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Combining the Water Framework Directive with Agricultural Policy Scenarios: A Multi-Objective Analysis for the Future of Irrigated Agricultural in Portugal

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Abstract:
It is clear that the successful management of water resources must take into account the influence of policies affecting the irrigated agriculture sector. Among these, the importance of the Common Agricultural Policy (CAP) and of the Water Framework Directive (WFD) is well recognised.
In Portugal, more than 606,000 hectares (INE 2001b) are allocated to irrigated agriculture, which accounts for 74.8% of all water uses (INAG 2002). To study the combined effect of these policies, two irrigated regions of Portugal, Baixo Alentejo and Lezíria do Tejo, were analysed in case studies. Multi-Criteria Decision Making models (MCDM) were applied to characterise farmers' decision-making attitudes of the main irrigated agriculture systems of these regions.
The implications of environmental (WFD) and agricultural (CAP) policy change are assessed by reproducing farmers' decision-making behaviour.
Simulation results indicate that changes in these policies are conducive to substantial adjustments within the irrigated agriculture sector. This study demonstrates that the consequences of implementing the WFD are dependent both on the water price level set by the WFD and on the agricultural policy strategy in place.

Palavras-chave/Keywords: Water Framework Directive; Multi-objective Programming; Irrigated Agriculture; Water Economics; Portugal

Classificação JEL/JEL Classification: Q25; Q15; C61

INTRODUCTION

Freshwater resources worldwide are estimated in the vicinity of 43219Km^3 (UN 2003). On average the agricultural sector accounts for the largest share of water withdrawals, with 71% of the total water consumption (UN 2003). A similar proportion is found in European Mediterranean countries and in Portugal, where the irrigated agriculture withdrawals represent 70% (EEA 2003) and 74.8% (INAG 2002) of the total water consumption, respectively. Since irrigation is responsible for the dominant share of water use, it is clear that the success or failure of water resources management is to a large extent influenced by policies affecting the irrigated agriculture sector. Among these, the importance of the Common Agricultural Policy (CAP) and the Water Framework Directive (WFD) is well recognised within the European Union (EU).

Recent research with identical objectives and closely related methodologies has been conducted in other European countries under the EU funded research Project WADI – *Sustainability of European Irrigated Agriculture under the Water Directive and Agenda 2000* – EVK1-CT-2000-00057. WADI focused on the impacts of various policy instruments for irrigation water management and on the combined effects of the WFD and CAP scenarios. In the United Kingdom (Morris et al. 2005); Greece (Manos et al. 2005; Manos et al. 2003), Italy (Bazzani et al. 2002; Gallerani et al. 2005); Spain (Berbel et al. 2005; Berbel and Gomez-Limon 2000; Gómez-Limón et al. 2003; Gómez-Limón and Riesgo 2005; Gomez-Limon and Riesgo 2004) and in Portugal (Pinheiro and Saraiva 2005; Saraiva and Pinheiro 2003).

Models based on mathematical programming are widely applied in agriculture (Hazell and Norton 1986). These models often seek to optimise one single objective, such as profit, gross margins or the value of sales. However, in reality the decision maker seeks a compromise solution between several objectives (Romero and Rehman 1989). To overcome this problem the modelling approach adopted in this project was based on multi-objective mathematical programming models, supported by the Multi-Criteria Decision Making and Multi-Attribute Utility Theory (see Bazzani et al. 2005; Romero et al. 1987; Sumpsi et al. 1996; Varela-Ortega et al. 1998). This permits the decision-making patterns of farmers belonging to different farming systems to be incorporated into policy analysis. In this paper, the farmer's objectives of maximizing farm income, minimizing risk, employment and operative capital were considered as variables in the utility function.

This study quantifies the predictable implications that the implementation of the WFD may have on two major irrigation regions of Portugal – Baixo Alentejo and Lezíria do Tejo regions – when a volumetric tariff is applied. The WFD effects are analysed in the context of the Agenda 2000 agricultural policy measures, and in the context of CAP post-Agenda 2000 policy scenarios. The time horizon considered is the year 2010 – the year of the compulsory application of a water-pricing policy. In both regions the study of irrigated agriculture is further disaggregated in types of irrigated agriculture systems.

