WaterStrategyMan
EVK1-CT-2001-00098

DELIVERABLE 5

SET OF REPRESENTATIVE PARADIGMS

Prepared by the
National Technical University of Athens

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Summary

This document is the Deliverable on the **"Set of representative Paradigms"** of the WaterStrategyMan (WSM) Project (EVK1-CT-2001-00098). The Deliverable presents the paradigms that were identified as representative of the specific character of the regions analyzed in the project. These Paradigms include a plethora of water supply options, water uses, economic and environmental frameworks and water cost recovery policies based upon the research that was carried out in the Work Package 3 of the project, "Developing a Systematic Typology of Comprehensive Problematique". Paradigms should be relevant to the situation in each country, being complementary without overlapping with each other.

The objectives of this Deliverable are:

- To provide the framework of developing, analyzing and evaluating alternative water resources allocation scenarios and management options, and
- To present the procedures that have been followed in identifying Paradigms.

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)

Table of Contents

1. Introduction

Water resources management policies around the world have used alternative paradigms and approaches. The pattern of development varied in different countries, but general trends are discernible. The traditional planning approaches that dominated showed a reliance on physical solutions, major new constructions and large scale water transfers from one region to the other.

Today, the planning and decision processes begin to explore efficiency improvements, implement options for managing demand, and reallocating water among users to reduce projected gaps and meet future needs. The European Water Framework Directive has stressed the necessity of an integrated water management approach, for improving and maintaining environmental quality, using tools such as full recovery of the costs incurred in water supply, including environmental costs.

The term "Paradigm" has been used to describe a set of assumptions about reality held in common by a group of people. Philosophers have discussed its true meaning for many years. To ensure the understanding of the word "Paradigm", a terminology definition is presented along with some of a Paradigm's characteristics.

In the literature, "*Paradigm*" means a pattern or a model. It may be defined as "*a set of rules and regulations (procedures, standards or routines) that*:

i) establishes boundaries, namely gives the edges or the borders, and

ii) provides solutions to problem-solving within those boundaries."

A paradigm is formed through a set of procedures. It is a sign of maturity in the development of the solution to any given problem. Before its formation there is a continual competition between various views that represent incommensurable ways of seeing the world. The laws, theories, applications and instrumentations that are used form the Paradigm (Kuhn, 1970).

Paradigms filter incoming experience, and affect judgment and decision-making by influencing one's perceptions. This "set of rules", can have a positive or negative effect; it can focus attention to important information and enhance the perception of a problem, but it can also blind one to "alternative" and unexplored under the old paradigm solutions (paradigm effect). Paradigms can be challenged on a regular basis in order to identify potentially better ideas that exist outside the old paradigms (paradigm flexibility). On the contrary, believing that the only way to solve problems is the existing paradigms, can lead to the rejection of a new and different way of solutions, because it does not fit the rules that have already been followed and successfully used (paradigm paralysis).

When someone has used a certain Paradigm, it is difficult to change it, even though it is evident that the change is beneficial. One is seduced by success (paradigm paradox). On the other hand, there are practitioners of old paradigms who choose to change to a new

one early in its development, even though there are no proofs for its success (paradigm pioneers). When the established Paradigm fails to provide effective solutions to emerging problems, a Shifting Paradigm usually occurs, which is a revolutionary new way of thinking about old problems.

In order to describe the Dominant Paradigm, one can utilize the indicators already determined in the DSPIR approach, which describe the processes taking place under different sets of conditions. The responses to the state of the water resources, the pressures applied to them and the impacts those pressures have can be used to define the current paradigm in managing the water resources. The DPSIR Indicators of each region are presented in Chapter 2, and after the definition of these parameters, the Set of Paradigms applicable to each region, and a description of the Dominant Paradigms follow.

2. The DPSIR Indicators approach

The DPSIR (Drivers – Pressures – State – Impacts – Responses) concept can be 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. In this section the main elements of the DPSIR approach are defined, while in the next sections, an effort is made to identify the main elements of the DPSIR framework for the regions analyzed.

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 relate to the social response via policies, laws, measures etc.

These indicators are relevant to the formulation of water resources management Paradigms, mainly through analysis of the **responses** selected to adapt to drivers, relieve pressures, face states and mitigate impacts under conditions of water deficiency. The differences in responses between regions suggest the presence of different schools of thought with regard to water management. The Dominant Paradigms of each region are therefore reflected through these responses, as they have evolved over time under the specific conditions of each region and each distinct country.

The full DPSIR indicators for the fifteen regions are presented in the Annex.

3. Paradigms in Water Resources Management

In Water Resources Management, the word **Paradigm** describes a school of thought on prioritizing Policy Options for the Management of Water Resources. The formulation of a Paradigm is a difficult and complicated procedure as it reflects the conflicts between the established scientific and technological approach and the political and social opinions and demands. In order to define the range of and collect concepts that describe structural (dams, pipes) and human (administration, financial management) parameters of a water system, one must understand the technical, social, financial, cultural and environmental issues of the Paradigm.

The understanding of the existing policy options and actions that have been followed in order to manage water resources and their theoretical background, leads to identification of some basic and distinguished Paradigms of Water Resources Management for each region. Therefore, a dominant Paradigm for each region is the existing, traditional way of "how things have always been done".

Each Paradigm refers to the:

- geographical entities and their grouping regarding physical and human criteria,
- driving forces like population or economic activity trends,
- physical parameters of the available water resources (state, uses, effects),
- planning and measures regarding the available resources.

The first point offers the *Case Studies* for the Paradigm, the second and third point introduce the *analytical methodology* and the *qualitative and quantitative elements*, whereas the fourth point provides the *axiological, theoretical and practical socio-economical and political background*.

The twentieth century water development paradigm was based mainly on finding new sources of supply to meet new demand. The construction of massive engineering projects for flood control, water supply, hydropower and irrigation besides having undeniable benefits, it also has costs that are not purely economic, such as ecosystem degradation and water resources contamination. As these impacts become more obvious, the approach of water resources development starts to change. A *Shifting Water Paradigm* forms, which emphasizes on incorporating ecological values into water policy. The shifting paradigm is an alternative prioritizing of policy options, and respective actions, aiming at achieving Integrated Water Resources Management, particularly in water deficient regions, in a sustainable way.

This shift towards a new Paradigm is what is currently being effected in Europe through the Water Framework Directive. The WFD has introduced a new model of water management and planning, which has been prepared in order to accomplish a more effective governance of water in the environment. The directive enforces new structures and behaviors that aim to accomplish Integrated Water Resources Management and

maintain or improve the environmental integrity of aquatic systems. The current, Dominant Paradigms will therefore need to shift, as the passage of enforcement deadlines continues, in order to accommodate the legislative aspects of the WFD.

Table 1 presents elements regarding practices that were used as dominant paradigm and those that can be used as shifting paradigm.

Table 1. Elements of Water Management Paradigms

Practice \ Paradigm		Dominant	Shifting
Governance	Authority	Command and Control, little regulation or participation	Distributed authority, coordinated approach, more regulation, more stakeholder involvement
	Regulatory structure	Weak regulations	Stronger regulations
	Centralization	Centralized	Decentralized
	Process	Simpler, more authoritarian decision-making	Searching for new processes for coordination and conflict resolution
	Ownership	Mostly public ownership	More flexible approach, more privatization
Coordination	Geographic	Little basin or area-wide coordination	Watershed and area-wide approaches
	Competing uses	Priority uses such as irrigation dominated	More complete consideration of competing uses, including environmental
	Purposes	Fewer purposes	More purposes
	Values	Focus on economic goals	Balances values with appropriate consideration of social and environmental values to go along with economic and political
	Stakeholders	Less involvement of units of government and stakeholders	Consideration of views of wide range of stakeholders
	Disciplines	Engineering dominance	Multi-disciplinary
Technical	Hydrologic	Focus on yield of hydraulic structures and systems	Focus on natural systems and sustainability
	Administrative	Simpler command-and-control administrative systems with less regulation and participation	Dynamic process adapting to changing conditions
	Legal	Water law focused on allocation with less emphasis on environmental issues	Extensive bodies of statutory, administrative, and case law
	Engineering	Focus on structural solutions	Consideration of wider ranges of options to include non-structural and management strategies as well as structures
	Planning and assessment	Focused on economic issues	Extensive use of sophisticated planning tools to identify and assess alternatives throughout the planning and decision cycles
	Economic	Traditional benefit-cost analysis	Identifies full range of economic water needs and economic tools for use as incentives
	Ecological	Not very evident in water management	Identifies and considers full range of ecological water needs
Information Technology		Centralized control of limited information	Distributed control of much information on real-time basis
Financial	Fairness and equity	Not very sensitive to social issues	Considers social aspects of financial resources to provide appropriate solutions
	Feasibility	Less stress on ability-to-pay	Advances affordable options
	Subsidies	More subsidies	More market-based
Education and Ethics	Continued improvement	Not evident in old paradigms	Enhances water quality and quantity
	Stewardship	Weakly valued	Added emphasis on stewardship of water resources
	Sustainability	Not in old paradigms directly	Managed on sustainable use basis
	Contributions to society	Less emphasis on contributions to society	Fosters public health, safety, and community good will
	Capacity-building	Little attention to capacity-building	More attention to capacity-building

Source: A New Paradigm for Water Management, N. Grigg

3.1. Dominant Paradigms in Greece

3.1.1. Attica

The development priorities for the capital city and the surrounding areas include mostly the development of infrastructure in order to meet the needs of the growing population. Regarding water management, the main issues in this region are pollution prevention and mitigation, and the management of water demand. The response to water shortages in the region has been basin transfer from richer water regions, which is a very expensive and non-viable way of covering the demand. Attempts towards demand management have been made through conservation campaigns and pricing control. It is therefore apparent that for the Region of Attica, the Dominant Paradigm is Supply Enhancement, followed by Demand Management.

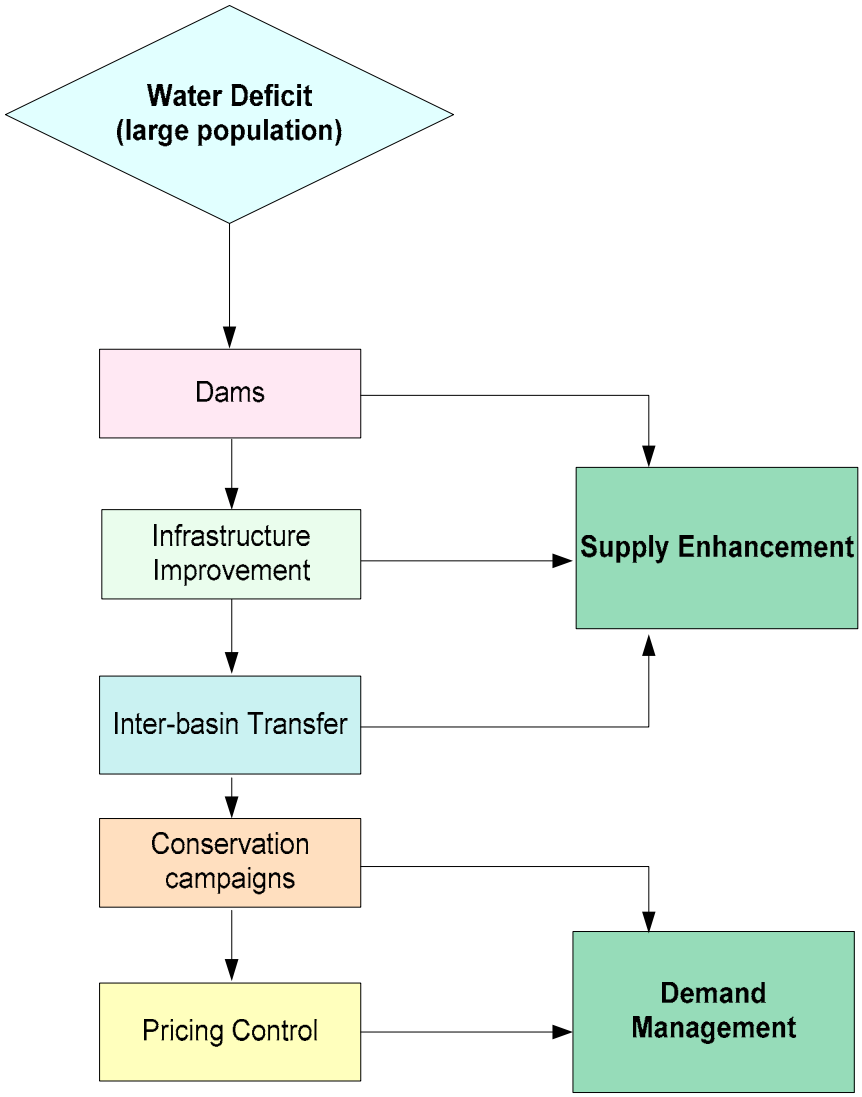

Figure 1. Attica Dominant Paradigm

3.1.2. Thessaly

Priorities for the region include the resolution of the conflicts that arise, the reallocation of water resources among uses that will allow for tourist development and the modernization of the antiquated agricultural practices. Current practices have severe disadvantages like overuse of water and the pollution of aquifers and surface water resources with agrochemicals, as well as the overexploitation of the local aquifers. There is a planned inter-basin transfer of large quantities of water ($600hm^3/y$) from neighboring regions, which however has already caused significant disputes. The Dominant Paradigm for this region is Supply Enhancement, followed by Environmental Policy.

