Putting the WFD into practice:
Strategy formulation for IWRM under scarcity conditions

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ABSTRACT

This paper presents a framework for the development and evaluation of strategies for water deficient regions which focuses on the mitigation of water stress and applies the principles of Integrated Water Resources Management and the EU Water Framework Directive. The adopted methodological approach is presented through a tentative application in the island of Paros, of the Cycladic Complex in Greece. The island faces intense supply coverage problems during the summer tourist season, while, like in most Mediterranean coastal regions, groundwater resources are overexploited in order to address the high irrigation and domestic water requirements. The elaboration of two alternative strategies is complemented with the formulation of an alternative model for water resource allocation and management, where there is free competition of the two economic sectors (tourism and agriculture) over scarce water resources and water supplies are developed through private initiatives.

Key Words: Arid regions, Water Stress, Strategic Planning, Cost recovery.

1. INTRODUCTION

Water problems are neither homogenous, nor constant or consistent over time. They often vary significantly even within a single country between regions, from one season to another, and from one year to another (Biswas, 2000). Solutions to water problems depend not only on water availability; two of the most important factors are the processes through which water is managed and the prevailing regional socio-economic and environmental conditions.

In most Mediterranean regions, the presence of continuous sources of water stress is combined with periodic droughts. The decline of water resources and increasing demand for freshwater cause threats to the environment and provoke conflicts between competing uses, even in comparatively water-rich areas (Margat and Valée, 2000). New infrastructure (dams for interseasonal storage, extensive conveyance systems) needs to be built to address the need for adequate supply; this in turn raises the question of adequate funding, institutions and administration that can enable the development and management of such infrastructure. Further compounding the problems, the coastal regions, where population tends to concentrate are an attractive tourist destination. This seasonal peak, which normally coincides with the irrigation season, creates strong competition of users over scarce resources, and should be taken into account in infrastructure planning. The imposed economic burden and low water availability potentially result in low recovery of costs, especially under drought. At the same time, environmental impacts from water usage are significant: wastewater collection and treatment systems are inadequate or even barely developed, while in many regions water resources are overexploited. The development of cost recovery mechanisms and appropriate pricing schemes also needs to address the potentially high resource and environmental costs, and existing cross-subsidies between use sectors and users.

Following from the above considerations and principles, the development of appropriate, integrated water management strategies for arid regions should reconcile multiple goals and objectives: guarantee the provision of water of sufficient quantity and quality for sustaining and developing dominant economic activities while protecting vulnerable ecosystems; ensure the financial sustainability of water services and the appropriate maintenance and renewal of infrastructure while taking into account the affordability of water users. By definition, a strategy is a detailed plan or method that is employed to obtain a goal and a means of translating policy into action. In the present work, strategies are considered to be a set of actions or sequence of responses to existing and emerging conditions, suited/available for the fulfilment of a selected goal.

With this definition, the following paragraphs demonstrate a methodological approach for the development of strategies for water deficient regions, with the goal to alleviate water scarcity. The approach is based on the application of a Decision Support System (WSM DSS), developed in the framework of the EC-funded WaterStrategyMan project (‘Developing Strategies for Regulating and Managing Water Resources and Demand in Water Deficient Regions’ – Contract no: EVK1-CT-2001-00098). The methodological approach is applied to the Case Study of the island of Paros of the Cycladic Complex in Greece. Paros is a typical case where water shortages occur on a seasonal basis due to the coinciding high tourist influx and irrigation peak season. The elaboration of suitable strategies is thereby followed by the development of an alternative regional development model, based on the free competition of the two dominant economic sectors, agriculture and tourism over scarce resources. In this context, additionally required infrastructure is developed through private initiatives, by the end-users.

2. FORMULATION OF WATER MANAGEMENT STRATEGIES FOR THE ISLAND OF PAROS, GREECE

2.1 The island of Paros

The island of Paros (Figure 1) is one of the most popular tourist destinations in the Cycladic Complex. During the summer months seasonal population is almost three times greater than the permanent residents, while during the winter months local authorities estimate that only 50% of the permanent registered population lives on the island.