The results of this study indicate that the implications of implementing the WFD are dependent on the region and on the types or agriculture practiced. In addition, it is demonstrated that the consequences of raising the water price to reflect the WFD objectives, are inextricably linked to the CAP policy in place.

THE WATER FRAMEWORK DIRECTIVE

The EU Water Framework Directive (Directive 2000/60/EC 2000), was enacted in the first half of 2000 and establishes a framework for Community action in the field of water policy. One of the most relevant dimensions of the WFD concerns the emphasis placed on the use of economic instruments for water management. In the light of the WFD, EU Member States are obliged to put into practice a cost recovery strategy, as part of their basic programmes of measures, and to implement a water pricing policy by the year 2010.

Prior to the WFD, in spite of the "patchwork" (Lanz and Scheuer 2001) of legislation enacted for water protection, only particular environmental problems or specific economic activities were being addressed (Chave 2001). In the WFD, this problem is overcome by reuniting all isolated legal acts, directly and indirectly related to water quantity and quality, in one single legislative instrument (Chave 2001; Lanz and Scheuer 2001; OECD 1999a). This has produced a powerful instrument for the integrated protection and management of water resources in the EU, in the sense that it provides operational tools, backed up by law, following common principles of action, and in a comprehensive and coherent framework.

The WFD main purpose is to establish a framework for the environmental protection of all waters, maintaining and improving the Community aquatic environment. This very broad aim should be reached by a set of overall objectives leading to sustainable use and long-term protection of the available water resources. The WFD aims to prevent any further deterioration of the aquatic ecosystems conditions, protecting water bodies and improving their status; to reduce the pollution both on surface and ground waters, progressively reducing discharges and emissions of hazardous substances; to mitigate the effects of floods and droughts and help to provide sufficient good quality supply of water resources, "as needed for sustainable, balanced and equitable water use" (Directive 2000/60/EC 2000).

To accomplish these tasks, the major innovation and greatest paradigmatic change of the WFD consists in the emphasised use of economic instruments in environmental policies (European Commission 2000). The WFD is based on the enforcement of demand management instruments (Directive 2000/60/EC 2000) instead of relying on water supply leading strategies. Water-pricing is the privileged method to promote sustainable water use levels, and to provide an adequate contribution of the different water users to the cost recovery of water services (Directive 2000/60/EC 2000; European Commission 2000).

The use of economic pricing policies is targeted to reflect the Full Cost Recovery (FCR) of water services. The underlying notion to the FCR is that if the water price does not reflect the long-run marginal cost of supply and distribution, water will be overused by economic activities below its opportunity cost (OECD 1999b). The water price should consider all the costs involved in the provision of water in sufficient quantity and appropriate quality (Directive 2000/60/EC 2000), such as abstraction, storage, treatment and distribution of water, as well as economic/financial costs (such as investment, devaluation, capital interests), externality costs and resource costs. In other words, the water price should integrate both the user-pay and polluter-pays principles (Directive 2000/60/EC 2000; European Commission 2000).

Case Study Description, Irrigated Agricultural Systems

Two representative irrigated regions of Portugal (see Figure 1) were chosen as case studies: Baixo Alentejo and Lezíria do Tejo. The study of the irrigated agriculture in these areas is differentiated by farming systems, considering crops types and farming areas.

Figure 1. Location of the case studies

The representative farming systems analysed provide altogether a good description of the irrigated agriculture in these regions. In the case of Baixo Alentejo a Vegetables typology represents small farms in which intensive crops such as vegetables and processing tomatoes are predominant. An Extensive Farming typology characterises irrigation systems based on extensive cereal and oilseed production. The last typology considered in this region, General Agriculture, corresponds to an in between situation of the previous typologies; it is composed by a non intensive component of vegetable and agro-processing crops, as well as cereals and oilseed crops. In the Lezíria do Tejo region a Vegetable and General Agriculture are suffice to characterise irrigation. Table 1 shows the crop acreages in each farming system.