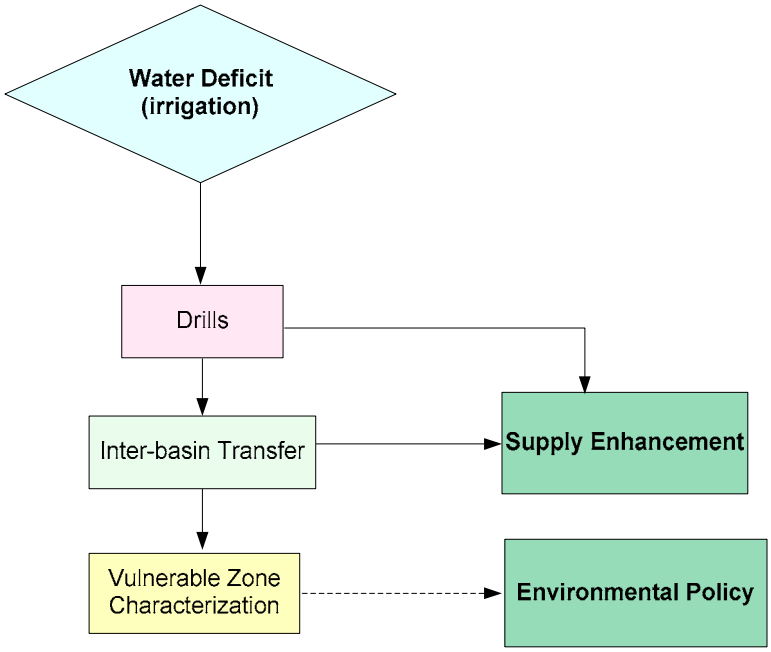

Figure 2. Thessaly Dominant Paradigm

3.1.3. Cyclades

The infrastructure of the islands is insufficient to cover the needs of the seasonal and in some cases even the permanent population, while at the same time the local resources are sparse and the increased demand is met through water transfer from the mainland, construction of small surface reservoirs and technological solutions such as desalination. Thus, the Dominant Paradigm for the region is the enhancement of the local supply, the creation and maintenance of infrastructure capable of meeting the needs of the permanent and seasonal population, and the conservation of water.

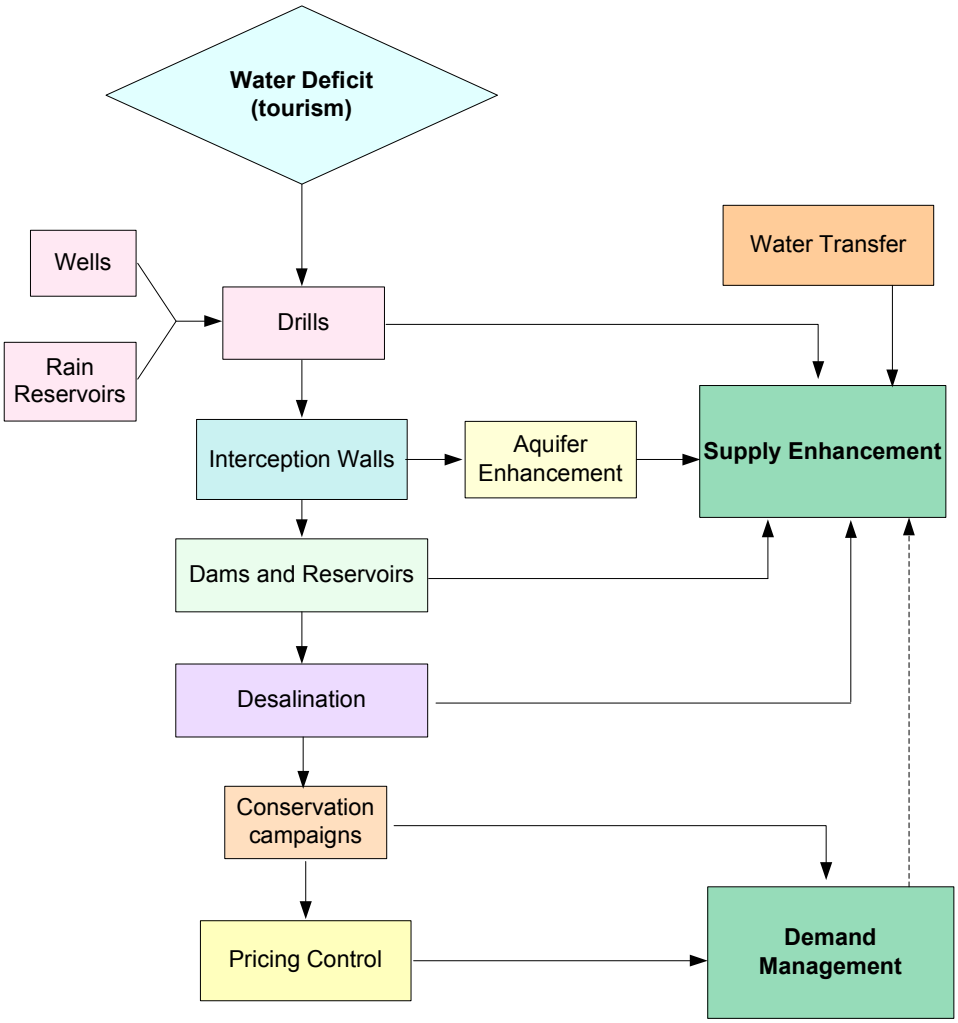

Figure 3. Cyclades Dominant Paradigm

3.2. Dominant Paradigms in Italy

3.2.1. Emilia-Romagna

In Emilia-Romagna the Dominant Paradigm regards the protection and maintenance of Apennine's rivers and torrents. Therefore it involves the Demand Management option concerning the indirect solution of a shift from Apennine's streams water use towards further exploitation of surface water from the Po River and his tributaries and increase of abstraction from aquifers, a water resource already overexploited.

Regarding eutrophication of the Po River basin fresh water and degradation of its ecosystem, the Dominant Paradigm focuses the attention on concentrations of nitrates and phosphorus of the water exiting the waste treatment plants which have to comply with standard values. If necessary, the building of new plants is considered. This solution aims to reduce the pollutant loads discharged in the Po River.

The Dominant Paradigm in the field of increased domestic and agricultural water demand and consumptions, water losses along supply networks and decreased piezometric levels of aquifers, takes into account Supply Enhancement and Demand Management measures such as building of new supply and distribution networks, enhancement of existing reservoirs and pumping stations capacities, improvement of management efficiency of reservoirs and supply networks and use of more efficient irrigation techniques. The problem of over-exploitation of aquifers is partially solved by decreasing the abstractions and shifting towards surface water of river and reservoirs.

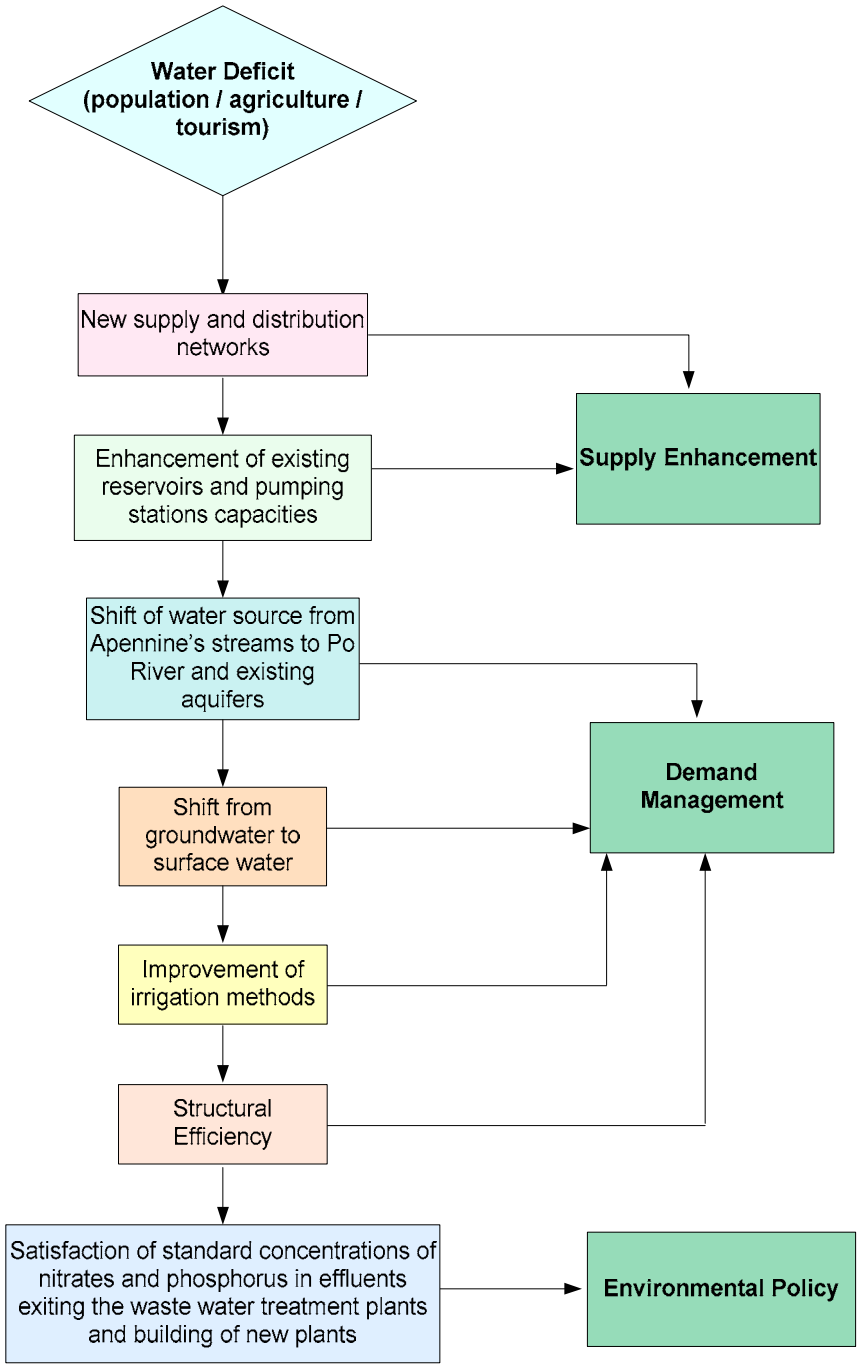

Figure 4. Emilia-Romagna Dominant Paradigm

3.2.2. Belice Basin-Sicily

The Dominant Paradigm regarding water deficit during the irrigation period involves the Supply Enhancement option mostly. It consists of transfers of water from neighboring reservoirs and aqueducts, building of new proper connections, exploitation of unofficial wells and construction of further desalination units. Reservoirs feed water to agricultural sites mostly whilst unofficial wells and desalination plants feed municipalities. The social

option is involved as well, addressing the change of water use of existing reservoirs from hydropower generation towards agriculture that has maximum priority.

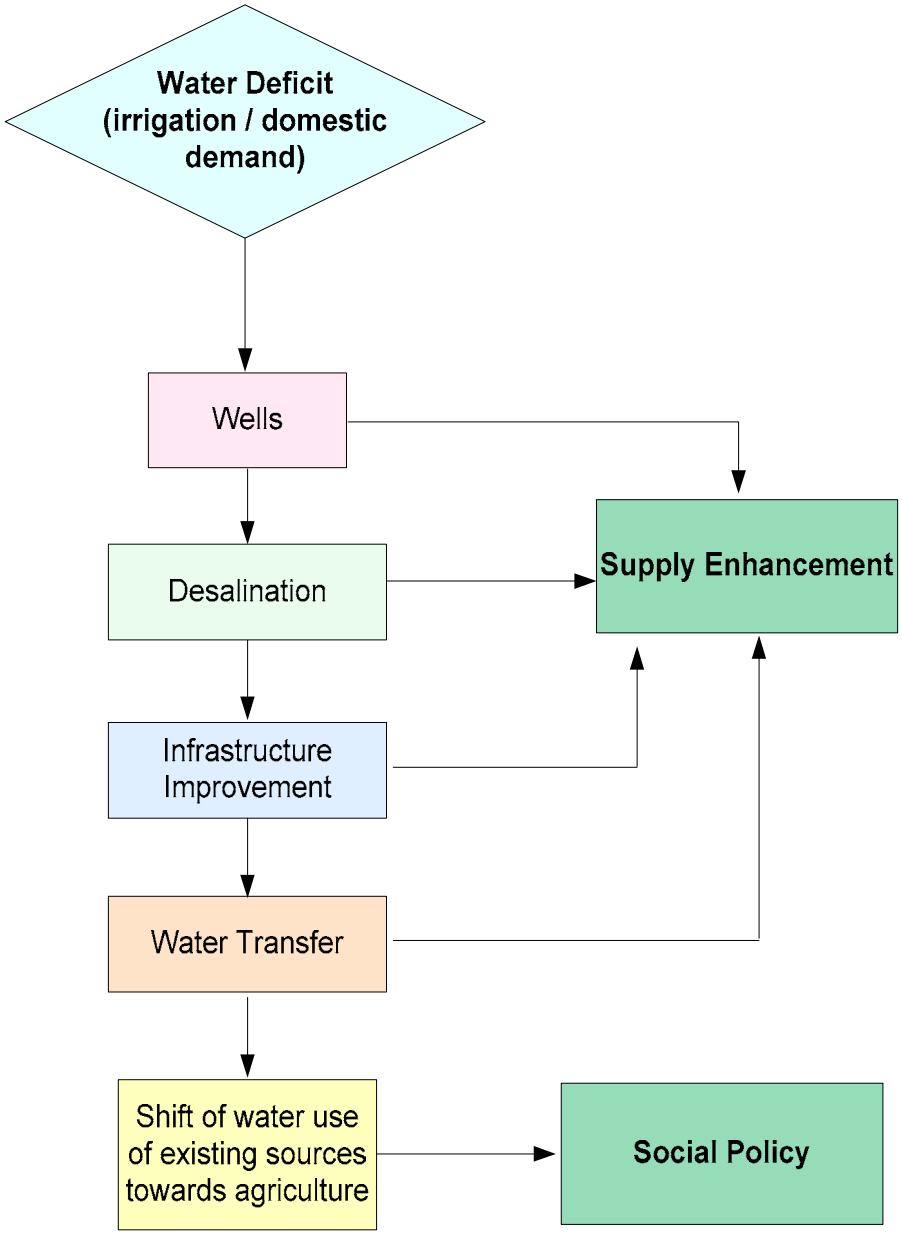

Figure 5. Belice Basin Dominant Paradigm

3.3. Dominant Paradigms in Israel

3.3.1. Tel Aviv

The region is located in the coastal plain on the eastern shore of the Mediterranean 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. The region has 160,000 dunam (1 dunam = 0.10 hectares) 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. About two third of the fresh water supplied to the region via the national water system operator by the national water company, Mekorot. The remaining third of the fresh water is provided by private producers from the coastal aquifer. In the future, this region is slated to receive a significant amount of the desalinated sea water.