The development of tourism and the consequent prosperity of the island began slowly in the early 1960s, after many years of decadence. Since 1950 local inhabitants were mostly farmers and fishermen. Between 1950 and 1965 a large emigration trend was observed that resulted in a great population decrease. In the 1970s this trend was reversed due to tourism that grew rapidly during the 1980s, bringing about changes in the traditional way of living. Unfortunately this development took place without planning and control, leading to the problems that the island is facing today, both economic – offer of accommodation being greater than demand of accommodation – and environmental – great seasonal pressures exerted on water resources. Simultaneously, the agricultural activity that had been abandoned was enhanced to a large extent by this growth, and the resulting demand for local traditional products (e.g. local wines).

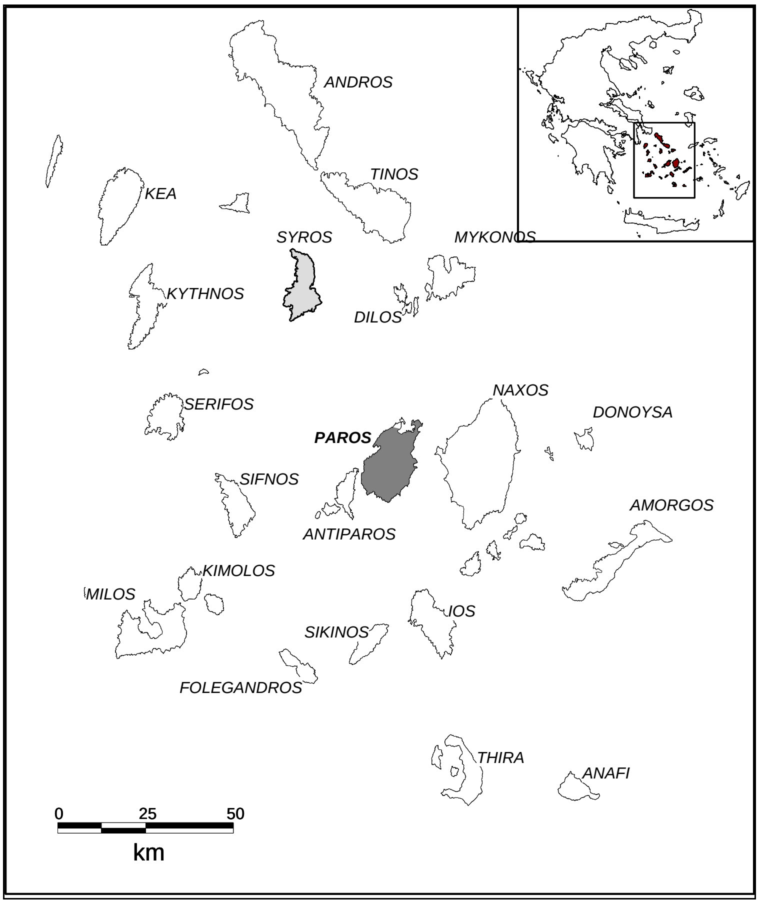


Figure 1: The island of Paros in the Cycladic Complex

Water demand growth in the last decades was mostly addressed through the construction of extensive water drillings to supply the domestic and agricultural sectors. Paros is a typical case where water shortage occurs on a seasonal basis. Tourism and irrigation demand reach their peak during the summer months, creating conflicts between uses and problems with water supply adequacy during peak consumption. The island has the potential to combine multiple activities; both tourism and agriculture can offer a prosperous future for the inhabitants under suitable planning and control. So far however, the existing infrastructure has proven to be inadequate for dealing with these issues. Therefore new water management responses are needed to address the problem and ensure the sustainable management of water resources.

