
- COD = 26250 ton/year
- Total nitrogen = 6425 ton/year
- Total phosphorus = 2194 ton/year

The percentage of population served with water supply is currently of 84% and a similar percentage (83%) applies to wastewater drainage, but only 67% benefit from treatment facilities. There is a low overall efficiency in agriculture water use (about 60%). The total annual water consumption is 419 hm^3 (with about 98 hm^3 returning back to the hydric environment), with the following distribution: about 400 hm^3 of water are used in agriculture, 14.5 hm^3 in domestic uses, 3.3 hm^3 in industry, and in tourism about 1.4 hm^3. The percentage distribution of water uses per sector can be seen in Figure 60, whereas the percentage of the total water use in Guadiana's basin in proportion with the water use in Portugal Continental territory can be seen in Figure 61. Again it should be stressed that water demands are expected to increase due to Alqueva new multi-purpose hydraulic plant in construction, namely on agriculture, due to the development of the currently predicted new irrigation areas.

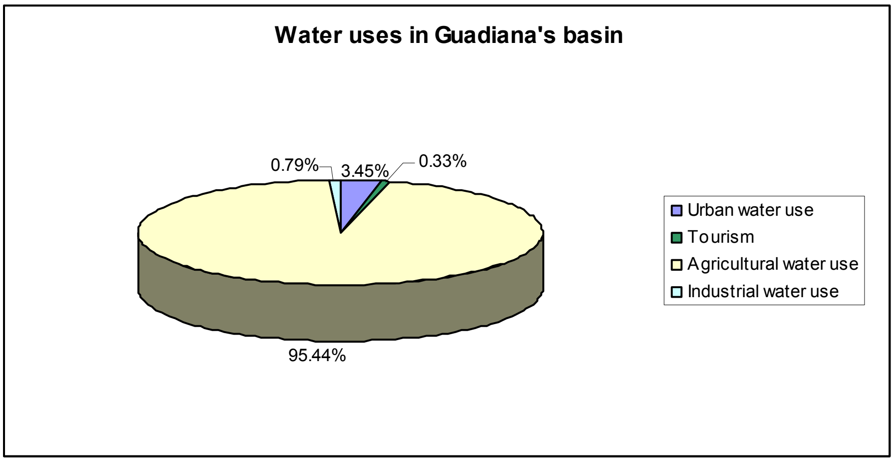

Figure 60. Water uses in Guadiana's basin

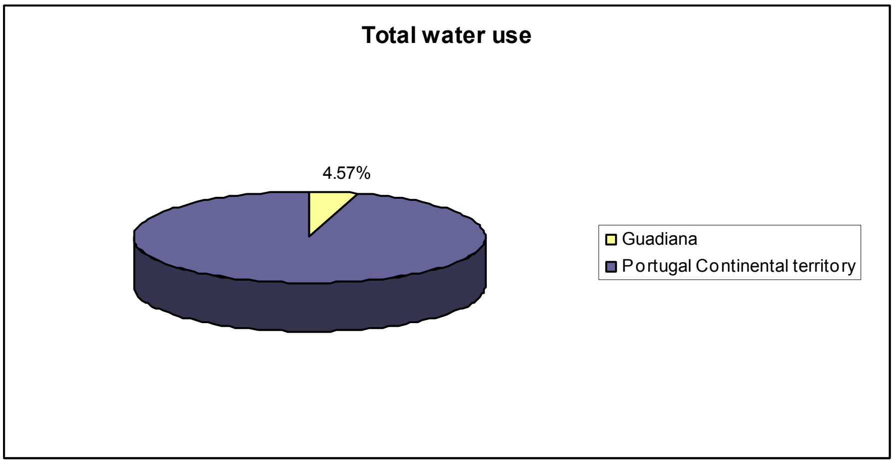

Figure 61. Percentage of the total water use in Guadiana's basin in proportion with the water use in Portugal Continental territory

The average household income in 2000 was 13562 €/year, with only 0.89% of this value allocated to domestic water supply, which indicates the low water pricing (0,70 €/m^3), although much higher than for irrigation water (0,06 €/m^3), which is strongly subsidised, as already referred. The cost recovery is correspondingly low (23% in the urban water sector).

Agriculture is (even if indirectly) the most important economic activity in the region, with the viticulture sector assuming high importance and contributing to the increase of the tertiary sector in the region.

There is a recent inter-municipal urban (main) water supply and wastewater drainage and treatment systems' company (Águas de Portugal group) that only "covers" the northern part of the basin. Thus the pricing of water is mostly (still) a political issue and not currently aiming cost recovery.

I.6.4. Ribeiras do Algarve

Ribeiras do Algarve river basin covers an area of 3,837 km^2 and its population is 324,100 inhabitants (1998), with a population density of about 84 inhabitants per km^2, a value still smaller than the average for Portugal Continental territory (110 inhabitants per km^2) but the greatest among all southern (of Tejo) river basins, namely Sado and Guadiana. The region is mostly plain, with altitudes ranging from 0 to 100 m, and only a few spots above these values. Most of the area presents formations mainly composed by volcanic rocks (especially basalts).

The climate is Mediterranean temperate, characterized by rainy winters and dry summers. The average temperature is 18 ºC. The average annual sunshine duration is maximum along the south coastal areas (3180 hours). The average annual precipitation is 840 mm, occurring 50-75 days per year in almost all the region. As to potential evapotranspiration its yearly average is 1229 mm and it increases in the dry semester. Figure 62 presents the mean monthly precipitation and potential evapotranspiration in Ribeiras do Algarve basin. The total runoff is 348 hm^3/year.