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. The climate in the region is Mediterranean, semi-arid, with annual precipitation of 450 mm.

It is important to emphasize that in principal, the majority of the area of Israel (including the region of Tel Aviv) can be treated as a single geographic entity regarding the water economy for the following reasons:

- The National Water Carrier (NWC) connects all major sources of freshwater into a single network. Water can be transferred from one region to another, so that water from one aquifer may be used in a few geographical regions. In addition to the NWC which transfers water from the Sea of Galilee in the north to the centre and the south of the country (Negev), there are some additional major pipelines connecting various regions of the country.
- The Shafdan, a plant for the treatment of urban and industrial effluent of the greater Tel Aviv metropolitan area (which includes more than 30% of the country's population), is responsible for transferring recycled water to the southern region (Western and Northern Negev) for agricultural use. Two large additional networks convey recycled effluent from the Jerusalem metropolis to the Negev Plain and from the Haifa metropolis to the Western Jezreel Valley, respectively.
- Water prices by quality and sector (agricultural, industrial, and urban) are more or less uniform throughout the country.

The Israeli water economy is in the midst of a severe crisis whose main features are a shortage of fresh water and a steadily increasing deficit, poor and declining ground water quality (gradual salinization) and pollution of most of the streams by untreated urban, industrial and agrochemical effluents. The commonly agreed-upon policy of maintaining a long term balance between the potential of available water and the utilization of water resources could not meet consumer pressure, especially the pressure of the agricultural sector. The main quantitative expression of the crisis is a sharp decrease in the ability to pump groundwater without crossing predetermined red lines, where the agricultural sector bears the brunt of the necessary cuts. In the event of drought in the coming two to three years, the supply of water for domestic and industrial needs will also be in jeopardy.

Among many factors contributing to the water crisis are population growth and economic development, resulting in increased domestic and industrial consumption of freshwater. The transfer of freshwater to Jordan as required by the peace agreement and the over-pumping from the western mountain aquifer by the Palestinians both contribute to the crisis. Some decline in the natural renewal of water resources due to global climatic changes in the eastern Mediterranean region may result in a gradual decrease of the water potential. Additional crucial factors contributing to the crisis are inefficient institutional and administrative mechanisms for water allocation and control, and a poor decision-making culture (hydro-politics).

The Tel Aviv region is an integral part of the national water system and thus its current paradigm represents most of Israel's regions, which are connected to this system.

The Dominant Paradigm for the Tel Aviv region forms due to the facts that:

- There is no private ownership of water in Israel. By the Israeli Water Law of 1959 all water sources are publicly owned and their utilization is controlled by the Water Commissioner. The allocation of water is administrative: the commissioner issues permits for production (extractions) to suppliers as well as allocations (quotas) for agricultural consumers.
- Prices of water delivered by the national company Mekorot are set by the government, and are determined in a procedure which is open to political pressure (skillfully applied by the agricultural lobby). Viewing water prices not as an allocation instrument, but as a means to improve income distribution, water charges depend on the type of use: farmers pay the lowest prices, industry pays higher prices and households pay the highest. Within each sector prices do not depend on location; users in all parts of the country face the same prices, regardless of the supply price of water. Private water suppliers are subject to quotas but can set prices independently.

The actual planning of water allocation made by the Water Commission follows several stages:

- Predicting annual water demand by sector and region (including, of course, that of Tel-Aviv), given the actual water prices,
- Determination of "red lines" for each of the major water sources and the implied total production permits of fresh water,
- The gap between aggregate demand and total supply of fresh water is bridged via investments in the water economy aimed at: (i) increasing the volume and flexibility of the within-region and between-regions conveyance systems of fresh water, (ii) development of additional (environmentally safe) water treatment plans, reservoirs and conveyance systems; (ii) improving the quality of fresh water as well as of the recycled effluents; and, in the longer run, (d) desalination of sea water.

The current management practices result in:

- Continuous pressure on the governmental budget to increase the share allocated to investments in the water economy and continuous pressure of the budget department of the Ministry of Finance to increase water prices, including the prices for agricultural use.
- The above pressure to raise prices is balanced by the agricultural lobby which is very influential in Israel. The main interest of the farmers is to receive as large as possible an allocation of fresh water at the lowest attainable price. The consequences of the success of the agricultural lobby have been over-utilization of water for many years, hydrological deficits, the intrusion of seawater into the coastal aquifer, contamination of reservoirs, and the reduction of the carry-over capacity of the system. A major part of the hydrological crisis is also an environmental crisis, with continuous pollution of the rivers, aquifers and other natural resources. Serious ecological damage affecting unique natural resources and landscapes often results. These detrimental effects are among the major reasons for the current severe water crisis. Although still very influential, the agricultural lobby lost some of its political power in the last two decades.
- Additional conflict in the water economy exists between the agricultural and the urban sectors regarding the purification standards for disposal set for the cities by the government. Another conflict is over the allocation of the costs and the benefits associated with recycling between the generators of sewage (the municipalities) and the agricultural users. An additional conflict is the issue of assurance for the municipalities that the farmers will not reduce usage suddenly (due to an economic crisis for example) and leave the cities with treated water that cannot be disposed of.
- New and forthcoming partial privatization of water supply is a potential source of conflict between the government-owned company, Mekorot, and private entrepreneurs on two issues: the control of the supply of newly developed water

resources (mostly desalinated sea water and recycled wastewater) and the responsibility for the operation of the intra-cities water systems (currently operated by the cities themselves).

The current paradigm is the result of inefficient institutional and administrative mechanisms for water allocation and of a poor decision making culture (hydro-politics). The unsolved ongoing conflicts partially paralyze the water economy. This is especially true in a run of dry years (as in 1998-2001) in which many of the problems become more severe. The main quantitative expression of the current crisis is the severe reduction in the ability to produce freshwater from the aquifers (approximately 500MCM) without operating additional wastewater reclamation systems and desalination plants. The agricultural sector bears the brunt of the cuts (since the demand of the other sectors is rigid), and its allocation was recently reduced by about 40%.

To conclude, Israel (with the Tel Aviv region being a representative example of the situation associated with the national water system) is an example of a developed water economy experiencing a man-made water crisis. There has been neglect, much need for repairs, and attention must be paid to changing circumstances. A sustainable growth of the water sector requires a new paradigm. Fortunately, the fundamental structure of the sector is sound and the basis for reform exists.

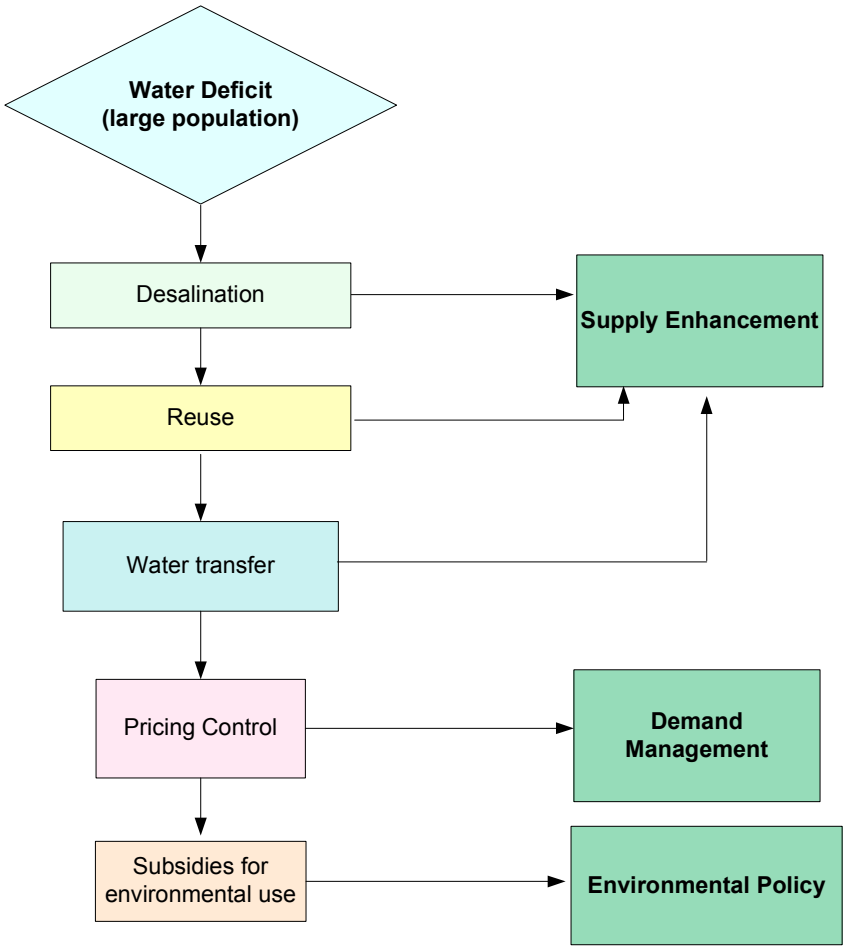

Figure 6. Tel Aviv Dominant Paradigm

3.3.2. Arava Region

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. Land prices are low and there is no demand for additional urbanization. Domestic consumption per capita in this region is particularly high, 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. Climatic conditions in the region: arid climate, very low precipitation (up to 10 mm rain per annum), aridity index 0.65. The climatic conditions favour intensive cultivation of vegetables, flowers and date palms. Some 40% of the greenhouses in Israel are located in this region.

The water supply system in the Arava is not part of the national water system. The region receives water from local sources only, via the national water company Mekorot. Drillings in the centre 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 of 600-1,100 mg chlorine per liter. 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 Dominant Paradigm for the Arava region forms due to the facts that:

- 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 of Mekorot, after discounting state grants.
- The desalination plant of Red Sea water provides water for the local population in Eilat, the only city in the region.
- The utilization of recycled waste water produced in Eilat for irrigation is insufficient and inefficient, due to lack of adequate storage facilities and conveyance systems as well as poor institutional structure. The potential to recycle wastewater produced in the rural villages is not utilized as well.

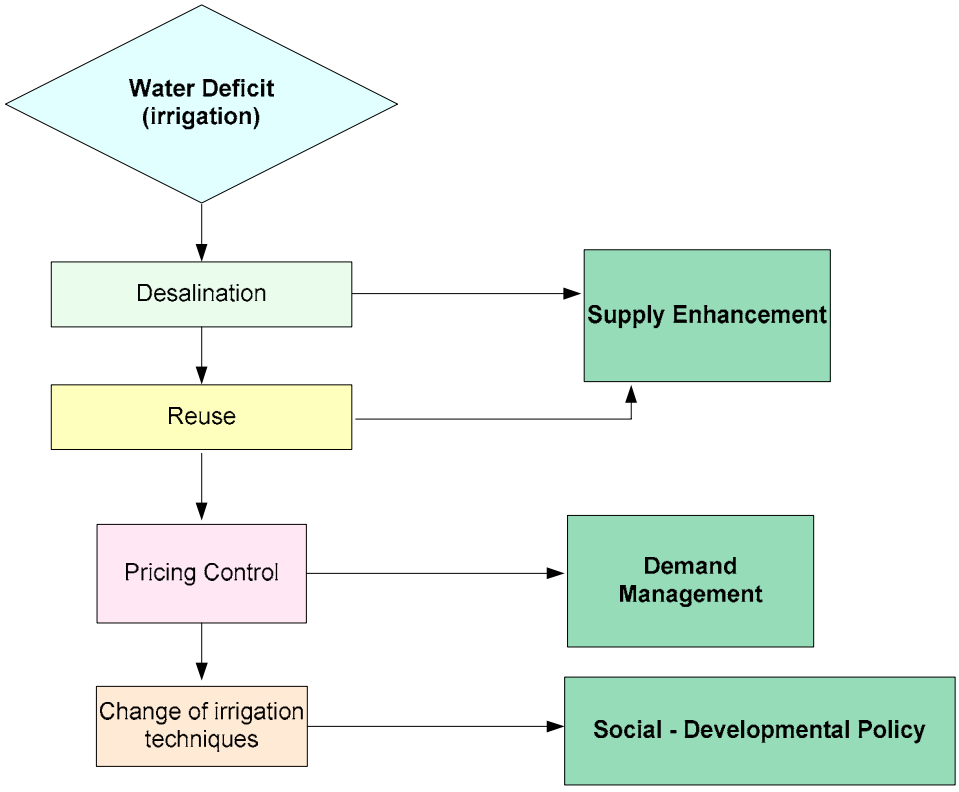

Figure 7. Arava Dominant Paradigm

The Arava region borders with Jordan. The water production balance – drillings and water production from the local aquifer – is affected by the peace treaty with Jordan.