2.2 Strategy formulation

The goal for the formulation of strategies for the island of Paros was to reconcile water supply and demand in order to promote tourism development, while at the same time preserving traditional agricultural activities. The strategies that were formulated aimed at medium to long-term planning, and therefore take into account a 25 year horizon, spanning the period 2005-2030. The targets set for the analysis were to meet (a) at least 80% of the domestic and irrigation needs in the peak summer period, and (b) 100% of the demand during the rest of the year. At the same time, secondary objectives in the overall process was the achievement of (a) economic efficiency, through the maximisation of economic output, (b) environmental sustainability through impact mitigation and reduction of groundwater extractions to sustainable levels, and (c) equity by achieving a more equitable allocation of incurred direct, environmental and resource costs to users.

Appropriate measures and instruments, and their potential limitations were identified through the examination of the current responses to water stress issues and consultation with the local stakeholders. A summary is portrayed in Figure 2.

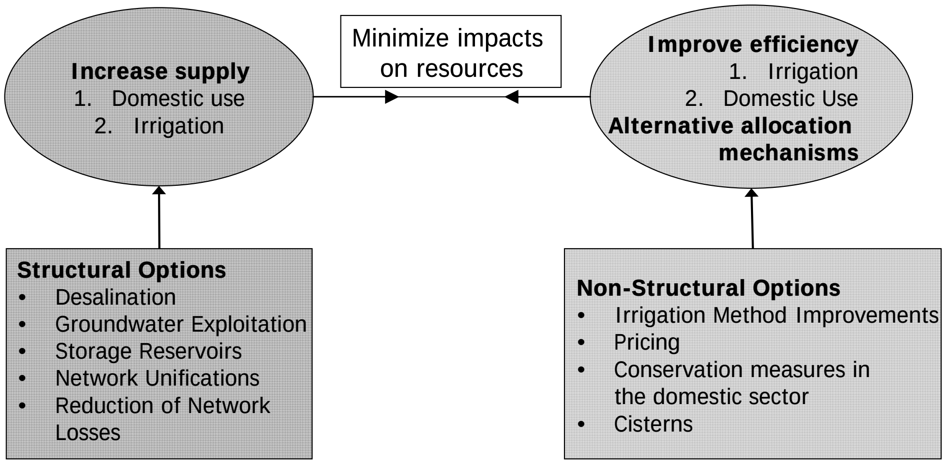


Figure 2: Summary of identified feasible and available options for the island of Paros

Subsequently, the most suitable options were integrated into coherently formulated water management strategies. Two alternative approaches were distinguished, after the water resource planning paths elaborated by Gleick (2003):

- The **hard-path approach**, mostly oriented towards supply enhancement through the application of structural solutions, and incorporating new technologies such as desalination;
- The **soft-path approach**, integrating demand management options, and small-scale decentralised structural interventions to alleviate major water shortages. Potential demand management responses for the island concern mostly conservation efforts and efficiency improvements, promoted through economic incentives.

A summary of the measures incorporated in the two strategies is presented in Table 1. Measures were subsequently formulated in a suitable timeline, determined through an iterative procedure, and were compared and evaluated against each other and against the reference case on which they were built. The reference case was defined as the foreseen evolution of the water system, including a business-as-usual demand scenario (1.5% growth for permanent and tourist population, stable irrigation demand), and constant, average availability conditions. Planned and already decided interventions were also taken into consideration.

Evaluation results regarding the effectiveness and cost of the two approaches are presented in Figure 3 and Table 2. In terms of effectiveness, both strategies can meet more than 95% of domestic needs; set targets are also met for irrigation water supply. However, in the latter case, the soft-path approach has a slightly better performance, especially after the full introduction of measures that target the agricultural sector, i.e. irrigation method improvements, and measures that limit domestic consumption. Therefore, it becomes evident that agricultural activities can more effectively be sustained through the introduction of measures that improve the efficiency of water usage.