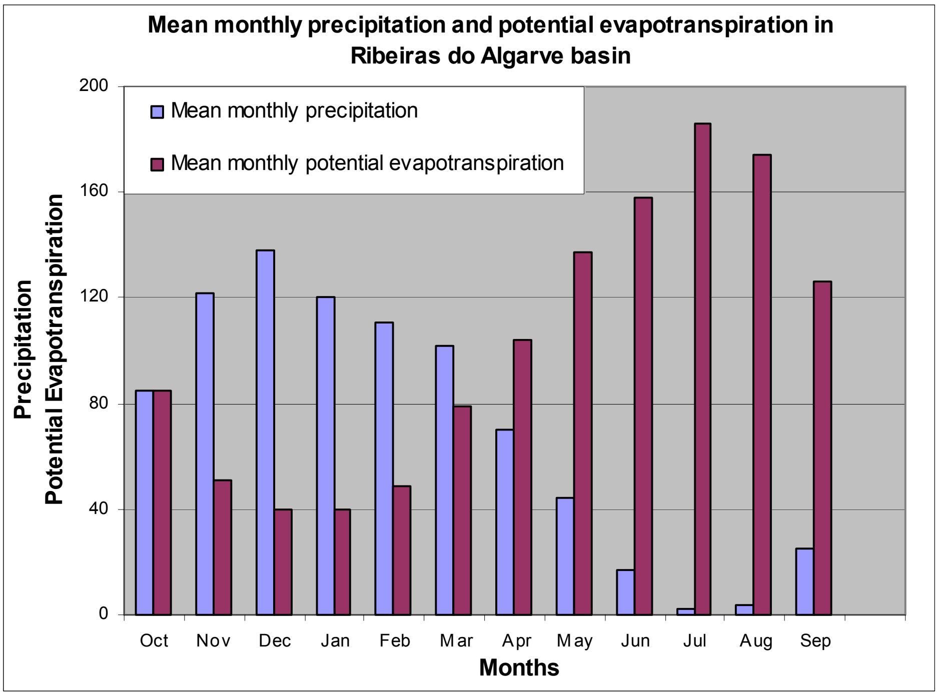

Figure 62. Mean monthly precipitation and potential evapotranspiration in Ribeiras do Algarve basin

The overall water availability is currently, in average year, of 599 hm^3/year, consisting of 327 hm^3 of surface water (160 hm^3/year in dry years) and 272 hm^3 of exploitable ground water. Algarve's storage capacity is small (about 63 hm^3).

Surface water presents quality problems, as rivers have almost no flow in dry period and receive the pollution caused by urban areas and agriculture. Dam storage reservoirs assume a high importance in water supply due to that fact, but also some quality problems occur on it, especially in the summer. The same can be applied to groundwater with parameters like calcium, sodium, chlorides and nitrates exceeding the maximum acceptable values for drinking water and irrigation water. As to coastal waters the quality is good, with the exception of one or two polluted spots.

The main pollutant loads are mostly generated by urban wastewater, animal husbandry and non-point source loading from agriculture. The loads produced in Ribeiras do Algarve basin in 1998 were estimated as:

- BOD5 = 11678 ton/year
- TSS = 17492 ton/year
- COD = 12091 ton/year

- Total nitrogen = 2140 ton/year
- Total phosphorus = 980 ton/year

The percentage of population served with water supply is currently of 82%, higher than the value correspondent to wastewater drainage (73%), with only 72% benefiting of treatment facilities. Urban water supply overall losses are currently high (with an average of 37%) and there is a low overall efficiency in agriculture water use (about 60%). The total annual water consumption is 340 hm^3 (about 95 hm^3 returning back to the hydric environment), distributed as follows: 305 hm^3 of water are used in agriculture, 21.8 hm^3 in domestic uses, 11 hm^3 in tourism, and in industry about 2.4 hm^3. The percentage distribution of water uses per sector can be seen in Figure 63, whereas the percentage of the total water use in Ribeiras do Algarve basin in proportion with the water use in Portugal Continental territory can be seen in Figure 64.