Table 1. Crop acreages in each farming system

Main Crops (ha)	Agricultural Systems				
	Vegetables		General Agriculture		Extensive Farming
	B. Alentejo	Lezíria Tejo	B. Alentejo	Lezíria Tejo	B. Alentejo
Sweet Pepper	0.36	0.16			
Tomato (fresh)	0.24	0.15			
Letuce	0.14	0.27			
Onions	0.36	0.15			
Brocoli	0.18				
Melon	3.51	0.33	2.00		
Tomato (proc.)	5.20	3.71	3.34	4.78	
Carrots		0.22			
Common Wheat			12.59		28.20
Durum Wheat			6.32		14.20
Hibrid Maize			9.74	12.95	21.80
Sugar Beet			2.29	1.89	5.20
Sunflower			9.87		22.00
Rice				4.09	
Set Aside			3.85	1.30	8.60
Area (ha)	**10.0**	**5.0**	**50.0**	**25.0**	**100.0**

(Based on INE 2001a; INE 2001b)

The relevance of each agricultural system in each region, or the weight of each typology to the regional aggregated results, is presented in Table 2. Aggregation is obtained by the horizontal summation of each typology results affected by their respective coefficient.

Table 2. Representativeness of each agricultural system to the regional aggregated results

	Vegetables	General Agriculture	Extensive Farming
Baixo Alentejo	0.031	0.517	0.452
Lezíria do Tejo	0.205	0.795	-

METHODOLOGY

Models based on mathematical programming are widely applied in agriculture (Hazell and Norton 1986). These models often seek to optimise one single and well define objective; their objective function usually considers the optimisation of profit, gross margins or the value of sales. Unquestionably, this is an assumption which does not hold true for most farms. In reality, the decision maker – the farmer – seeks a compromise between several objectives (Romero and Rehman 1989).

The analysis of agricultural and water policy effects followed in this study is based on a Multi-Criteria Decision Making (MCDM) mathematical programming model (for a discussion on MCDM see Hazell and Norton 1986; Maccrimmon 1973; Romero and Rehman 1989), and optimises a multiple objective/attribute (Multi-Attribute Utility Theory) utility function. Using this methodology, the farmer's utility is not singularly conditioned by profit or gross margin maximisation; there are other objectives to which he reacts to, such as risk, hired labour dependency, capital investments, fixed costs, leisure time or indebtedness (Hazell and Norton 1986; Romero and Rehman 1989).

The weights attached to each objective are determined by goal-programming techniques. This permits constructing multi-attribute utility functions, consistent with the actual farmers' preferences (Arriaza et al. 2002; Berbel and Rodriguez-Ocana 1998; Gómez-Limón et al. 2002; Sumpsi et al. 1996). This approach provides a better framework for modelling the implications of policy change at the farm-level, reproducing decision-making criteria and farmers' behavioural patterns.

Methodology Summary

Given the fact that the fundamental methodological components followed in this project are well reported elsewhere (see Bazzani et al. 2005), only a short summary is presented to avoid unnecessary and overlapping sections. The first section of this behavioural model determines a pay-off matrix – presenting all the objective values when a particular objective is optimised. The next phase consists in calculating the values of the objectives using each agricultural system observed crop-mix selection. The objective coefficients (weights) that reproduce "the decision-making plan as close as possible to the farmers' real-life decision plan" (Gomez-Limon and Berbel 2000) are obtained by goal programming, minimizing the sum of differences between the observed objective values and the pay-off matrix ones (Gomez-Limon et al. 2003). An additive utility function that reflects farmers' preferences is written (Eq. 1), following the Multi-Attribute Utility Theory (see Bazzani et al. 2005) approach. To ensure that additivity is kept, this form normalises the objective units with the ideal and anti-ideal pay-off values. The objectives considered in the utility function (RFE, RISK, TL and K) are immediately described below.