Table 1: Measures incorporated in the two alternative water management strategies

Hard-path approach	Soft-path approach
	Network Unifications
Groundwater Exploitation A total of 4 additional boreholes, yielding 204,000 m^3/yr	**Groundwater Exploitation** 1 additional borehole, yielding 75,000 m^3/yr
Surface water exploitation Interception dam for aquifer enhancement Capacity of 98,000 m^3	**Surface water exploitation** Interception dam for aquifer enhancement Capacity of 98,000 m^3
Reduction of Network Losses From 25 to 20 %	**Reduction of Network Losses** From 25 to 20 %
	Conservation measures in the hotel sector 10% reduction of consumption
	Irrigation Method Improvement Substitution of current methods with drip irrigation
Desalination Additional capacity of: 1300 m^3/d in 2010 2000 m^3/d in 2020 2700 m^3/d in 2030	**Desalination** Additional capacity of 600 m^3/d

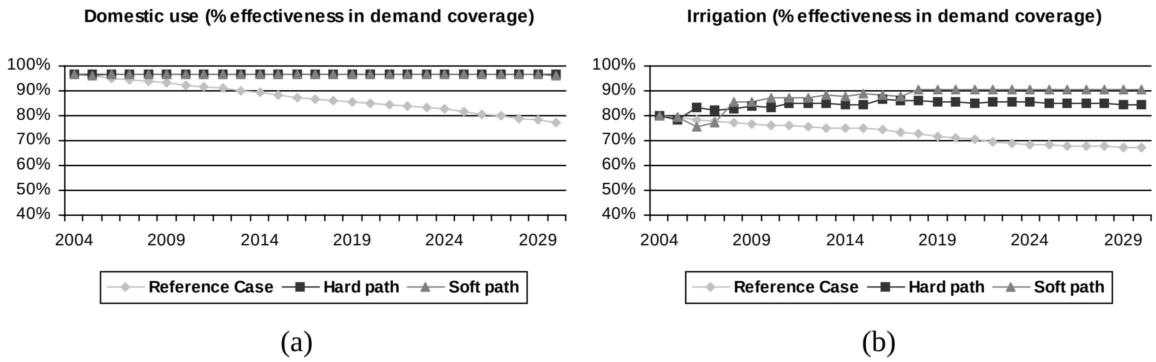


Figure 3: Effectiveness of the proposed strategies in meeting the set targets (a) domestic use (b) irrigation water provision

Estimated costs for the two strategies and the reference case are outlined in Table 2. Direct costs include capital and operational costs for measure implementation, and costs associated with the operation of the water system (e.g. pumping costs for irrigation and domestic supply, network costs, administrative costs etc). Environmental cost is associated with the cost of preventive/mitigation measures and includes two components: one incurred from groundwater over-abstractions, and one dealing with pollution generation from inadequately treated urban return flows.

Table 2: Comparison of strategy costs

	Direct Cost	Resource Cost	Environmental Cost	Groundwater over-abstractions (hm^3-2015)
	(PV, 4%, 2004-2030, million €)			
Reference	27.59	5.07	36.07	0.63
Hard-path	33.99	3.88	35.89	0.58
Soft-path	30.33	0.87	33.84	0.45

The soft-path approach seems to occupy an advantageous position, presenting lower values for direct, environmental and resource costs. The reduction of direct costs is primarily due to the introduction of efficiency improvements, which limit the required desalination capacity (i.e. 600 vs. 2,700 m^3/d). Similar results are obtained for environmental costs, since in most aquifers the abstractions considered "unsustainable" (exceeding the safe yield) are significantly lower.

Therefore, a preliminary conclusion that can be drawn from this analysis is that soft-path approaches can be effective in mitigating water stress, while at the same time incurring lower costs to consumers. This issue is further elaborated in the following section.

2.3 Addressing Cost Recovery Issues

An additional step in the process of defining appropriate strategies is the development of cost recovery scenarios which could ensure the financial sustainability of water services. These scenarios are formulated for each water use sector and service by setting appropriate cost recovery targets to be achieved within a set timeframe, and taking into account the present institutional and administrative framework.