3.4. Dominant Paradigms in Cyprus

3.4.1. The Akrotiri area

The current strategy for ensuring adequate water supply for all uses, responding to the current conditions of water deficit, is based on a combination of a number of policy options including supply enhancement, demand management, social – developmental policies and institutional policies:

- Supply enhancement
  - Efficient pumping control: 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. About 90% of the annual extraction is metered and recorded at monthly intervals. The area is well surveyed and studied. A good database exists and numerous studies have been performed including groundwater modeling.
  - Water transfer from surface reservoirs: Until 1998 part of the irrigation requirements of the area were covered by water from the Germasogeia dam. Since that year the Germasogeia- Akrotiri pipe is used to transfer recycled water to the Germasogeia dam and as a consequence no water transfer is anymore possible from the Gerrmasogeia dam. Due to the water deficit problems, water is transferred from the Kouris dam (~ 6 Mm^3 in 2002).
  - Artificial recharge with water from surface reservoirs: Water from Kouris dam is transferred to the area in order to recharge the aquifer at selected locations. This policy option depends on the available quantities of water in the dam (in 2002 2.6 Mm^3 were transferred, compared to only 42,000 m^3 during the drought period of 1998)
  - Direct use of recycled water: Currently a major project using tertiary treated effluent (up to 6 million m^3) from the Limassol Central Sewerage Treatment Plant is in operation for irrigation purposes. The recycled water during the winter period is stored in Polemidia dam whilst during the summer period is used directly for irrigation.
  - Exchange of pumping for domestic supply with desalinated water: A major desalination plant of 20,000-40,000 m^3/d capacity is planned for commissioning by 2004 to be built at the western part of the area. Surplus water that may arise from the operation of this plant will allow a better coverage of the agricultural demand and will also allow the built up of strategic reserves in the groundwater aquifer which are already to a very low level.

- Demand Management
  - Application of special measures for water allocation (quotas): A quota system is applied for the allocation of government irrigation water in the Akrotiri area, on an annual basis and on the basis of the current groundwater conditions and the content in the surface reservoirs. The quota system in conjunction with penalty charges for over withdrawals contributes to the efficient use of the water. Under conditions of water scarcity, especially

during droughts, priority and preference is given to covering a higher proportion of the domestic supply followed by greenhouse agriculture and permanent crops. Seasonal crops under these conditions are reduced dramatically.

- Application of special measures (water conservation law) which controls drilling and pumping on an annual basis requiring water metering (quotas): Special permits are issued on an annual basis governing the quantity of the water to be pumped. Preference is given to areas with problems of getting water from existing irrigation schemes.
- Water recycling (Limassol Central Sewerage Treatment Plant): Quantities of tertiary treated effluent (from the Limassol Central Sewerage Treatment Plant - LCSTP) are transferred at the Kouris river "Delta" area to recharge artificially the Akrotiri aquifer. It is expected that 5.25 m^3 of recycled water per year will be produced during the first stages of the operation of the LCSTP, and 10.6 m^3 per year at later stages.

- Social – Developmental Policy
  - Implementation of Good Agricultural Practice Code regarding use of fertilizers and pesticides: The provisions of the Code of Good Agricultural Practice are applied through the Akrotiri area. The code includes: control of fertilizer use, use of improved irrigation systems and preparation of irrigation schedules, relocation (wherever is possible) of animal husbandry units, slurry collection, mechanical separation and land application of piggery waste, on-going farmer training programs, etc.

- Institutional Policies
  - Implementation of block tariffs, seasonal prices and over-consumption penalties to domestic consumption: The Water Boards and the local Authorities and the area set progressive block tariffs, seasonal prices and over-consumption penalties to promote domestic water consumption efficiency and water conservation.
  - Adjustment of water pricing to reflect true cost of irrigation water: contrary to the costs of domestic water that is almost full charged to customers, the price of irrigation water does cover neither the full financial nor the economic costs. The present tariff for the Akrotiri area is Cy £0.06/m^3 which is equivalent to 22.3% of the weighted average unit cost of water, although the Loan Agreements with the World Bank dictate that the price of the water should be at least 38% of the weighted average unit cost. As a result the WDD is examining the case to revise the prices upwards to reflect the true cost of the water. This will promote efficiency and water conservation measures contributing towards a sustainable water management alleviating the current water shortage problem. Such an approach complies also with the provisions of the new Water Framework Directive of EU, although it is well understood that its implementation will be very difficult.

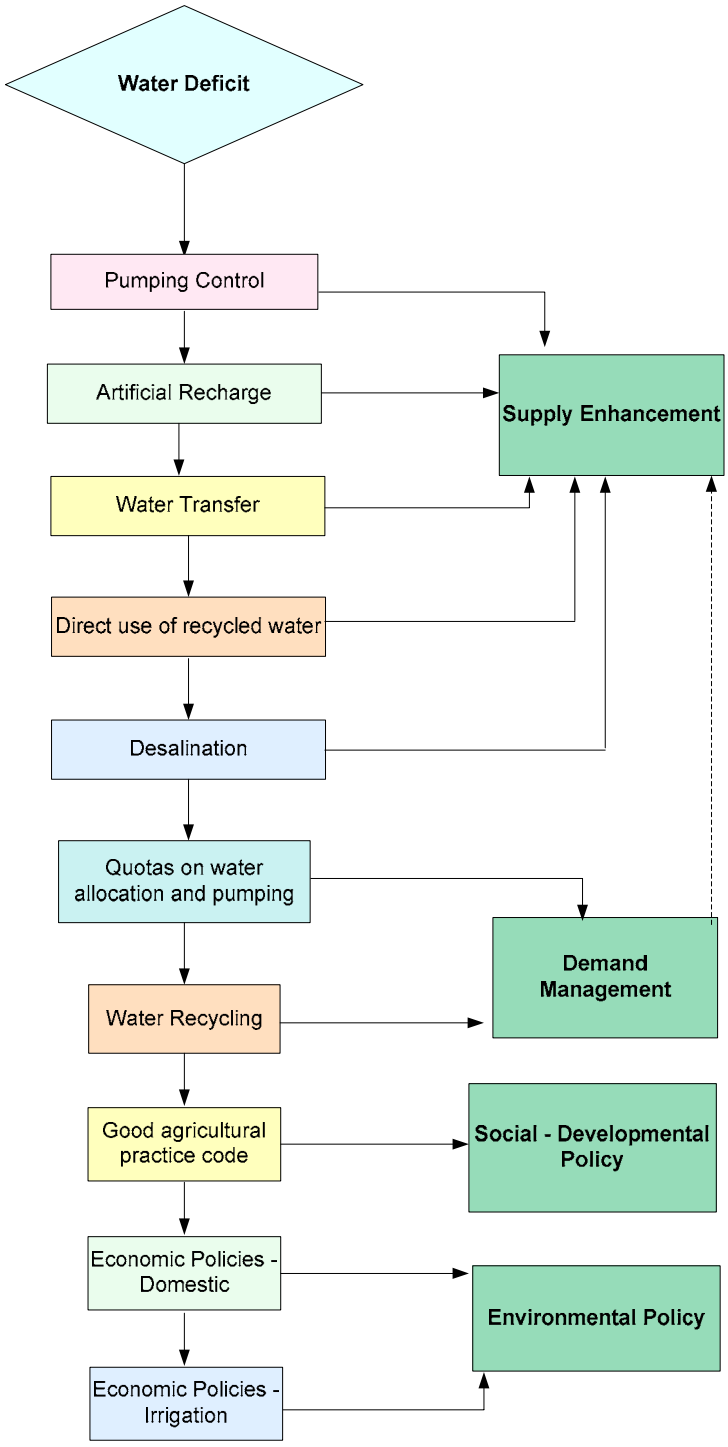

Figure 8. Akrotiri Dominant Paradigm

3.4.2. Germasogeia Area

The current strategy for ensuring adequate water supply for all uses, responding to the current conditions of water deficit, is based on a combination of a number of policy options including supply enhancement, social-developmental and institutional policies:

- Supply enhancement

- Coordinated program of releases from Germasogeia and Kouris dam for artificial aquifer recharge: 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. Since the construction of the Germasogeia dam recharge of the aquifer depends on controlled releases from the dam and its spills and supplementary on releases from the Kouris dam (6.5 Mm^3 in 2002 compared to 2.3 Mm^3 in 1998).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 made necessary the development of a coordinated program of releases from the dam for artificial recharge to cope with the extraction and minimize groundwater losses to the sea. With such action the sea intrusion is controlled and at the same time an efficient use of the scarce water resources is made. This conjunctive use of the surface and groundwater reservoirs enabled a dramatic increase in the extraction from this aquifer (more than three times its active storage capacity is being pumped annually) deferring the need for an expensive treatment plant for many years. 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.
- Efficient pumping control: In the aquifer 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 on a monthly basis by water meters. The releases for recharge are monitored on a daily basis. A good database exists and GIS as well as groundwater models exist for the area.

- Social – Developmental Policy
  - Strict control of urbanization within aquifer through Town Planning zoning and of domestic sewage management: A fast growing urbanization within the aquifer area (the aquifer is crossed by the Limassol-Nicosia highway, by local important roads, the main SCP pipeline, the main pipeline and the irrigation network of the Germasogeia dam, the main pipelines of the Limassol-Amathus raw and treated sewage, the local sewage system, etc.) and tourist development are causing concern about the environmental conditions (mainly the possible deterioration of the quality of groundwater) of this highly susceptible aquifer. As a result the aquifer is considered as a high risk aquifer. A number of protection measures have been applied including: strict control on the planning zones of the area, Germasogeia Municipality was one of the first Municipalities to be connected to the Limassol Central Sewerage System.
  - Reduction of pumping for the domestic supply and replacement with water from other sources: The WDD is examining alternative potable water sources for the areas within the aquifer, in order to reduce the pumping from it and use it for strategic planning.
  - Increased monitoring of sea intrusion propagation and adjustment of artificial recharge regime accordingly: The hydrogeological regime and the water balance of the aquifer are "regulated" by controlled releases from the

dam into the river valley and continuous monitoring of sea/fresh water interface (conductivity logs are kept for 10 boreholes.

- Development of protection areas around wells and well-fields: Due to the susceptible character of the aquifer, all the wells and boreholes in the Germasogeia aquifer are surrounded by a protection zone within which development is prohibited.

- Institutional Policies
  - Implementation of block tariffs, seasonal prices and over-consumption penalties to domestic consumption: The Water Boards and the local Authorities and the area set progressive block tariffs, seasonal prices and over-consumption penalties to promote domestic water consumption efficiency and water conservation.

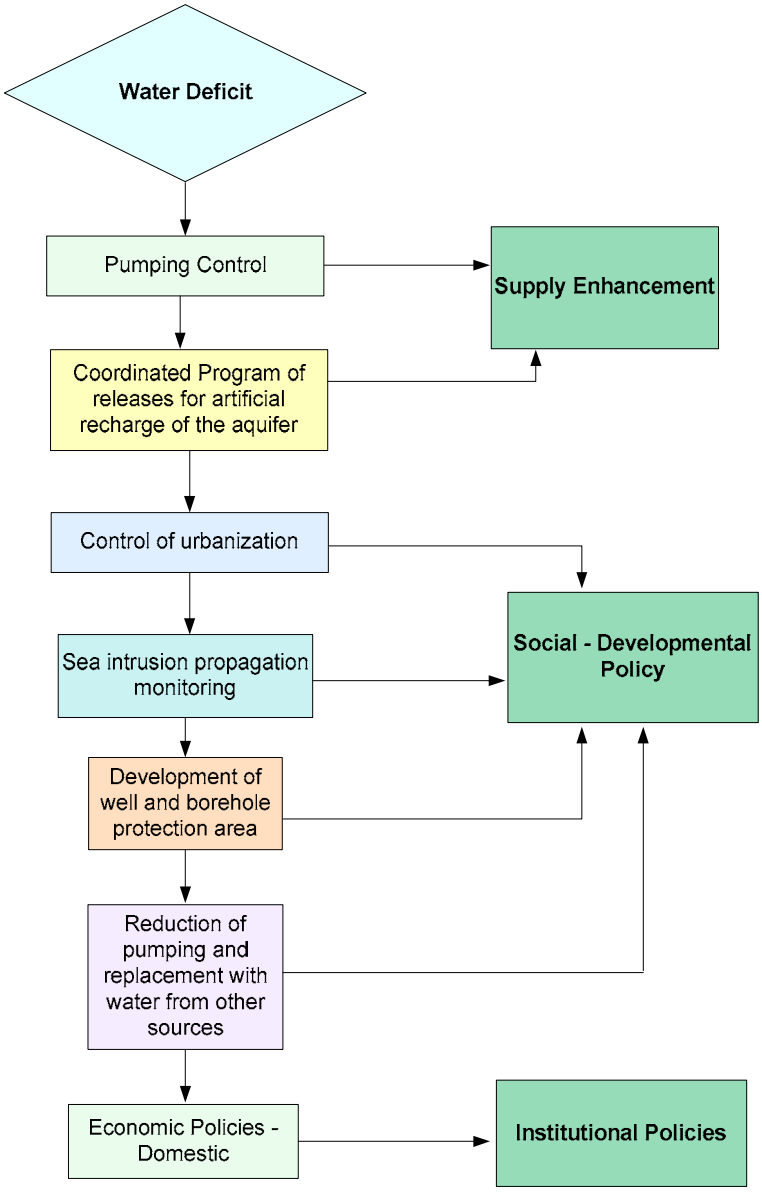

Figure 9. Germasogeia Dominant Paradigm

3.4.3. Kokkinochoria Region

The current strategy for ensuring adequate water supply for all uses, responding to the current conditions of water deficit, is based on a combination of a number of policy options including supply enhancement, social-developmental and institutional policies:

- Supply enhancement
  - Inter-basin transfer: 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 allows the continuation of the agricultural activity in the area. However during the last four years (drought period) no more than 2 Mm^3 (annually) were transferred in the area to cover only the demand of the permanent plantations of the area.
  - Exchange of pumping for domestic supply with desalinated water: Desalination is meeting most of the domestic water demand of the area. The area is served by the Dhekelia Desalination Plant. The Plant was established in 1997 with a capacity of 40,000 m^3/day.