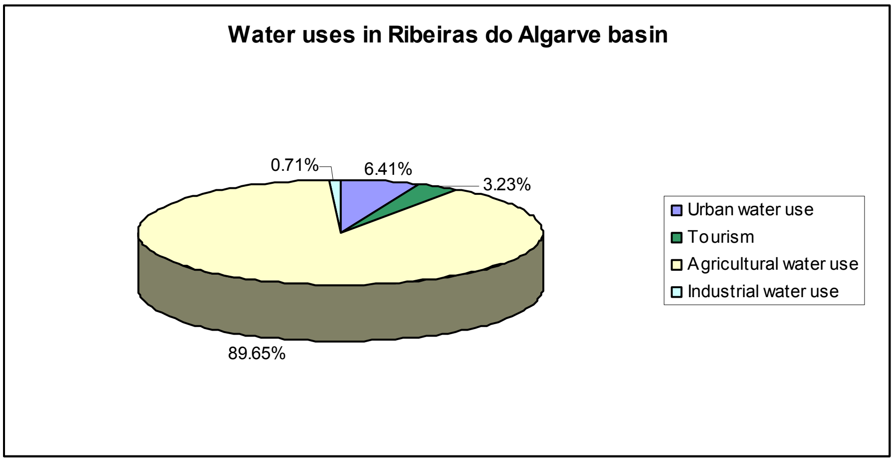

Figure 63. Water uses in Ribeiras do Algarve basin

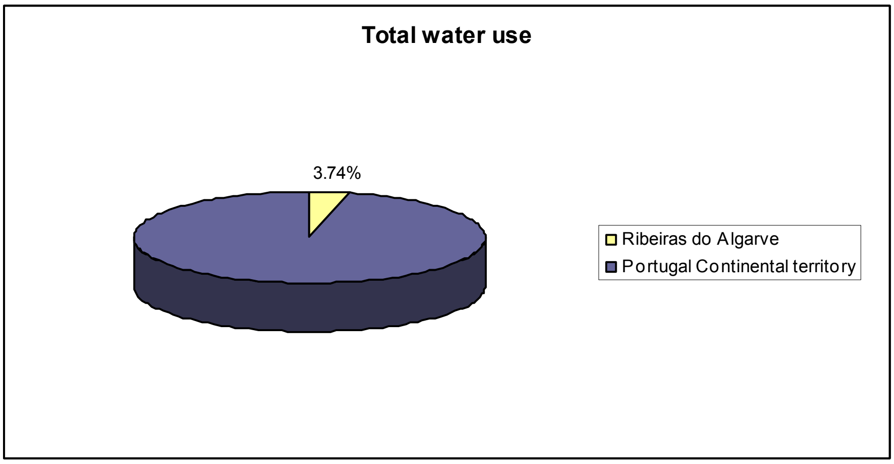

Figure 64. Percentage of the total water use in Ribeiras do Algarve basin in proportion with the water use in Portugal Continental territory

Water shortage occurs in the summer period, when the demands of water are higher, once this is an area that attracts a large number of tourists (currently estimated as 780,000, more than twice the permanent population) and also with strong needs of water for irrigation. Thus the conflict of uses of water between the two sectors.

The average household income in 2000 was 13573 €/year, with only 0.90% of this value allocated to domestic water supply, which indicates a low water pricing (0,68 €/m^3), although much higher than for irrigation water (0,07 €/m^3), which is strongly subsidised as already referred. The cost recovery is correspondingly low (40% in the urban sector).

There are two inter-municipal urban water supply, wastewater drainage and treatment systems covering most of the region, both under a company (Águas de Portugal group) which is the responsible for the "primary system" overall management. The secondary (domestic) water supply and wastewater drainage systems are of municipal responsibility. Thus the pricing of water is (still) a political issue and not currently aiming cost recovery.

Annex II - Matrices of circumstances

Table of Contents

II.1. Greece

Table 1. Attica Matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Mediterranean
		Aridity Index	0.31- Semi-Arid
		Permanent Population	3,761,810
	Water availability	Total Water Resources /Availability (hm³)	449
		Trans-boundary water	388
	Water quality	Quality of surface water	-
		Quality of groundwater	Poor
		Quality of coastal water	Fair - Poor
	Water Supply	Percentage of supply coming from: Groundwater Surface water Desalination, Recycling Importing[1]	 17% - - 83%
		Network coverage: Domestic Irrigation Sewerage	 100% - 90%
Economic and Social System	*Water use*	Water consumption by category: Domestic Tourism Irrigation Industrial and energy production	 71% - 25% 4%
		Population to resources index	4494
	Water demand	Water Demand trends	Decreasing
		Consumption index	69%
		Exploitation index	49%
	Pricing system	Average household budget for domestic water (pa)	€117
		Average household budget for agricultural water	
		Average household income	€ 20639
		Cost recovery	Good
		Price elasticity	Fair
	Social capacity building	Public participation in decisions	Poor
		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
	Water Policy	Local economy basis	Tertiary sector
		Development priorities	Urban growth

[1] Surface and ground water from other Water Regions

Table 2. Thessaly Matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Mediterranean Continental
		Aridity Index	AI>=0.65 0.2<=AI<0.5
		Permanent Population	753,848
	Water availability	Total Water Resources /Availability (hm^3)	3094
		Trans-boundary Water (hm^3)	
	Water quality	Quality of surface water	Good
		Quality of groundwater	Average
		Quality of coastal water	Poor
	Water Supply	Percentage of supply coming from: Groundwater Surface water Desalination, Recycling Importing	 15.7% 68.3% - 16.0%
		Network coverage: Domestic Irrigation Sewerage	 45%
Economic and Social System	*Water use*	Water consumption by category: Domestic Tourism Irrigation Industrial and energy production	 3.3% 95.8% 0.9%
		Population to resources index	204
	Water demand	Water Demand trends	Stable
		Consumption index	38%
		Exploitation index	31%
	Pricing system	Average household budget for domestic water (pa)	€ 149
		Average household budget for agricultural water	
		Average household income	€ 10,582
		Cost recovery	Poor
		Price elasticity	Poor
	Social capacity building	Public participation in decisions	Poor
		Public education on water conservation issues	Average
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	 Regional National
	Water Policy	Local economy basis	Primary sector
		Development priorities	Agriculture

Table 3. Cyclades Islands Matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Mediterranean Temperate
		Aridity Index	0.3- Semi-Arid
		Permanent Population	112,615
	Water availability	Total Water Resources / Availability (hm³)	212
		Trans-boundary water	Yes
	Water quality	Quality of surface water	-
		Quality of groundwater	Poor
		Quality of coastal water	Good
	Water Supply	Percentage of supply coming from: Groundwater Surface water Desalination, Recycling Importing	 22.5% 77.5% Yes Yes
		Network coverage: Domestic Irrigation Sewerage	
Economic and Social System	*Water use*	Water consumption by category: Domestic Tourism Irrigation Industrial and energy production	 9% 14% 77%
		Population to resources index	531
	Water demand	Water Demand trends	Increasing
		Consumption index	50%
		Exploitation index	15%
	Pricing system	Average household budget for domestic water (pa)	€ 231
		Average household budget for agricultural water	
		Average household income	€ 13730
		Cost recovery	Poor
		Price elasticity	Poor
	Social capacity building	Public participation in decisions	Poor
		Public education on water conservation issues	Average
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	 Municipal National
	Water Policy	Local economy basis	Tertiary Sector
		Development priorities	Tourism