Domestic water supplies in Paros are under the administration and management of a municipal water utility company (DEYAP) since 1999. Increasing block tariffs (IBTs) set by the DEYAP recover operation and maintenance costs for water supply and wastewater collection and treatment, and part of capital costs. Although maintenance and control follow a centralized and better-organised decision-making path than before, there are still remnants of the past administrational structure, when each municipal department used to develop its own water resources. One of these is the differentiation of block tariffs per municipal department. A Local Board for Land Improvement (TOEV) manages irrigation water supplies in the northern part of the island; however most agricultural needs are met through private boreholes and crop irrigation relies solely on groundwater. In this case there is no recovery of any kind of either environmental or resource costs.

On a preliminary basis, cost recovery scenarios were formulated through the definition of flat-rate volumetric prices and charges, to be re-adjusted every five years in order to achieve a set recovery of direct and environmental costs. For this purpose, costs were allocated to each use according to the *'polluter pays'* through the WSM DSS. More specifically, direct and environmental costs associated with supply provision were allocated proportionally to the volume supplied to each use(r) from each supply source, whereas environmental costs from pollution generation according to the loads generated from each use.

For irrigation water, where financial costs are fully covered by the users, environmental cost recovery is effected through charges (penalties) for over-abstraction. It should be noted that the actual implementation of such an instrument would involve the specification of abstraction limits per borehole, and the metering of extracted quantities at the end of the irrigation season. The definition of the maximum charge per 5-year period is based on the consideration that the private welfare surplus (i.e. the difference between benefits and the water costs charged to the consumers) from agricultural activities should be positive. This limited the maximum possible recovery of environmental costs to 50%. On the other hand, tariffs for the Water Utility were formulated to achieve a 100% recovery of direct costs for the entire planning period. The targeted recovery of environmental costs in 2005 was set at 50%, and was gradually increased, reaching 70% in 2030.

The estimation of prices and charges to be eventually applied was based on an iterative process, where demand and allocated volumes were re-estimated according to assumed demand elasticities. Resulting prices and charges are presented in Table 3.

Table 3: Prices and charges estimated for the two strategies, in €/m^3

	2005	2010	2015	2020	2025	2030
Domestic Use						
Hard path	2.19	2.19	2.19	2.27	2.32	2.32
Soft path	2.14	2.14	2.18	2.27	2.32	2.32
Irrigation						
Hard path	0.09	0.12	0.12	0.12	0.13	0.13
Soft path	0.07	0.11	0.11	0.11	0.12	0.12

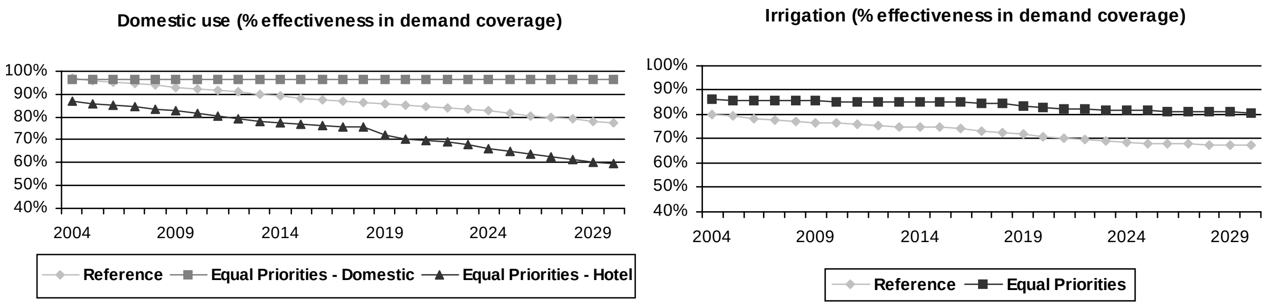
It becomes therefore evident that in principle, and at least up to 2010, the adoption of soft approaches can also result in lower costs charged to consumers. After 2020 both strategies result in similar prices and charges. Although costs for non-structural solutions are lower, due to the reduction of consumption, the volume of water sales is also smaller; therefore higher prices are required in order to attain the same cost recovery targets.