- Demand Management
  - Application of special measures for water allocation (quotas): A quota system is applied for the allocation of government irrigation water in the Kokkinichoria area, on an annual basis and on the basis of the current groundwater conditions and the content in the surface reservoirs. The quota contributes to the efficient use of the water. Under conditions of water scarcity, especially during droughts, priority and preference is given to covering a higher proportion of the domestic supply followed by greenhouse agriculture and permanent crops. Seasonal crops under these conditions are reduced dramatically.
  - Alternative employment opportunities: A lot of the workforce shifted from agriculture to other employment associated with the locally thriving tourist industry.

- Social – Developmental Policies
  - Implementation of Good Agricultural Practice Code to avoid excessive use of fertilizers: The provisions of the Code of Good Agricultural Practice are applied through the Kokkinochoria area. The code includes: control of fertilizer use, use of improved irrigation systems and preparation of irrigation schedules, on-going farmer training programs, etc.
  - Change of cropping patterns: Due to the water deficiency problems in the area attempts to modify the existing cropping patterns shifting to winter (more rain-fed) potato are promoted. The Extension Services of the Department of Agriculture provide help to farmers in the modification of their cropping pattern while the Agricultural Research Institute provides the

necessary scientific background in the process of introducing new profitable less water demanding crops.

- Institutional Policies
  - Stricter enforcement of legislation: Thousands of illegal boreholes exist in the area. The associated uncontrolled over pumping lead in a dramatic depletion of the aquifer. As a result attempts for a stricter promotion of the legislation regarding the illegal boreholes are promoted.
  - Adjustment of water pricing to reflect true cost of irrigation water: Contrary to the costs of domestic water that is almost full charged to customers, the price of irrigation water does cover neither the full financial nor the economic costs. The present tariff for the Kokkinochoria area is Cy £0.07 /m^3 which is equivalent to 26% of the weighted average unit cost of water, although the Loan Agreements with the World Bank dictate that the price of the water should be at least 38% of the weighted average unit cost. As a result the WDD is examining the case to revise the prices upwards to reflect the true cost of the water. This will promote efficiency and water conservation measures contributing towards a sustainable water management alleviating the current water shortage problem. Such an approach complies also with the provisions of the new Water Framework Directive of EU, although it is well understood that its implementation will be very difficult.

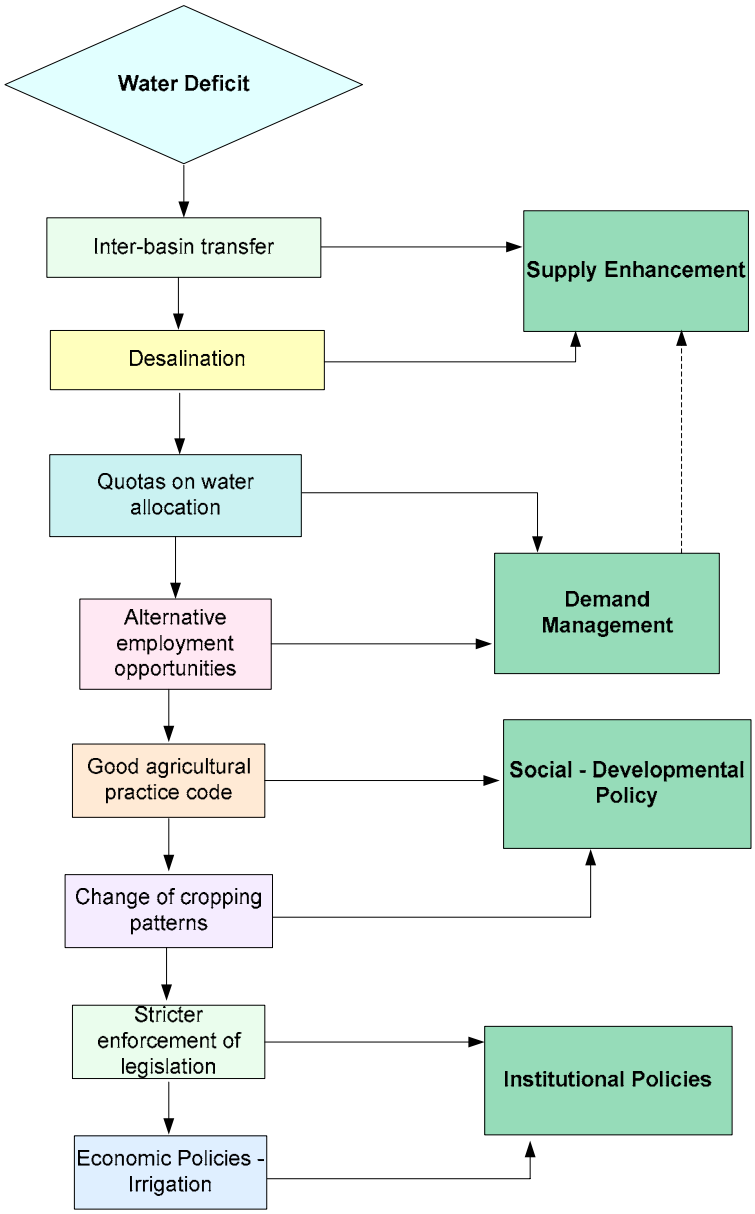

Figure 10. Kokkinochoria Dominant Paradigm

3.5. Dominant Paradigms in Spain

3.5.1. Canary Islands

The Canary Islands face an uncontrolled growth of the population and the sector tourism. On the main islands (Tenerife and Gran Canaria), where the greatest part of population is concentrated, urban and tourist consumption dominate. In the minor islands of the archipelago with a strong tourist penetration, tourist water consumption is progressively approaching the urban one (in Fuerteventura, whereas in Lanzarote tourist water consumption is higher than urban consumption). Also, agricultural consumption is a priority on islands like La Palma and El Hierro, reaching the 80% of total consumption. The water demand has been exceeding for a long time the renewable resources available in several islands. The current responses described as follows lead to the formulation of the Dominant Paradigm for Canary Islands.

Tenerife

The island of Tenerife represents an exemplary case with regard to the problems derived by progressive water scarcity and new difficulties of supply, due to very rapid rise in population accompanied by an arbitrary spatial distribution. This rise has been caused by the striking tourist growth that has been experienced in the last years (3,811,990 in 2001 - Source: ISTAC-Canary Islands Government).

On the island of Tenerife, there has been a significant exploitation of groundwater through wells and drills. Rain reservoirs were also used along with regulatory reservoirs. The construction of Desalination Plants followed a practice on an increasing trend. Therefore Supply Enhancement is the dominant paradigm for this island, although there have been some actions towards Demand Management with water reuse and leakage control.

Lanzarote

Water availability has traditionally been very limited on the island of Lanzarote, characterized by extreme aridity. It is its low altitude, in fact, that does not allow the condensation of humidity that the trade winds supply to the higher islands of the Canary archipelago. The island could historically support a population slightly higher than the limit imposed by the lack of water thanks to the development of a surprising system of cultivation without water on volcanic sands that are able to collect humidity from the environment. To this we have to add a very complex water culture and the traditional saving systems. The island's opening to tourism started in the 1970s, and transformed the whole water system, driving the island to depend almost entirely on the production of desalinized water. In effect Lanzarote is the first European centre of large-scale water desalination deployment, having passed through all the technological stages (multi-stage flash, pressure steam and, finally, reverse osmosis).

The Dominant Paradigm for this island is again Supply Enhancement, but with the use of advanced technological methods, such as desalination and water reuse. On the island

of Lanzarote, 97% of water supply is from desalination. Actions towards Demand Management have also been taken, like the establishment of tourist labels and eco-taxes and water campaigns.

El Hierro

Within the Canary archipelago, El Hierro has been among the islands where water scarcity and variability had the most dramatic repercussions. The lengthy droughts during 19th century lead to famine that decimated up to 30% of the population. For the same reason almost 40% of the population emigrated between 1930 and 1960. The island possesses a most valuable and particular water culture that includes amazing facts such as planting trees to capture the humidity contained in the fogs generated by trade winds, being each tree provided with an ingenious system for water collection at its base. El Hierro has been declared a Biosphere Reserve by UNESCO, to acknowledge not only its landscape and natural value but also for the importance of the exceptional water culture and the strategy for water production within the framework of the 100% RES project, since the island, after finalizing this project will be the first island in the world to be entirely supplied from renewable energy sources.

Contrarily to Tenerife and Lanzarote, this island faces water deficit because of agricultural and domestic demand. Because of this difference, the Dominant Paradigm is Developmental Policy using water culture programs, substitution of crops, desalination with the use of renewable energy sources and new technologies on preserving water resources. Demand Management is also used additionally to the previous mentioned practices.

La Palma

The island of La Palma shows pronounced contrasts. The Northern and North-western part of the island are characterized by plenty of water, both surface and aquifers, while the South is an area extremely marked by recent volcanism. Massive development of agriculture for export (bananas), very high water-demanding, creates cases of local scarcity and overexploitation of some aquifers. Furthermore, new areas of tourist development, located in the South and the East, started to establish their water demand showing imbalance between areas and generating new transport demands.

On this island monitoring of water resources along with stakeholders involvement and the establishment of tourist environmental standards are the common acts regarding water resources management. Therefore, Institutional Policies form the Dominant Paradigm, reinforcing by Environmental Policy as well.

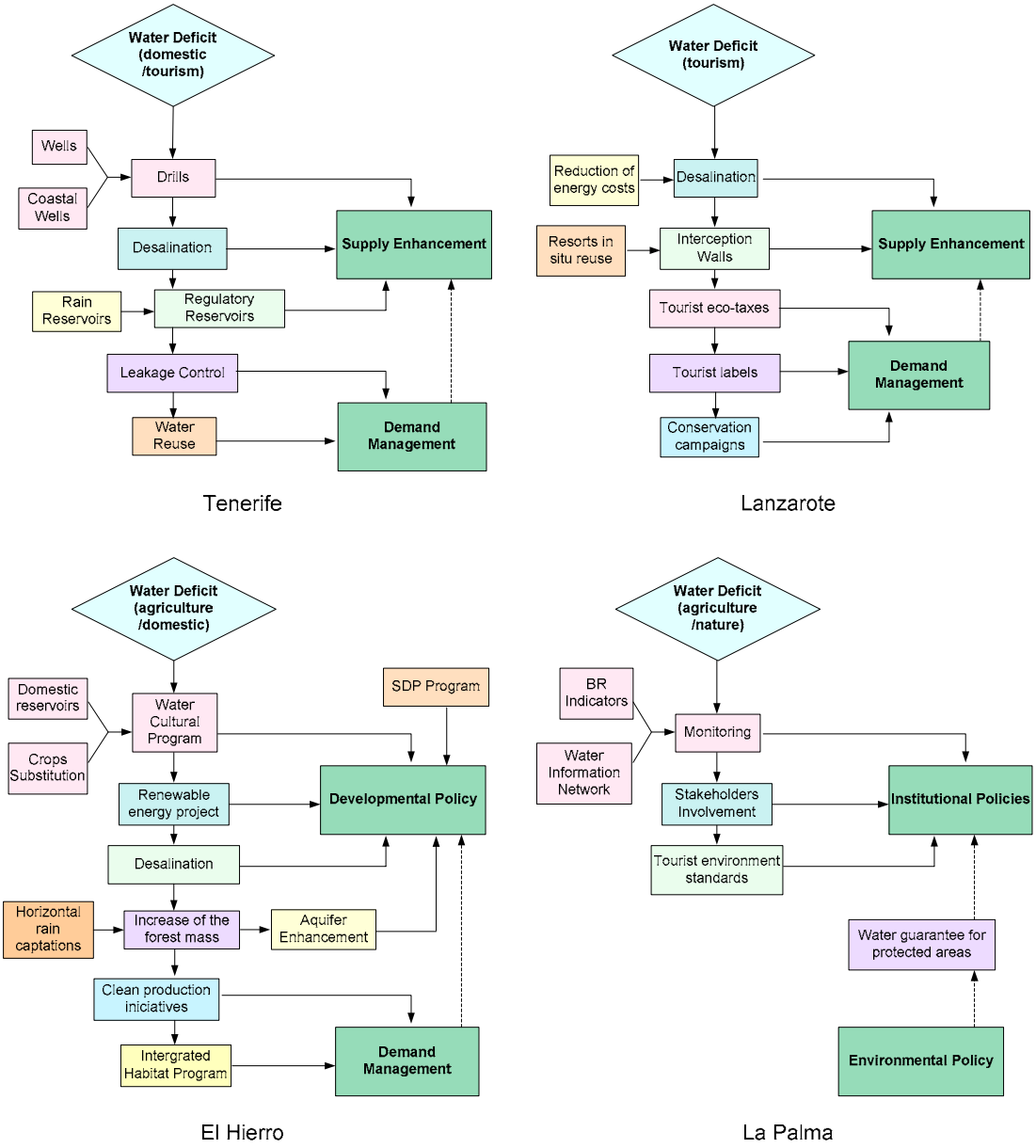

Figure 11. Canary Islands Dominant Paradigm

3.5.2. Doñana

Doñana is a typical case of commitment both to the conservation of the nature and the significant agricultural and domestic demand. It is a territory in which the most important European wetlands coexist, the National Park of Doñana that includes areas of rice fields, intensive crops and a considerable tourist activity, mainly concentrated on the coastline.