II.2. Italy

Table 4. Emilia-Romagna Matrix

Natural conditions and infrastructure	*Regional Context*	Climate type	Sub-Continental
		Aridity index	1.6
		Permanent population	3,924,456
		Area	22123
	Water Availability	Total water resources / availability	1925
		Trans-boundary water	0 (No)
	Water quality	Quality of surface water	Medium
		Quality of groundwater	Good
		Quality of coastal water	Medium
	Water supply[2]	Percentage of supply coming from: Groundwater Surface water Desalination, recycling Importing	 24 % 76 % 0 (No) 0 (No)
		Network coverage: Domestic Irrigation Sewerage	 94.8 % 100 % 71 %
Economic and social system	*Water use*[2]	Water consumption by category: Domestic Tourism Irrigation Industrial and energy production	 15 % included in domestic 32 % 53 %
		Resources to Population index	720
	Water demand	Water demand trends	Stable
		Consumption index	64 %
		Exploitation index	83 %
	Pricing system	Average household budget for domestic water (pa)	0.65 %
		Average household budget for agricultural water	2.5 %
		Average household income	20228
		Cost recovery	Good
		Price elasticity	Medium
	Social capacity building	Public participation in decisions	Average
		Public education on water conservation issues	Average
Decision making process	*Water resources management*	Water ownership	Public
		Decision making level regarding: Water supply for each sector Water resources allocation for each sector	 Regional –Municipal Regional -Municipal
	Water policy	Local economy basis	Agriculture and Tertiary sector
		Development priorities	Demand Management and Waste Water Re-Use

[2] Water supply and water use computed from 1997-2000 data and power generation counts for 900 Hm^3

Table 5. Belice Basin (Sicily) Matrix

Natural conditions and infrastructure	*Regional Context*	Climate type	Warm-Temperate
		Aridity index	0.38
		Permanent population	55329
		Area	967
	Water Availability	Total water resources / availability	80
		Trans-boundary water	0.56
	Water quality	Quality of surface water	Good
		Quality of groundwater	Good
		Quality of coastal water	Good
	Water supply	Percentage of supply coming from: Groundwater Surface water Desalination, recycling Importing	 19 % 81 % 0 (No) 0 (No)
		Network coverage: Domestic Irrigation Sewerage	 100 % 100 % 100 %
Economic and social system	*Water use*	Water consumption by category: Domestic Tourism Irrigation Industrial and energy production	 27 % (inc. in Domestic) 64 % 9 %
		Resources to Population index	390
	Water demand	Water demand trends	Increasing
		Consumption index	100 %
		Exploitation index	100 %
	Pricing system	Average household budget for domestic water (pa)	0.47 %
		Average household budget for agricultural water	5 %
		Average household income	16740
		Cost recovery	Good
		Price elasticity	Medium
	Social capacity building	Public participation in decisions	Bad
		Public education on water conservation issues	Bad
Decision making process	*Water resource management*	Water ownership	National (Public)
		Decision making level (municipal regional national) regarding: Water supply for each sector Water resources allocation for each sector	 Regional Regional
	Water policy	Local economy basis	Agriculture, Tourism
		Development priorities	Agriculture, Tourism

II.3. Israel

Table 6. Tel-Aviv Matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Semiarid
		Aridity Index	0.05-0.2
		Permanent Population	1,883,700
	Water availability	Total Water Resources / Availability	338
		Trans-boundary water	
	Water quality	Quality of surface water	-
		Quality of groundwater	Good
		Quality of coastal water	-
	Water Supply	Percentage of supply coming from: Groundwater Surface water Desalination Recycling Importing	 97% 0% 3% 0%
		Network coverage: Domestic Irrigation Sewerage	100% 100% 100%
Economic and Social System	*Water use*	Water consumption by category: Domestic Irrigation Industrial and energy production	 56% 17% 27%
		Population to resources index	
	Water demand	Water Demand trends Domestic Industrial Agriculture Rivers	 Steadily increasing Steadily increasing Transfer to recycled water Use of recycled water
		Consumption index	Stable per-capita urban cons.
		Exploitation index	100%
	Pricing system	Average household budget for domestic water (pa)	$100
		Average household budget for agricultural water	
		Average household income	
		Cost recovery	
		Price elasticity	Agriculture - somewhat elastic. Urban and industrial - small.
	Social capacity building	Public participation in decisions	Very High
		Public education	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
	Water Policy	Local economy basis	National
		Development priorities	Recycling / Desalination