3. AN ALTERNATIVE REGIONAL DEVELOPMENT MODEL

Water resource planning, as presented in the previous paragraphs, was based on the assumption that supply enhancement and demand management are financed through public funds, which are afterwards recovered through the water bill. In addition, strategies were developed taking into account the Greek Law 3199/2003 with regard to priorities for supply provision. Accordingly, the provision of water for domestic purposes, which also includes tertiary sector activities such as tourism, was considered of first priority, to be guaranteed under all circumstances.

This section outlines the development of an alternative model, where users develop supplies required for sustaining economic activities through private initiatives. Water supply for households is of the highest priority, and provided by the public authorities. Free competition over scarce resources is promoted between tourism and agriculture, which both receive water at a lower and equal allocation priority.

The graphs of Figure 4 portray the evolution of effectiveness in demand coverage, assuming that no measures are taken towards supply enhancement. The reference case corresponds to the original priority setting, where no distinction is made between households and the hotel sector. Under the current priority assumptions, the improvement in residential and irrigation demand coverage is evident, while tourism demand is not adequately met. Most importantly however, Figure 4a) portrays that no further action is required to guarantee adequate water supply for households.



(a) (b)

Figure 4: Effectiveness of the two allocation schemes for the coverage of (a) residential and tourist demand and (b) irrigation demand

The set allocation priorities directly affect total economic output: in present value terms, foregone benefit from tourism reaches 13.11 million €, while benefits accrue from agricultural activities are only equal to 7.54 million €. Similarly, the total social welfare surplus (i.e. the difference between the total value or benefit and the total direct and environmental costs) is also reduced by approximately 8%.

A first response to this income loss could be the enhancement of water supplies by the hotel industry, in order to safeguard tourism revenues. Similar responses, through the installation of small, privately owned desalination units have been considered by hotel and lodging owners in the past in similar popular tourist destinations. For Paros, the required total desalination capacity in order to meet the peak mid-August tourism demand is estimated at 5,700 m^3/d in 2010, and 9,500 m^3/d in 2030. Electricity grid constraints limit maximum installed capacity to 5,000 m^3/d for the period 2005-2020 and 6,000 m^3/d for 2021-2030. The additionally required water supply can originate from surplus of public water supply sources and water purchases from irrigation boreholes. The supply mix for the hotel sector, as estimated through the WSM DSS, is presented in Figure 5.

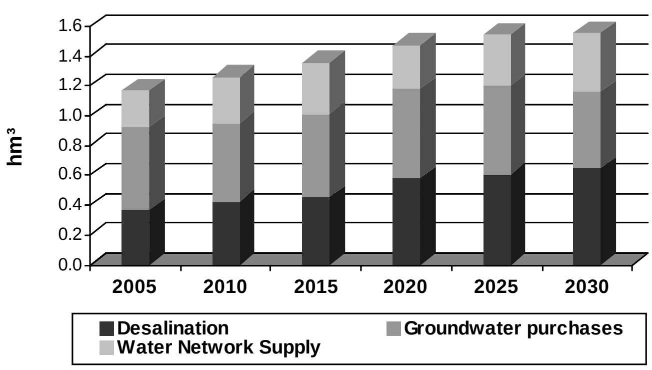
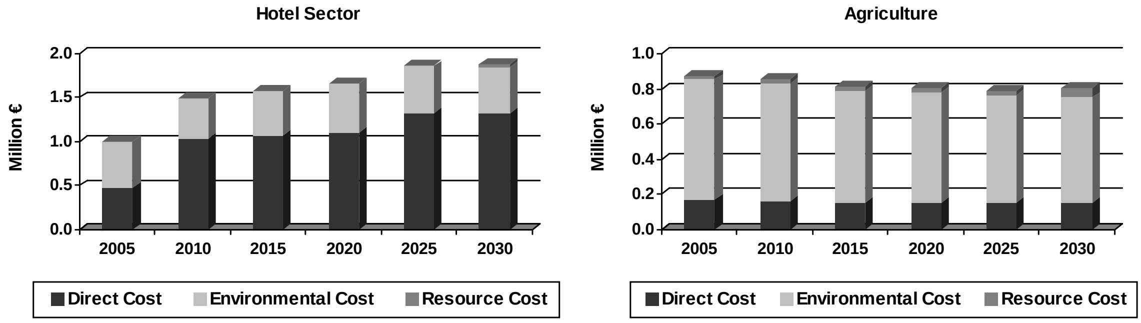