These multiple activities resulted in a change 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.

Another interesting fact is the hydrological characteristics of the area. It is divided into two domains:

- The coastal wetland. It is a 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.

The conflict between preservation and a balanced leverage of water resources in Doñana materializes with the solving and recognition of the following actions. These actions include reduction of groundwater exploitation, alternation of crops and tertiary treatment of sewage and have succeeded to maintain the aquifer level and the regeneration of the natural hydrological Systems. The Dominant Paradigm for this region is consequently the promotion of Environmental Policy.

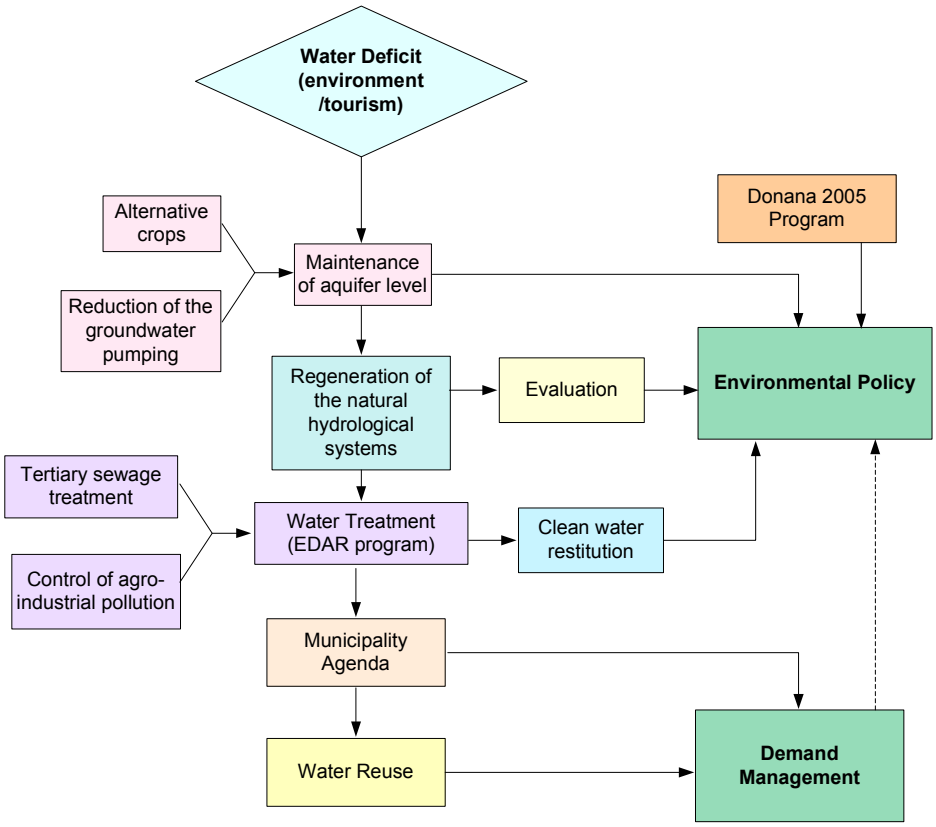

Figure 12. Donana Dominant Paradigm

3.6. Dominant Paradigms in Portugal

The Regional Paradigms shall be framed on the current and foreseen national reality and policy options as well on its Dominant Paradigms and on the regional currently foreseen constraints and water policy strategic aims. That way, although the following analysis will refer only to the Syros paradigm components, it should be kept in mind that the referred main national specific policy options –"Transboundary Interdependence", "EU and National Water Policy Integration" and "Land-use and Water Policy Integration"- shall also add to those. The three Portuguese chosen regions present specific realities that should be considered in the paradigm components definition.

3.6.1. Sado river basin

Sado is the Portuguese river basin with the biggest storage capacity when compared to annual mean flow. Up until now, the local economy was based in agriculture and industry. The Sado Basin concentrated an important part of the heavy industry, namely chemical industry. Nowadays this industry is stagnated and it is no more a region's priority. Currently, the already chosen strategic option seems to focus (again) mostly on agricultural development. The Dominant Paradigm includes an improvement on management efficiency of reservoirs and supply networks, in order to increase water availability (Development Policy).

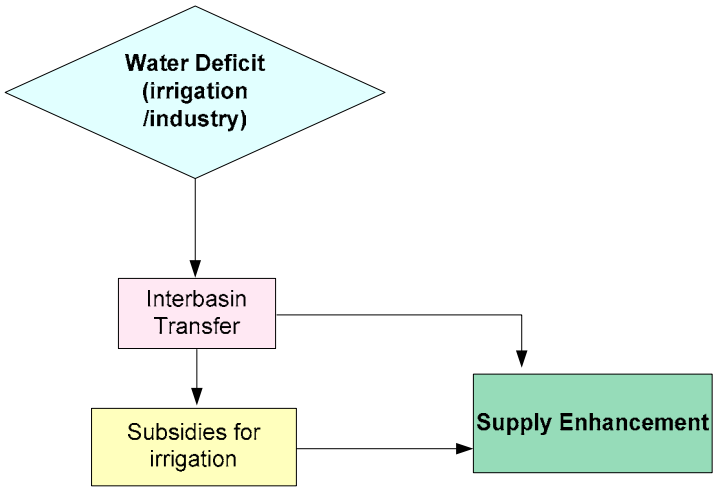

Figure 13. Sado Dominant Paradigm

3.6.2. Guadiana river basin

Guadiana is one of the regions that have lastly been more affected by droughts. The Guadiana basin, mostly because of the construction of Alqueva hydraulic plant, is on a transition phase. Until now, the large agriculture exploitations were on the basis of the local economy, and that is expected to stay unchanged on a mid-term development period. However, the low income existing in this region is still an important issue. That

way, the huge increase on water storage capacity due to the construction of Alqueva hydraulic plant (Supply Enhancement / Social Policy) is an obvious major component of the Dominant Paradigm, but its medium and long-term effects cannot be determined and quantified.

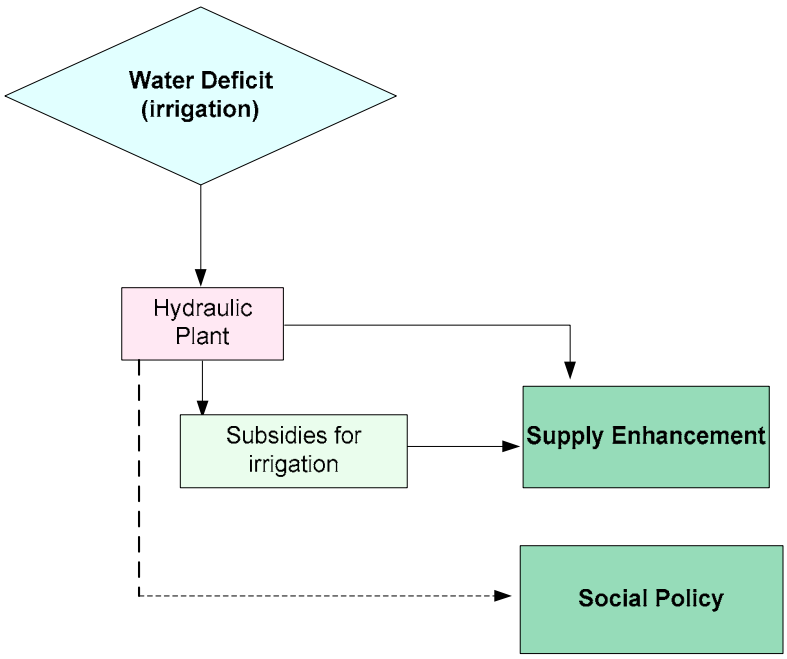

Figure 14. Guadiana Dominant Paradigm

3.6.3. Ribeiras do Algarve river basin

The Ribeiras do Algarve basin is the most important tourist destination in Portugal. This area attracts a large number of people, currently estimated as 5,000,000 tourists per year. The Ribeiras do Algarve basin suffers, mostly during the summer period, from the conflict of uses between urban needs and irrigation demands. Tourism is, and will remain, the development priority. Inter-basin water transfer and irrigation subsidies are the common used acts that form the Dominant Paradigm.

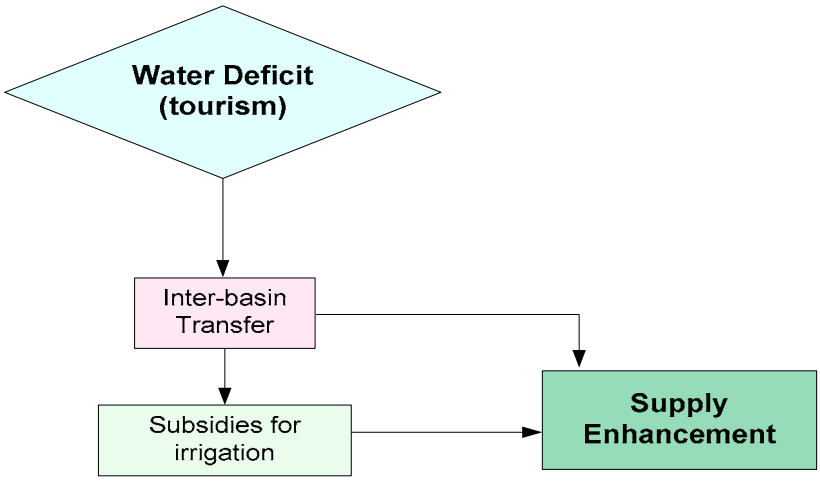

Figure 15. Ribeiras do Algarve Dominant Paradigm

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4. Annex – DPSIR Indicators for the 15 Regions

4.1. DPSIR Indicators for Greece

4.1.1. Attica

The special characteristic of Attica is that it includes the largest city of Greece and is inhabited by more than a third of the country's population. The area, from ancient times, suffered from severe water shortage problems.

- Driving forces are the:
  - large population (population density is the highest in the country),
  - land use change in order to accommodate the large population,
  - periodic droughts which are a common phenomenon in the region,
  - waste generation from industries and permanent population.

- Drivers result to pressures which are exerted on natural and human environment. These are the:
  - pollution generation problem due to untreated effluent disposal,
  - low water availability due to periodic droughts,
  - very high water demand due to population size.

- These result to a state of:
  - permanent water shortage,
  - severe pollution problems for most aquifers and coastal waters of the region.

- Impacts refer mostly to:
  - ecosystem degradation around the capital city and the surrounding areas,
  - public health concerns.

- The response for the high water demand, the reduced supply and the poor quality of local water resources has been:
  - inter basin transfer from other richer water regions,
  - in order to accommodate the large population and the change of land use patterns, an extended network had to be developed,
  - finally, in order to cope with the increasing water demand during the periodic droughts, information campaigns and pricing control were applied.

4.1.2. Thessaly

Thessaly is a mainly agricultural region, and it includes two of the larger Greek cities. The region also has significant industrial activity, while the regional authorities are promoting

the tourist development of the coastal areas. Despite the fact that the region is rich in water resources, there is a seasonal deficit during the irrigation period that leads to intense conflict between the two main water uses, irrigation and the urban water supply. This has caused considerable unrest and public dissatisfaction.

- Driving forces in the region are the:
  - intensive agriculture,
  - antiquated agricultural activities. The current irrigation practices and cultivations require vast amounts of water, thus producing a conflict with urban supply.

- Pressures exerts on the:
  - natural water resources
  - in addition, in spite of the fact that water availability is rather high, there is a surge of demand during the summer irrigation period,
  - the problem with pollution of aquifers and surface water resources from agrochemicals is a severe pressure imposed on ecosystems.

- The current state is the:
  - seasonal water deficit during the irrigation period,
  - nitrates concentration for both surface and ground waters exceeds (in a few sampling points) the limit values for drinking water while results for pesticides also show elevated values.

- Impacts from the seasonal deficit are:
  - significant economic pressures for the agricultural sector which result also to social discomfort with significant protests from the farmers during the irrigation period,
  - environmental impacts can be very important. Pollution, eutrophication of the waters, and the severe decrease in flow during the times of maximum abstraction compromises the aquatic ecosystem integrity and the ecology of the surrounding areas.

- The responses during water shortage periods are:
  - groundwater overexploitation,
  - long – term solutions are interbasin transfer from neighboring regions and for economic support, significant subsidies for irrigation water and agricultural products,
  - finally, in an effort to prevent deterioration of ground and surface water quality, the Thessaly plain has been designated as a vulnerable zone in order to take the appropriate measures for the protection of the area.