Table 7. Arava Matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Hyperarid
		Aridity Index	0.5-0.65
		Permanent Population	45,200
	Water availability	Total Water Resources / Availability (MCM)	41
		Trans-boundary water	
	Water quality	Quality of surface water	-
		Quality of groundwater	Poor
		Quality of coastal water	-
	Water Supply	Percentage of supply coming from: Groundwater Surface water Desalination Recycling Importing	84% 0% 16% 0%
		Network coverage: Domestic Irrigation Sewerage	100% 100% 100%
Economic and Social System	*Water use*	Water consumption by category: Domestic Irrigation Industrial and energy production	22% 76% 2%
		Population to resources index	
	Water demand	Water Demand trends Domestic Industrial Agriculture Rivers	Stable Stable Transfer to recycled water -
		Consumption index	Stable per-capita urban consumption
		Exploitation index	100%
	Pricing system	Average household budget for domestic water (pa)	$130
		Average household budget for agricultural water	
		Average household income	
		Cost recovery	
		Price elasticity	Agricultural - somewhat elastic. Urban and industrial - small.
	Social capacity building	Public participation in decisions	Very High
		Public education	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	Local Local
	Water Policy	Local economy basis	National
		Development priorities	Recycling and Desalination

II.4. Cyprus

Table 8. Akrotiri Area Matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Csa-Mediterranean
		Aridity[3] Index	Semi-arid (0.330)
		Permanent Population	156000
	Water availability	Total Water Resources /Availability	30 Mm³
		Trans-boundary water	-
	Water quality	Quality of surface water	Very Good
		Quality of groundwater	Fair - Poor
		Quality of coastal water	Good
	Water Supply	Percentage of supply coming from:	
		Groundwater	33%
		Surface water	62%
		Desalination, Recycling	5%
		Importing	
		Network coverage:	
		Domestic	100%
		Irrigation	>85%
		Sewerage	Apx. 75%
Economic and *Social issues*	*Water use*	Water consumption by category:	
		Domestic	30%
		Tourism	10%
		Irrigation	60%
		Industrial and energy production	
		Resources to population index	192 m³/c
	Water demand	Water Demand trends	Increasing
		Consumption index	100% Increasing
		Exploitation index	100% Increasing
	Pricing system	Average household budget for domestic water[4]	€ 99.2/yr
		Average household budget for agricultural water	€0.11/m³
		Average household income[4]	€24207urban €18488 rural
		Cost recovery	Dom €0.58/m³, Irr €0.11
		Price elasticity	Very small
	Social Capacity building	Public participation in decisions	Fair
		Public education on water conservation issues	Fair
Decision Making Process	*Water Resources Management*	Water ownership	State- (partly private)
		Decision making level regarding: Water supply for each sector; Water resources allocation for each sector	National; National
	Water Policy	Local economy basis	Agri/tertiary
		Development priorities	Agri/tourism

[3] Aridity = 407/ (4.5x365x.0.75) 1961-1990
[4] Family Budget Survey 1996/97 Statistical Service of Republic of Cyprus

Table 9. Germasogeia Area Matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Csa- Med/ean
		Aridity[5] Index	Semi-arid (0.356)
		Permanent Population	10000
	Water availability	Total Water Resources /Availability	20/12 Mm^3
		Trans-boundary water	-
	Water quality	Quality of surface water	Very Good
		Quality of groundwater	Very Good
		Quality of coastal water	Good
	Water Supply	Percentage of supply coming from:	
		Groundwater	15%
		Surface water	50%
		Desalination, Recycling	35%
		Importing Exporting	
		Network coverage:	
		Domestic	100%
		Irrigation	>70%
		Sewerage	Apx. 80%
Economic and *Social issues*	*Water use*	Water consumption by category:	
		Domestic	0.6 Mm^3
		Tourism	0.9 Mm^3
		Irrigation	6.5 Mm^3
		Industrial and energy production	
		Resources to population index	1200 m^3/c
	Water demand	Water Demand trends	Increasing
		Consumption index	67% increasing
		Exploitation index	67% Increasing
	Pricing system	Average household budget for domestic water[6]	€ 99.2/yr
		Average household budget for agricultural water	€0.11/m^3 depends on land
		Average household income[6]	€24207urban €18488 rural
		Cost recovery	Dom €0.58/m^3 Irr €0.11
		Price elasticity	Very small
	Social Capacity building	Public participation in decisions	Fair
		Public education on water conservation issues	Fair
Decision Making Process	*Water Resources Management*	Water ownership	State- (partly private)
		Decision making level (municipal, regional, national) regarding:	
		Water supply for each sector	National
		Water resources allocation for each sector	National
	Water Policy	Local economy basis	Agri/tertiary
		Development priorities	Agri/tourism

[5] Aridity = 478/ (4.9x365x.0.75) 1961-1990
[6] Family Budget Survey 1996/97 Statistical Service of Republic of Cyprus

Table 10. Kokkinochoria Area Matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Csa-Med/nean
		Aridity[7] Index	Semi-arid (0.268)
		Permanent Population	30000
	Water availability	Total Water Resources /Availability[8]	30 Mm^3 **
		Trans-boundary water	-
	Water quality	Quality of surface water	Very Good
		Quality of groundwater	fair
		Quality of coastal water	Good
	Water Supply	Percentage of supply coming from:	
		Groundwater	30%
		Surface water	-
		Desalination, Recycling	13%
		Importing	57%
		Network coverage:	
		Domestic	100%
		Irrigation	>85%
		Sewerage	Apx. 70%
Economic and *Social issues*	*Water use*	Water consumption by category:	
		Domestic	6%
		Tourism	10%
		Irrigation	84%
		Industrial and energy production	
		Resources to population index[8]	1000 Mm^3/c
	Water demand	Water Demand trends	Increasing
		Consumption index	100%Increasing
		Exploitation index[9]	300%Increasing
	Pricing system	Average household budget for domestic water[10]	€ 99.2/yr
		Average household budget for agricultural water	€0.11/m^3 depends on land
		Average household income[10]	€24207urban €18488 rural
		Cost recovery	Dom €0.58/m^3 Irr €0.11
		Price elasticity	Very small
	Social Capacity building	Public participation in decisions	Fair
		Public education on water conservation issues	Fair
Decision Making Process	*Water Resources Management*	Water ownership	State- (partly private)
		Decision making level regarding: Water supply for each sector; Water resources allocation for each sector	National; National
	Water Policy	Local economy basis	Agri/tertiary
		Development priorities	Agri/tourism