Figure 5: Supply mix for the tourism sector

Figure 6 present the costs allocated to the hotel and agricultural sectors. In the first case, direct costs represent the costs of public water supply provision, the capital and operational costs associated with desalination unit construction and operation, and the cost of groundwater purchases. Prices for the latter are estimated in order to compensate for income loss from agricultural activities, and thus represent a lower limit for this cost.



(a) (b)

Figure 6: Incurred direct, environmental and resource costs to the hotel and agricultural sectors under the alternative development model

Flat-rate tariffs for supply from the public water system are estimated by assuming the same cost recovery targets. Table 4 presents the resulting unit costs incurred to users for 2015. The most important difference is observed in prices incurred to households, which are even lower than the current weighted average tariff of 1.47 €/m^3. On the other hand, the economic burden imposed on the hotel sector is almost insignificant, with the average unit cost being only 6% higher than the one of the hard-path approach.

Table 4: Costs incurred to consumers under different management plans (2015, €/m^3)

<table>
<tr><th></th><th>Households</th><th>Hotel Sector</th><th>Agriculture</th></tr>
<tr><td>Hard-Path</td><td colspan="2">2.19</td><td>0.12</td></tr>
<tr><td>Soft-Path</td><td colspan="2">2.18</td><td>0.11</td></tr>
<tr><td>Alternative Model</td><td>1.29</td><td>2.32</td><td>0.08</td></tr>
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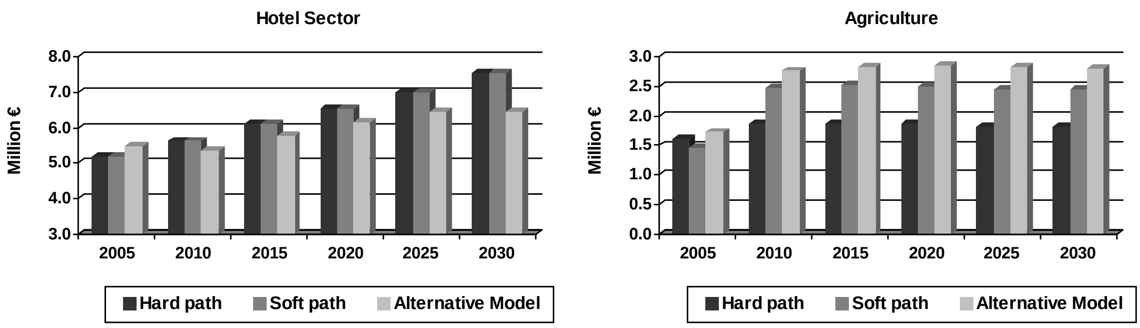
Finally, Figure 7 presents a comparison of the private welfare surplus for the two economic sectors and for each examined planning scheme.



(a) (b)

Figure 7: Incurred direct, environmental and resource costs to the hotel and agricultural sectors under the alternative development model

In line with the estimated costs, the economic impact of the alternative allocation scheme in the short run does not influence much the total net benefit accrue to users; the difference becomes larger at the end of the simulation period, when the installed desalination capacity is considerably higher and costs incurred to consumers increase.

4. CONCLUDING REMARKS

The development of strategic plans following the principles of Integrated Water Resources Management and the Water Framework Directive should be based on a thorough examination of the institutional and administrative frameworks, and of regional development patterns and users' expectations. In spite of the model used – public or private water supply development, strong regulatory frameworks are necessary in order to ensure the sustainable management of water supplies and the preservation of traditional economic activities, vital to the social structure. This however should not compromise the need for the decentralisation of decision-making, which can help at addressing emerging water management issues locally.

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