4.1.3. Cyclades

The Cyclades Islands are currently among the most popular tourist destinations in Greece. The island economy is mostly based on tourism, while at the same time the geographical fragmentation of the region emphasizes the importance of the local agricultural production.

- The driving forces are identified as the:
  - tourist development experienced during the last few years,
  - aridity of the islands (average rainfall is very low). Limited precipitation results in very limited natural renewable water resources while tourist development and irrigation produce a surge of demand during the summer period.

- The current state is a:
  - seasonal water deficit for domestic and irrigation sectors, leading to groundwater overexploitation in order to cope with the increasing demand,
  - over- abstraction results to salinization problems in most coastal aquifers.

- As impacts, one could identify the:
  - poor quality of most aquifers,
  - economic impacts from the seasonal water deficits for both tourism and agriculture,
  - the deficit experienced results to social conflicts and unrest between the dynamic tourist sector and the traditional agricultural activities.

- Short term responses are:
  - water transfer with ships from the mainland,
  - in an effort to provide permanent solutions to the problem the local authorities and the government have tried to construct many small surface reservoirs and desalination units, in an effort to support the main economic activities (tourism and agriculture).

4.2. DPSIR Indicators for Italy

4.2.1. Emilia-Romagna

- Driving Forces:
  - use of fertilizers and pesticides with nitrates,
  - domestic and industrial production of nitrates and phosphorous loads,
  - positive demographic trend,
  - over-exploitation of groundwater,
  - over-exploitation of water from Apennine's rivers and torrents,

- seasonal migration flows of resident people towards the Apennine and the Adriatic Coast during summertime plus tourists flows.

- Pressures:
  - positive trend of domestic consumption,
  - positive trend of agricultural consumption,
  - positive trend of nitrates concentration in groundwater,
  - salt intrusion in groundwater,
  - negative trend of piezometric level of aquifers,
  - seasonal peaks of water demand in the Apennine and the Adriatic Coast during summertime.

- State:
  - increased domestic and agricultural water demand and consumption,
  - high concentration of nitrates and salinity in groundwater,
  - water losses along supply networks,
  - decreased piezometric level of aquifers,
  - eutrophication of the coastal water,
  - eutrophication of the Po River basin fresh water.

- Impacts:
  - groundwater use for domestic purposes could be compromised by high nitrates and salt concentrations,
  - if the water discharge of the Apennine's rivers and torrents goes under the Minimum Vital Discharge, the fluvial ecosystem in terms of river basin morphology, interactions with aquifers, water quality, and hydrology could dramatically change,
  - Po River basin ecosystem degradation.

- Responses:
  - assure the Minimum Vital Discharge along Apennine's rivers and torrents,
  - building of treatment plants for nitrates abatement and re-use of urban waste water for irrigation,
  - change the water sources from groundwater to surface water by increasing the uptake from reservoirs and rivers,
  - improvement of management efficiency of reservoirs and supply networks
  - use of more efficient irrigation techniques,
  - change the irrigation water source from the Apennine's rivers and torrents to treated waste water,
  - selection of and priorities given to relevant cultivations,
  - use of technologies for water re-use in industrial processes and related water price incentives,

- reduce heavily the load of nitrates and phosphorus produced by civil municipalities over the whole Po River Basin.

4.2.2. Belice Basin-Sicily

- Driving Forces:
  - reduced precipitation of the latest years: in particular year 2001 circa 200-250 mm lower than the mean value of the last thirty years,
  - absence of the necessary structural maintenance of artificial reservoirs and supply networks,
  - uneven distribution of available water all over the regional reservoirs,
  - population growth,
  - intensive agricultural activities,
  - pollutant loads generated from agricultural activities and domestic use of water.

- Pressures:
  - increased exploitation from aquifers,
  - minimum storage levels in reservoirs,
  - positive trend of agricultural water demand and consumption,
  - positive trend of domestic consumption.

- State:
  - actual irrigated area less than the total area equipped for irrigation,
  - water losses along supply networks,
  - increased domestic and agricultural water demand and consumptions,
  - deficit in crop production.

- Impacts:
  - no recharge of the aquifers,
  - the lack of water for irrigation damages the fruit and vegetables harvests with bad effects on the local agriculture-based economy. Tourism could be damaged too, as agriculture has water supply priorities.

- Responses:
  - increase the distribution system efficiency,
  - re-use of treated waste water for agriculture,
  - building of further small private lakes and their co-ordinated management with others water sources,
  - use of efficient irrigation methods,
  - facilitate within basin and inter-basin water transfers.

4.3. DPSIR Indicators for Israel

4.3.1. Tel Aviv

- Driving Forces:
  - large population, approximately 2 million residents (most densely populated region in Israel),
  - location: above coastal aquifer (as source for natural water) and proximity to Mediterranean Sea (potential for desalination),
  - freshwater supply system connected to national system,
  - large quantities of sewage water requiring treatment and disposal,
  - potential for reuse of treated sewage water, either for the region itself or for southern region of Israel with transportation via central pipeline,
  - present state of coastal aquifer: below "red lines", resulting in problems both with water quality and with rising salinity,
  - crisis situation in national water supply system,
  - instability of level of recharge of coastal aquifer (periodic droughts),
  - high demand for water for public parks and for river rehabilitation,
  - high value of land.

- Resulting pressures:
  - large existing demands for water (domestic use, industrial and agricultural sectors, environmental needs),
  - difficulties of national water system in supplying unsatisfied demands,
  - conflicts regarding the use of reclaimed sewage water: within the region or in southern area of country,
  - uncertainty regarding quantity of agriculture (and of its water use) in same region resulting from current trend to redirect land from agricultural to real estate uses,
  - high cost of land for erection and maintenance of reservoir for treated sewage.

- Present state:
  - massive cuts in water supply for agriculture, including drying of some lands (especially citrus orchards),
  - rise in salinity of water for domestic and industrial use as a result of rise in salinity of water in coastal aquifer,
  - drying out of rivers and danger to entire river ecosystem.

- Impacts:
  - concern regarding fresh water shortages, including for domestic use,
  - fear of irreversible damage to stream ecosystem,

- Responses:
  - desalination of sea water in facilities along Mediterranean sea coast (increases water supply while decreasing average water salinity),
  - desalination of water from saline wells (less expensive than desalination of sea water),
  - high level treatment of sewage water and its use for river rehabilitation, for parks and agricultural irrigation,
  - increased local use of treated sewage water and decreased transportation to southern area of country,
  - pricing system adapted to water deficit,
  - support (subsidies) for environmental uses of water,
  - "import" of water from northern aquifer (Sea of Galillee), in limited quantities because of national shortage.

4.3.2. Arava Region

- Driving forces:
  - independent water system, not connected to national water system,
  - small and low-density population,
  - single small city (Eilat) and agricultural villages,
  - agricultural region, mostly for export: important center for greenhouse production of vegetables and flowers, also large areas of date orchards,
  - City of Eilat located on Read Sea coast and in proximity to rare coral reef,
  - some of water for agriculture from drilling with very high level of salinity,
  - local aquifer shared by Israel and Kingdom of Jordan,
  - desert region, extremely arid with no rain,
  - high cost of water production in region, currently with subsidy for agriculture resulting in price lower than cost.

- Resulting Pressures:
  - relatively stable water supply, independent of national water crisis,
  - large urban demand for water reduces supply for agriculture,
  - sewage water from Eilat must be recycled for agricultural use or there will be damage to coral reef both ecologically and in tourism,
  - reduced profitability of agriculture resulting from exogenic factors such as: rise in water prices, difficulties in labor supply, lowered prices in export market.

- Present state:
  - difficulty of agriculture (particularly date orchards) to adapt to water from different sources with varying levels of salinity,
  - difficulty of agriculture in face of country's rising water prices, despite the fact that the Arava's water system is independent of the national water system,

- difficulty of agriculture to finance investments in reservoirs for reclaimed sewage water,
- 3.4 sea water desalination facility constructed in Eilat,
- agreements in principle regarding division of water in aquifer shared with Kingdom of Jordan exist in peace treaty between the two countries,
- financial assistance for investments in reservoirs provided by government and other public organizations (Keren Kayemet L'Yisrael).

- Impacts:
  - relatively stable and organized state.

- Responses (steps for further improvement and to decrease difficulties):
  - R&D activity regarding effects of irrigation with treated sewage water on greenhouse cultivation of dates and vegetables, particularly effects of salinity,
  - adaptation of local irrigation systems to different sources of water,
  - assurance of government assistance in reclaiming treated sewage water for agricultural use,
  - revision of water price system to specific regional conditions of supply and demand.

4.4. DPSIR Indicators for Cyprus

4.4.1. The Akrotiri area

The Akrotiri area was one of the most dynamic aquifers in the Island until 1987 when the Kouris dam was completed blocking the bulk of replenishment. The low topography, its large contact with the sea coast and Salt Lake and the continued pre-dam pumping pattern has resulted to serious problems to the aquifer. Citrus orchards and the supply for part of the domestic supply are threatened. The largest part of the area falls under the Sovereign British Base area which controls and limits tourist development. Agriculture is the main alternative left for the population in the area.

- The driving forces in the region were defined as the:
  - inability to transfer water for irrigation with the Germasogeia – Akrotiri pipe after the use of the pipe to transfer recycled water to the Germasogeia dam,
  - reduction of the surface flows and of groundwater recharge (Kouris river) due to the construction of the Kouris dam,
  - intensive use of fertilizers/reduction of flashing effect by natural recharge,
  - urbanization of the eastern and northern part of the aquifer,
  - low local rainfall,
  - over-exploitation of the groundwater,
  - on-going water extraction pattern based on the pre-dam conditions,
  - population growth,

- low topography – limitation on water storage capacity and immediate impact on groundwater levels by increased pumping,
- extensive contact with sea coast and Salt Lake,
- availability of expensive surface (dam) water and recycled water compared to relatively cheap groundwater,
- administrative control on development other than agriculture by Sovereign British Base Authorities,
- high proportion of permanent crops vs. seasonal crops,
- the area is under water conservation law (special measures) which controls drilling and pumping on an annual basis and requires water metering.

- Pressures exerted arise from:
  - salinization of ground water due to sea and Salt Lake water intrusion,
  - drop of the groundwater levels,
  - rising trend of nitrates and other nutrients and pesticides in groundwater,
  - increased storm run-off of doubtful quality,
  - need for water to maintain Salt Lake and marshlands of great ecologic importance,
  - high proportion of inelastic water demand for permanent plantations and domestic supply,
  - conflicts arising from cheap groundwater allocation compared to expensive surface (reservoir) water and tertiary treated effluent of dubious quality,
  - control of crop patterns and irrigation schedules.

- The current state of aquifer and area currently is:
  - reduced outflow from the groundwater system/inadequate leaching effect,
  - high concentrations of salinity in groundwater,
  - high nitrate built-up in the aquifer,
  - increased demand (domestic, agriculture),
  - groundwater levels below mean sea level throughout 80% of aquifer,
  - all pumping and use of water monitored through water-meters – annual permits and water allocation.

- As impacts were identified the:
  - deterioration of the quality of the water in the aquifer,
  - role of area for providing domestic water supply is being diminished – plans for desalination plant to replace supply are under development,
  - reduced income from agriculture due to cuts in water allocations,
  - threats on the ecosystem of the marshlands and the Salt Lake,
  - minor shift to less water consuming agriculture and other activities (Water Parks).

- The responses to the above are:

- more efficient pumping control,
- more effective water allocation with increased surface water and treated effluent component,
- on-going artificial recharge with water from the surface reservoir and the recycled water from the Limassol Central Sewerage Treatment Plant,
- exchange of pumping for domestic supply with desalinated water (by 2004) with plans under way,
- implementation of Good Agricultural Practice Code regarding use of fertilizers and pesticides,
- adjustment of water pricing to reflect true cost of irrigation water as a tool for water demand management.

4.4.2. Germasogeia Area

The Germasogeia aquifer is a very small alluvial aquifer but of immense importance to the area since it has been used for more than 20 years as a natural treatment plant for the domestic supply of a large proportion of the needs of the neighboring town of Limassol and it is the sole source of domestic supply for a number of village communities and the tourist development in their coastal area. More than three times its active storage capacity is being pumped annually by inducing water through releases from an upstream dam. Increased urbanization threatens the quality of the water resources in this area.

- The driving forces in the region were defined as the:
  - complete cut-off of natural replenishment of the aquifer due to the construction of the Germasogeia dam,
  - fast growing urbanization within the aquifer area,
  - rapid tourist development at the coastal area,
  - increasing water demand for domestic supply which for the communities and tourist development in the area can only be met by pumping from this aquifer.

- Pressures exerted arise from:
  - increased extraction from the aquifer**,**
  - possible deterioration of the quality of the ground water,
  - intensive management of water resources required – pumping and artificial recharge,
  - conflicts over land development measures and land owners.

- The current state of aquifer and area currently is:
  - increased domestic demand (Limassol city, neighboring villages),
  - increased agricultural demand,
  - regulation of the aquifer's water balance by controlled releases from the dam into the river valley,
  - state of aquifer fully dependant on contents of Germasogeia Dam,

- high intensity of aquifer utilization renders it liable to pollution – pumping is 3 times its active storage capacity made possible by artificial recharge,
- current quality and state is very good.

- As impacts were identified the:
  - deterioration of the quality of the groundwater by urbanization,
  - occasional sea intrusion – controlled by increased artificial recharge,
  - ground water for domestic purposes could be compromised by deteriorating water quality (salinization, high nitrate concentrations, etc.),
  - importance of aquifer and its protection limits the value of land for development – conflicts.