[7] Aridity = ((350+318+330)/3)/ ((4.6+4.4+4.6)/3)x365x.0.75) .. 1961-1990
[8] Includes import by SCP (17Mm^3), local groundwater (9 Mm^3) and Desalination (4 Mm^3)
[9] Exploitation index = 300% since 30Mm^3 are used against 10Mm^3 locally available
[10] Family Budget Survey 1996/97 Statistical Service of Republic of Cyprus

II.5. Spain

Table 11. Canary Islands Matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Oceanic
		Aridity Index	0.2 < AI < 0.6 coastal and oriental islands
		Permanent Population	1781366
	Water availability	Total Water Resources / Availability (hm3) Groundwater Surface water	 702 78
	Water quality	Quality of surface water	Good
		Quality of groundwater	Average
		Quality of coastal water	Poor
	Water Supply	Percentage of supply coming from: Groundwater Surface water Desalination	 87% 5% 8%
		Network coverage: Domestic Irrigation Sewerage	 60% 85% 60%
Economic and Social System	*Water use*	Water consumption by category: Agriculture Domestic and services Tourism (only accommodation) Industrial Non-used resources Losses (internal network)	 58% 27% 7% 3% 2.5% 2.5%
		Resources to population index	438
	Water demand	Water Demand trends	Variable - Increasing
		Consumption index	53%
		Exploitation index	58%
	Pricing system	Average household budget for domestic water (pa)	356 € (Average price 1,55 m^3)
		Average household budget for agricultural water	Variable
		Average household income	16800 €
		Cost recovery	Average
		Price elasticity	Average
	Social capacity building	Public participation in decisions	Poor
		Public education on water conservation issues	Poor
Decision Making Process	*Water Resources Management*	Water ownership Groundwater Surface water	 Mostly private Public and private
		Decision making level regarding: Water supply for each sector Water resources allocation for each sector	 Regional - Local Regional - Island
	Water Policy	Local economy basis	Tourism
		Development priorities	Tourism

Table 12. Donana Matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Mediterranean
		Aridity Index	0,4<AI<0.65
		Permanent Population	180000
	Water availability	Total Water Resources / Availability (hm3) Groundwater Surface water	 Min: 155 hm^3/year Max: 425 hm^3/year Min: 32 hm^3/year Max: 78 hm^3/year
	Water quality	Quality of surface water	Average
		Quality of groundwater	Average
		Quality of coastal water	Average
	Water Supply	Percentage of supply coming from: Groundwater Surface water Desalination	 97% 3% 0%
		Network coverage: Domestic Irrigation Sewerage	 95% 95% 60%
Economic and Social System	*Water use*	Water consumption by category: Agriculture Domestic and services Tourism (only accommodation) Industrial Non-used resources Losses (internal network)	 84% 4% 8% 1% 3% 30%
		Resources to population index	
	Water demand	Water Demand trends	Variable - Increasing
		Consumption index	53%
		Exploitation index	Max: 49%
	Pricing system	Average household budget for domestic water (pa)	50 €
		Average household budget for agricultural water	8114 €
		Average household income	7.535 €
		Cost recovery	Average
		Price elasticity	Fix
	Social capacity building	Public participation in decisions	High
		Public education on water conservation issues	Average
Decision Making Process	*Water Resources Management*	Water ownership Groundwater Surface water	 Public and private Public
		Decision making level regarding: Water supply for each sector Water resources allocation for each sector	 Regional - Local Basin
	Water Policy	Local economy basis	Agriculture Tourism
		Development priorities	Intensive Agriculture Tourism

II.6. Portugal

Table 13 .Sado matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Cs: Mediterranean Temperate
		Aridity Index	AI =0.54 Dry Sub-humid
		Permanent Population	292,960
	Water availability	Total Water Resources/ Availability (hm3)	1768 /1714
		Trans-boundary water	No
		Inter-basin water transfer	Yes (-2 hm³ (11) -10 hm³ (12))
	Water quality	Quality of surface water	Poor
		Quality of groundwater	Good
		Quality of coastal water	Good
	Water Supply	Percentage of supply coming from: Groundwater Surface water Desalination, Recycling Importing	 16% 84% - -
		Network coverage: Domestic Irrigation Sewerage	 97% 72% 87%
Economic and Social System	*Water use*	Water consumption by category: (hm3) Domestic Tourism Irrigation Industrial and energy production	 24.3 0.6 441 730.1
		Resources to population index	6035
	Water demand	Water Demand trends	Increasing
		Consumption index	68%
		Exploitation index	70%
	Pricing system	Average household budget for domestic water	0.75%
		Average household budget for agricultural water	0,06 €/m³
		Average household income	13562 €/year
		Cost recovery	Low (37%)
		Price elasticity	Very small
	Social capacity building	Public participation in decisions	Poor
		Public education on water conservation issues	Poor
Decision Making Process	*Water Resources Management*	Water ownership	Public (partly private)
		Decision making level regarding: Water supply for each sector Water resources allocation for each sector	 National/Municipal National
	Water Policy	Local economy basis	Agriculture and industry
		Development priorities	Agriculture