The normalized equation with the objectives considered is written as:

$$U = w_{RFE}\frac{RFE(\vec{X}) - RFE_*}{RFE^* - RFE_*} + w_{RISK}\frac{RISK_* - RISK(\vec{X})}{RISK_* - RISK^*} + w_{TL}\frac{TL_* - TL(\vec{X})}{TL_* - TL^*} + w_K\frac{K_* - K(\vec{X})}{K_* - K^*} \quad \textbf{[1]}$$

in which the symbols $[_*]$ and $[^*]$ indicate the anti-ideal (nadir) and ideal values of the corresponding objective and $\vec{X}$ indicates the vector of possible crops.

Decision Variables

A list of the decision variables (crops) simulated is provided in Annex I.

Objectives

The objectives of farm income (entrepreneurial and land revenue, RFE) maximization, and the minimization of risk (Risk), employment (TL) and operative capital (K), were considered in the utility function. Further objectives were simulated, such as the minimization of labour seasonality, and considered non-relevant to the decision-making process in these case studies.

- Entrepreneurial and Land Revenue (RFE) maximization – This indicator is used as a proxy for net profit. The use of gross margins, RFE or net margins as income indicators does not influence the weights attached to farmers' goals, and, therefore, does not change the simulation process at all.
- Risk minimization (Risk) – Risk is calculated as the variance of the RFE during the period 1997-99, following the classic Markowitz approach (Gomez-Limon and Riesgo 2004).

- Total Labour minimization (TL) – This objective refers to all agricultural labour hours, both hired labour as well as family one. The latter can be interpreted as the farmers' preference for leisure time.

- Operative Capital (K) minimization – K is a debt indicator. It minimises the maximum amount of capital needed to carry out the farmer's productive plan (crop selection). The computation of this objective is obtained by monthly defining crop sales and deducted them from crop costs. K is necessary value to finance farming activities, and corresponds to the maximum level of indebtedness that the farmer is willing to face.

Constraints

For the simulation of the Agenda 2000 situation, the following constraints were included in each agricultural system model:

- Land constrains. The total area of crops and set-aside must be equal or lower than the availability of land of the representative farming system.
- CAP constraints.
- Common Agricultural Policy set-aside measures were modelled. The compulsory set-aside surface was established at the 10 per cent value of COP crops (Cereals, Oilseeds and Protein crops); the voluntary set-aside was restricted to the maximum of fifty per cent of the area declared to support purposes (COP + voluntary set-aside).
- The level of crops subject to CAP quotas were maintained constrained to their present values (the case of durum wheat, sugar beet and industry tomatoes, for instances).
- Market constraints. To avoid biased and unlikely solutions, a maximum ceiling was imposed on vegetable crop areas.
- Technical constraints.
- Existing crop rotations force the area of Fall/Winter crops (winter cereals) to be identical to the occupied by Spring/Summer crop ones (maize and sunflower).
- Rice was superiorly bounded, given the necessary land preparation requirements.

PROSPECTIVE AGRICULTURAL POLICY SCENARIOS

For the purpose of modelling the impact of policy change in the irrigated agriculture sub-sector, evolution scenarios are analysed. Scenarios are statements of what is possible. Policy scenarios used in these models are to be understood as prospective futures rather than predictive. A brief description of each scenario is provided below.

- World Markets scenario simulates an accentuated emphasis on private consumption and a highly developed and integrated world trading system.

- Global Sustainability scenario has more pronounced social and ecological values, which are evident in global institutions and trading systems. There is collective action to address social and environmental issues. Growth is slower but more equitably distributed when compared to the previous scenario.

- Provincial Enterprise scenario also draws an emphasis on private consumption but with decisions being made at national and regional levels to reflect local priorities and interests. Market values dominate but within national/regional boundaries.

- Local Stewardship is characterised by strong local or regional governments which accentuate the importance of social values, encouraging self-reliance, self sufficiency, and conservation of natural resources and the environment.

Some general estimates for the time horizon of 2010, are presented in Table 3 (Bazzani et al. 2005; Morris and Vasileiou 2003). Estimates are expressed as indices of the Agenda 2000 situation.