- The responses to the above are:
  - development of protection areas around wells and well-fields,
  - strict control of urbanization within aquifer are needed through Town Planning zoning and of domestic sewage management,
  - coordinated program of releases mainly from the Germasogeia dam but also from Kouris dam for artificial recharge of the aquifer to compensate for the water extraction,
  - reduction of pumping for the domestic supply of Limassol and replacement with water from Kouris dam,
  - increased monitoring of sea intrusion propagation and adjustment of artificial recharge regime accordingly,
  - plans being considered to enable domestic supply from Kouris Water Supply Treatment Plant.

4.4.3. Kokkinochoria Region

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. This area has been the most productive region in the island in terms of value of agricultural produce, mainly potatoes, with well-developed export potentialities and practice. The high income of produce led to uncontrolled drilling and pumping for irrigation water mining the aquifer to exhaustion. Agricultural practices have been maintained to a large extent through inter-basin water transfers. Tourist development in the area has also allowed the employment of many farmers whilst desalination is meeting most of the domestic water demand. Climatic and soil conditions as well as quality of farmers make the continuation of this area as an agricultural region a high priority.

- The driving forces in the region were defined as the :
  - the area receives the lowest rainfall in the island,
  - absence of surface flows,
  - excellent land resources with very good soils,

- soils and climate suitable for potato production with very long local tradition and export potential,
- intensive high income agricultural activities,
- very experienced farmers – mechanized farming and use of high efficiency irrigation systems,
- intensive tourist activities attracting labor force and taking up agricultural land at the coast.

- Pressures exerted arise from:
  - overexploitation of the aquifer – serious mining of water reserves**,**
  - drop of the groundwater levels – serious reduction of well yields and loss of most productive part of aquifer due to sea intrusion,
  - little storage levels in the aquifer (15% of the original),
  - lack of water and high profit from produce results to illegal drilling (48% of wells)**,**
  - advantageous soil conditions for potato production,
  - increase of nitrate content in groundwater,
  - overland runoff from rains to coast from irrigated fields results to nitrate built up at the coastal zone with occasional eutrophication impacts affecting bathing areas,
  - conflict between agriculture and tourist development.

- The current state of aquifer and area currently is:
  - groundwater resources in the region are near exhaustion with the situation being almost irreparable,
  - transfer of water, through the Southern Conveyor Project, from the Kouris Dam some 70 km to the west maintains long-term agricultural practice. This supply is subject to availability depending on weather conditions,
  - increased demand (agricultural, domestic, tourist),
  - domestic and tourist demand is being met mainly by sea water desalination.

- As impacts were identified the:
  - loss of aquifer reserves,
  - sea intrusion,
  - reduction of well yield by 90% resulting to expensive groundwater if available,
  - the lack of water for irrigation compromises the potato production with negative effects on the local as well as the country's economy.

- The responses to the above are:
  - interbasin transfer of water through the Southern Conveyor from basins 70 km to the west,
  - introduction of alternative sources of supply (through desalination for potable water and import of tertiary treated water for irrigation),

- new water demand management practices – alternative employment opportunities,
- change of cropping patterns – increased shift to winter (more rain-fed) potato crop,
- application of the Code of Good Agricultural Practice to avoid excessive use of fertilizers,
- stricter enforcement of legislation regarding well permits and illegal drilling,
- adjustment of water pricing to reflect true cost of irrigation water as a tool for water demand management.

4.5. DPSIR Indicators for Spain

4.5.1. Canary Islands

Tenerife

- The driving forces are identified as the:
  - increase in population density (307 inhabitants/km^2 in 1991 and 366 inhabitants/km^2 in 2001),
  - high demand dispersion (both urban and tourist),
  - exponential tourist growth,
  - spatial changes of intensive agriculture characterized by high water demand.

- The current state is a:
  - progressive depletion of water galleries exploiting the upper aquifers,
  - groundwater over-exploitation by coastal wells, progressive salinization,
  - disproportionate growth of water supply infrastructures and increase in maintenance costs.

- As for impacts, the following can be identified:
  - progressive decline of water quality due to aquifer over-exploitation,
  - increase of water prices and appearance of competition between rural-agricultural and urban-tourist activities. Rise of social conflicts to the detriment of the countryside,
  - sewage problems due to house dispersion (aquifer pollution),
  - loss of critical habitats (particularly in gullies).

- Short and medium term responses are:
  - over-exploitation of aquifers,
  - response by the administration for the establishment of a Plan of reservoirs that would allow the increase in surface runoff utilization and agricultural supply by areas,
  - progressive increase in desalination capacity, basically aimed to urban and tourist supply,

- re-use of treated effluents,
- creation of the Island Water Agency and Development of the Hydrological Plan.

Lanzarote

- The driving forces are identified as the:
  - increase in population density (77 inhabitants/km^2 in 1991 and 122 inhabitants/km^2 in 2001),
  - tourist growth (from 200 beds in 1970 to 60,000 in 2000),
  - high increase in income and consumption.

- The current state is a:
  - absolute dependence on desalinized water. Only 4% of water resources correspond to the exploitation of the very saline aquifers.

- As for impacts, the following can be identified:
  - strong energy dependence and risk of running out of water.

- The responses are:
  - steady increase in desalinized water production,
  - start of water efficient use and saving strategies in the framework of the sustainable hotels strategy,
  - progressive capacity of water re-use (especially in the hotel and gardening sectors),
  - definition of a water strategy by the Biosphere Reserve Board,
  - progressive increase of the wind-power installed entirely used for water production. Start of experiences based on RES-WATER variable inputs autonomous systems.

El Hierro

- The driving forces are identified as the:
  - increase in cultivated land area,
  - increase in population due to return of immigrants,
  - important increase in income and consumption.

- The current state is a:
  - limitation of agricultural activity due to water scarcity and need to guarantee supply to local population,

- problems derived to quality of water for human consumption from wells and galleries, caused by the action of the volcanic materials where aquifers are located.

- As for impacts, the following can be identified:
  - extraction of water in very sensitive habitats (particularly in the last island's cloud forest redoubts),
  - high water treatment costs due to small scale of settlements, which obliges to develop integrated systems (anaerobic and aerobic treatment, ponds, algae).

- The responses are:
  - development of a water strategy in the framework of the island's Sustainable Development Plan,
  - development of a plan of reservoirs to establish systems for regulation and optimizing of water for agricultural use by hydrological areas,
  - doubling production of desalinized water. The entire water production will be powered by wind energy,
  - development of an ambitious Reforestation Plan that will allow the natural recharge of aquifers to the historic levels,
  - inclusion of minimum water consumption standards in the labels of the ecological products that support the island's Clean Production strategy,
  - recuperation, updating and modernization of traditional systems for water collection in houses, including advanced saving systems and municipal housing standards,
  - development of surface runoff collection, including systems to collect water from the road network,
  - consideration of the water sector as an innovator, productive sector within the strategy of island development, favoring water SME's.

La Palma

- The driving forces are identified as the:
  - generalization of intensive crops,
  - population increase,
  - tourist growth in the Southern and Eastern areas.

- The current state is a:
  - water scarcity in specific areas and seasonal scarcity during irrigation periods,
  - resource imbalance between areas, adjusted with high-cost water transfers.

- As for impacts, the following can be identified:
  - extraction of water in very sensitive habitats particularly affecting riverbed vegetation,

- infrastructural impacts derived from new water transfers,
- scarce development of the sewerage network due to population dispersion and decline of the aquifers water quality.

- The responses are:
  - development of the Hydrologic Plan and strengthening of the "Consejo de Aguas" (Water Council),
  - sustainable Tourist Destination strategy that includes water management dimension as a priority factor,
  - energy deployment program (mini-hydraulic) oriented to compensate water transport costs within the island imbalance,
  - development of a water-monitoring network in the framework of the island's institutional sustainable development, supported by the development of municipal Agendas 21,
  - technological innovation in the irrigation systems.

4.5.2. Doñana

- Driving forces in the region are the:
  - excessive surface of intensive agricultural cultivations,
  - excessive surface of antiquated agricultural activities (rice),
  - high level of concentration of tourist demand.

- Pressures exerts on the:
  - natural water resources,
  - the demand exceeds in many areas the limit of for the conservation of the wetlands,
  - in several areas the capacity recharge of groundwater exceeds (average 49% extraction in shortage period),
  - massive water derivation in shortage periods for the irrigated land,
  - the problem with pollution of aquifers and surface water resources from agrochemicals and agro-industry is a severe pressure imposed on ecosystems,
  - low percentage of treated waters (5%).
- The current state is the:
  - overexploitation of groundwater is seriously affecting natural areas of vital importance,
  - seasonal water deficit during the irrigation period,
  - excess of superficial water derivation,
  - nitrates concentration for both surface and ground waters exceeds (in a few sampling points) the limit values for drinking water while results for pesticides also show elevated values. Unacceptable values for the wetlands conservation,
  - permanent conflict between the farmers and the environmentalists.

- Impacts are:
  - loss of wetlands. Loss of biodiversity,
  - extension of the dry period,
  - groundwater overexploitation,
  - environmental impacts can be very important. Pollution, eutrophication of the waters, compromises the aquatic ecosystem integrity and the ecology of the wetland areas,
  - economic impacts from the seasonal water deficits for both tourism and agriculture.

- The response are:
  - to increase the water monitoring network,
  - diminution of the irrigated areas of rice with groundwater,
  - changes of intensive cultures, greater diversification,
  - increase of treated waters,
  - regeneration of the natural hydrological systems (Doñana 2005 Project),
  - development of the plans of sustainable use of the water by each basin,
  - information campaigns.

4.6. DPSIR Indicators for Portugal

4.6.1. Sado river basin

- As driving forces one could identify the:
  - irregular temporal precipitation distribution (about 78% concentrated in the humid semester),
  - important thermo electric energy production,
  - intensive and antiquated agricultural activities, with low efficiency in agriculture water use,
  - waste generation from agricultural and industrial activities.

- Pressures:
  - high agricultural water demand,
  - high water demand due to energy production,
  - high demand during the summer irrigation period,
  - increasing water demand trends,
  - high pollutant loads generated from agricultural and industrial activities.

- The current state is a:
  - current and short-term water shortage (on dry years), aggravated in the summer months, during the irrigation period,
  - significant urban water supply and irrigation losses,

- water quality inadequate to the various uses.

- The impacts are identified as the:
  - surface water pollution and the decrease in flow during summer time leading to ecosystem degradation,
  - economic impacts due to water deficits for agriculture.

- Short-term responses are:
  - important inter basin water transfer (450 hm^3/year) from Guadiana's basin when Alqueva new multi-purpose hydraulic plant will be operating,
  - significant subsidies for irrigation water.

4.6.2. Guadiana river basin

- The driving forces can be identified as the:
  - Spanish flow regularization,
  - irregular temporal precipitation distribution (more than 80% concentrated in the humid semester),
  - intensive and antiquated agricultural activities, with low efficiency in agriculture water use,
  - waste generation from agricultural and industrial activities.

- Pressures:
  - upstream water management decisions (low flow Spanish bordering discharges, on dry years),
  - high agricultural water demand,
  - foreseen short and long-term large increase on agricultural area,
  - high demand during the summer irrigation period,
  - low water availability due to periodic droughts,
  - increasing water demand trends,
  - high pollutant loads generated from agricultural and industrial activities,
  - foreseen short-term exporting water transfer (700 hm^3/year to Sado and Ribeiras do Algarve basins) based on Alqueva new multi-purpose hydraulic plant (which is on a final stage construction).

- The actual state can be defined by the:
  - current water shortage, aggravated in the summer months during the irrigation period,
  - high urban water supply and irrigation losses,
  - groundwater overexploitation due to water deficits,
  - surface and groundwater pollution.

- As impacts one could emphasize on the:
  - low flow (or even no flow, on dry years) on bordering stretches,
  - surface and groundwater pollution leading to ecosystem degradation,
  - economic impacts due to water deficits for agriculture.

- Short-term responses can be:
  - Alqueva new multi-purpose hydraulic plant (with a very large reservoir (useful water storage capacity of 3150 hm^3) foreseen to provide a solution to the water deficit problem,
  - significant subsidies for irrigation water.

4.6.3. Ribeiras do Algarve river basin

- As driving forces one could identify the:
  - irregular temporal precipitation distribution (more than 80% concentrated in the humid semester),
  - tourist development,
  - intensive and antiquated agricultural activities,
  - waste generation from both urban (permanent population and tourists) and agricultural sectors.

- Pressure:
  - high agricultural water demand,
  - high tourist influx,
  - high demand during the summer period,
  - conflicting uses – irrigation vs tourist demand,
  - high exploitation of aquifers,
  - increasing population density trends,
  - increasing water demand trends,
  - high pollutant loads generated from urban and agriculture sectors.

- The current state is a:
  - current and long-term foreseen water shortage, aggravated in the summer months during the irrigation period,
  - high urban water supply and irrigation losses,
  - surface and groundwater pollution,
  - salinization in most coastal aquifers (due to over-abstraction),
  - reservoir water eutrophication.

- The impacts could be identified as the:
  - surface and groundwater pollution and the decrease in flow (even no flow, on certain cases) during summer time, leading to ecosystem degradation,

- economic impacts due to water deficits for both tourism and agriculture,
- inadequate land use and water infrastructure.

- Short-term responses are:
  - current and foreseen (plus 250 hm^3/year on a short-term) inter basin water transfer from Guadiana's basin,
  - significant subsidies for irrigation water.