[11] Transferred to Guadiana's basin
[12] Transferred to Rib. Costa Alentejo basin

Table 14. Guadiana matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Csa (Temperate)
		Aridity Index	AI =0.46 Semi- Arid
		Permanent Population	182,580
	Water availability	Total Water Resources/ Availability (hm3)	7800 (2300)([13])/ 3585
		Trans-boundary water	5500
		Inter-basin water transfer	Yes (2 hm^3 ([14]) -30 hm3 ([15]))
	Water quality	Quality of surface water	Poor
		Quality of groundwater	Poor
		Quality of coastal water	Good
	Water Supply	Percentage of supply coming from: Groundwater Surface water Desalination, Recycling Importing	 55.5% 56% - 0.5%
		Network coverage: Domestic Irrigation Sewerage	 84% 76% 83%
Economic and Social System	*Water use*	Water consumption by category: (hm3) Domestic Tourism Irrigation Industrial and energy production	 14.0 1.37 400 3.3
		Resources to population index	42720 (12600)([16])
	Water demand	Water Demand trends	Increasing
		Consumption index	5.4% (18,2%)([16])
		Exploitation index	12%
	Pricing system	Average household budget for domestic water	0.89%
		Average household budget for agricultural water	0,06 €/m^3
		Average household income	13562 €/year
		Cost recovery	Low (23%)
		Price elasticity	Very small
	Social capacity building	Public participation in decisions	Poor
		Public education on water conservation issues	Poor
Decision Making Process	*Water Resources Management*	Water ownership	Public (partly private)
		Decision making level regarding: Water supply for each sector Water resources allocation for each sector	 National/Municipal National
	Water Policy	Local economy basis	Agriculture/Tertiary sector
		Development priorities	Agriculture

[13] Internal resources
[14] Imported from Sado's basin
[15] Transferred to Ribeiras do Algarve basin
[16] Considering "Total Resources" as "Internal Resources"

Table 15. Ribeiras do Algarve matrix

Natural conditions and infrastructure	*Regional Context*	Climate Type	Cs: Mediterranean Temperate
		Aridity Index	AI =0.68
		Permanent Population	324,100
	Water availability	Total Water Resources/ Availability (hm3)	620/599
		Trans-boundary water	No
		Inter-basin water transfer	Yes (30 hm^3) ([17])
	Water quality	Quality of surface water	Poor
		Quality of groundwater	Poor
		Quality of coastal water	Good
	Water Supply	Percentage of supply coming from: Groundwater Surface water Desalination, Recycling Importing	 71.5% 19.7% - 8.8%
		Network coverage: Domestic Irrigation Sewerage	 82% 77% 73%
Economic and Social System	*Water use*	Water consumption by category: (hm3) Domestic Tourism Irrigation Industrial and energy production	 21.8 10.9 305 2.4
		Resources to population index	1912
	Water demand	Water Demand trends	Increasing
		Consumption index	55%
		Exploitation index	57%
	Pricing system	Average household budget for domestic water	0.90%
		Average household budget for agricultural water	0,07 €/m^3
		Average household income	13573 €/year
		Cost recovery	Low (40%)
		Price elasticity	Very small
	Social capacity building	Public participation in decisions	Poor
		Public education on water conservation issues	Poor
Decision Making Process	*Water Resources Management*	Water ownership	Public (partly private)
		Decision making level regarding: Water supply for each sector Water resources allocation for each sector	 National/Municipal National
	Water Policy	Local economy basis	Tourism
		Development priorities	Tourism and Agriculture

[17] Imported from Guadiana's basin

Annex III - The DPSIR Framework

The DPSIR concept was also used as a basis for a framework to identify and develop indicators for Integrated Water Resources Management on a regional scale. The DPSIR framework identifies cause – effect relationships and allows for the separation of categories of issues and provides flexibility for usage and analysis. The DPSIR categories are defined as follows:

- Driving force indicators reflect pressures exerted by natural phenomena and anthropogenic activities that, in general, cannot be easily manipulated but provide essential information to understand the regional context.
- Pressure indicators reflect the pressures exerted on water resources and the water use groups of a region, as a result of the driving forces.
- State indicators assess the current status of water resource.
- Impact indicators assess the effect that a pressure has on the state of user groups and resources
- Responses related to the social response via policies, laws, measures etc.

In the next table the indicators and their importance/relevance are presented according to J. Walmsley (2002). This classification scheme has been followed to form a DPSIR Matrix for the selected regions.

Table 1. Indicators in DPSIR framework

Category	Indicator	Importance/relevance
Driving forces	Population density	A high or growing population can threaten the sustainability of water resources, particularly in arid catchments where freshwater resources are limited.
	Urbanization	The number of people living in urban and rural environments has an impact on the infrastructure requirements, as well as waste management and pollution potential.
	Proportion of households earning less than US$1000 per annum	Household earnings is an internationally accepted indicator of poverty. If a household is earing less than US$1000 per annum, it suggests that the household is barely subsisting and lower order needs are the prime concern.
	Gross geographic product per capita	Growth in the production of goods and services is a basic determinant of how the economy fares, as well as the level of development in a catchment. It measures income growth, and is an important indicator of consumption patters and the use of renewable resources.
Category	**Indicator**	**Importance/relevance**
Pressures	Catchment population as a proportion of the maximum sustainable population	There is a certain minimum amount of water required for development, which can be expressed on a per capita basis (1000 m^3/yr). If there is not enough water for the size of the population, development will not be possible and subsistence will predominate.
	Population without access to piped water on site	Because of past imbalances, not all South Africans have access to water on site. This has implications for the control of water consumption in the catchment, as well as for future infrastructure development.
	Population without access to toilet facilities	Not all people have access to adequate sanitation facilities. This has implications for waste disposal and pollution potential in the catchment, as well as future infrastructure development.
	Anthropogenic supply as a proportion of total available	In arid regions, there is a reliance in many catchments on importation of water from other catchments, or even downstream in the same catchment. If a catchment is too heavily reliant on water importation, the development of the catchment cannot be considered sustainable.
	Reserve as a proportion of mean annual runoff	The WFD has legislated that a reserve shall be established for each catchment. It consists of social requirements for essential use (minimum of 25 liters/day) and environmental requirements for the maintenance of the ecosystem. The higher the reserve requirement, the less water is available for development.
	Total liquid waste discharged as a proportion of supply	Liquid waste generation depends on industrial and agricultural processes as well as the population size. The more liquid waste that is discharged into the system, the more pressure is exerted on the system to maintain itself.
	Wastewater treated as a	If the capacity of wastewater treatment plant is inadequate, this could provide a serious pollution threat to the

Category	Indicator	Importance/relevance
	proportion of water care works' capacity	resource.
Category	**Indicator**	**Importance/relevance**
State	Total water available per capita	This is an internationally accepted basic indicator for water availability. It can be used at a catchment level and further split sectorally.
	Demand as a proportion of supply	This indicator is the core indicator of water balance. If demand is nearing supply, action with regard to water resource development is required. In many catchments, demand has exceeded supply and augmentation is required.
	Proportion of groundwater utilized	In certain areas in the country, groundwater is a significant supply of water for domestic and agricultural use. If the demand for groundwater is higher than the safe yield, then groundwater usage will not be sustainable.
	Proportion of boreholes contaminated	Groundwater supplies are particularly important in the more arid areas of the country. Good water quality is essential to regional development.
	Reservoir water quality	Reservoirs are a reflection of what is occurring in the catchment. Particular water quality problems that pertain to arid region catchments include salinization, eutrophication, microbiological contamination, toxic compounds and sedimentation. If receiving water quality objectives have been set, these can be compared to the ambient water quality.
	Water quality at the downstream point	The downstream point is an indicator of the sum of all activities in the catchment. This indicator will complement water quality in reservoirs to provide an accurate picture of problem areas.
	Reservoir capacity as a percentage of total water available	Arid regions are prone to periodic droughts and floods. River regulation in the form of reservoirs mitigates against these catastrophic events, and this indicator shows the capacity for doing so. It could also be viewed as an indicator of the condition of the natural resource, where a highly regulated system would be viewed negatively.
	Riparian zone with development	The riparian zone is the interface between freshwater and land systems. In the past, riparian land rights of landowners in some regions have led to extensive degradation of the riparian zones of rivers, and irreparable damage to river ecosystems.
Category	**Indicator**	**Importance/relevance**
Impacts	Biodiversity of wetland birds	Wetlands are some of the most endangered ecosystems. The diversity of wetland birds, which require functioning wetland systems for their survival, is a good indication of the quality of wetlands in a catchment.
	Fish assemblage integrity index (FAII)	Fish, being relatively long-lived and mobile, are good indicators of long-term influences on rivers. The number of species, the size classes and health of fish give a good indication of river health.
	Riparian vegetation index (RVI)	Healthy riparian zones maintain channel form and serve as filters for light nutrients and sediments. The status of riparian vegetation, including removal, cultivation, construction, inundation, erosion, sedimentation, and alien vegetation, gives an indication of the deviation from the natural, unmodified riparian conditions.

Category	Indicator	Importance/relevance
	Index of habitat integrity (IHI)	Habitat availability and diversity are major determinants of aquatic community structure. The IHI is useful in assessing the impact of major disturbances on river reaches, including water abstraction, flow regulation, and bed and channel modification.
	Recreational index for raw water	Poor water quality in catchments has related health risks. One of the important uses of water is for full- and partial-contact recreation. If water is too polluted for recreation, it will also be unacceptable for domestic use for informal settlements. It also has implications for access.
	State of satisfaction of catchment population	Public opinion often influences the behavior of people. The level of cooperation of the community in water resource management and conservation depends, along with other factors, on their satisfaction with water management in their area.
	Cost of water treatment	Water treatment costs rise with decreasing water quality. One of the major influences on water management decisions is the economic benefit of an action. If the cost of treating water exceeds the cost of pollution prevention activities, then pollution prevention will become the primary management thrust in a catchment.
Category	**Indicator**	**Importance/relevance**
Responses	Number of active hydrological monitoring stations per 100 km^2	Continual monitoring of water resources is important for immediate management. Rainfall is irregular over many catchments, and constant surveillance is needed on the amount of water available in the catchment.
	Number of water quality monitoring points per 100 km^2	Water quality information is important in the continual evaluation of pollution in a system and can be used as a warning system for spills.
	Level of forum establishment in the catchment	Water forums have been established, or are being established, in many catchments in South Africa with the objective of allowing participative management in the catchment. They are viewed as essential to the successful establishment of CMAs. One of their primary roles is the establishment of receiving water quality objectives.
	Establishment of catchment management agency	The WFD requires that CMAs are set up for all the major catchments, within a reasonable time. If a CMA has been established, management in that area will be catchment specific.
	Completion of catchment management plan	The WFD requires that each CMA develop a catchment management strategy for each catchment. The strategies must be in harmony with the national water strategy and should set the principles for allocating water taking into account the protection, use, development, conservation, management, and control of water resources in the catchment.