TABLE 3. Summary of the economic estimates for 2010 Agricultural Policy Scenarios

%	Agenda 2000	World Markets	Global Sustainability	Provincial Agriculture	Local Community
Output prices					
Cereals	100	80-90	90-100	100-110	140-150
Sugar beet/Potatoes	100	80-90	85-95	90-100	155-165
Vegetables	100	85-95	110-120	100-110	130-140
Tree fruits	100	85-95	95-105	100-110	135-145
Inputs prices					
Agro-chemicals	100	85-100	130-140	100-110	150-170
Machinery	100	85-95	120-130	100-110	130-140
Irrigation infrastructure	100	130-135	120-130	130-140	110-120
Labour	100	110-120	125-140	110-120	130-150
Others					
Area payments	100	-	95	100	100
Set aside subsidy	100	80	100	100	110-120
Set aside quota	100	0	95	100	105
Crop yields	100	110-120	110-125	100-110	85-95
Farm sizes	100	160-170	130-140	120-130	100-110

(Based on Morris and Vasileiou 2003)

RESULTS

Within the same typology, farmer preferences are maintained constant. As a consequence, variations in farmers' ability to respond to water price increases must be understood as being dependant on the assumptions of each scenario. It is important to draw attention to the necessity of understanding the results of these prospective scenarios merely as feasible and likely interval ranges were the future of irrigation might be situated.

WATER DEMAND

The water demand evolution in these typologies reveals that different farming systems have different sensibilities to the water price increase.

In vegetable typologies, the water demand is usually inelastic, resisting well to water price increases. In the Vegetable typology of Baixo Alentejo, for water prices below 0.20€/m^3, the water consumption is, with the exception of the Agenda 2000 situation, comprised between 3237m^3/ha (Global Sustainability scenario) and 3616m^3/ha (Local Stewardship scenario). In the case of the Vegetable typology of Lezíria do Tejo, the water demand below 0.20€/m^3 is comprised between 1961m^3/ha (World Markets scenario) and 3391m^3/ha (Provincial Enterprise scenario).

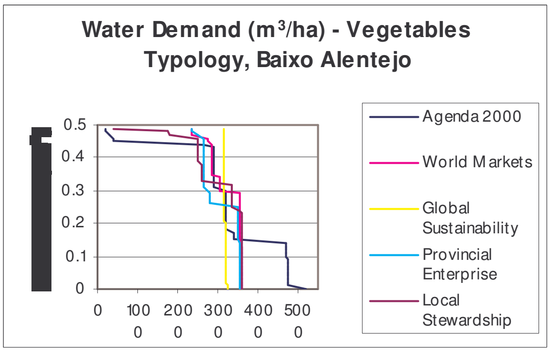
The Agenda 2000 appears to be the most water consumptive agricultural policy situation, both in the vegetable and in the general agriculture typologies. When comparing the general agriculture typologies of these regions, volumetric water pricing are likely to be more effective since low water prices in Lezíria do Tejo. Indeed, at the water price of 0.05€/m^3, water reductions vary from 19% (Local Stewardship scenario) to 67% (Agenda 2000); being the water savings in other scenarios above 30%.

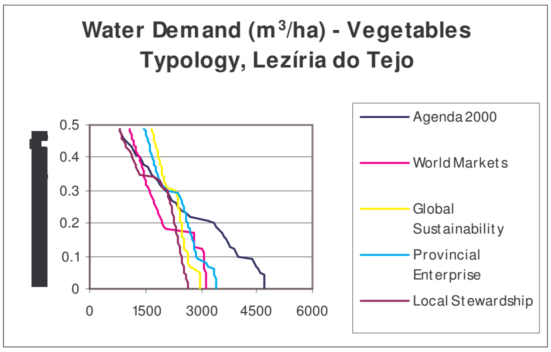
After the 0.10 €/m3 the water consumption is already close to the values reached at the end of the parametrization. At the 0.10 €/m3 water price the water savings amount to 68% in the Agenda 2000 and Provincial Enterprise scenarios, and 63% in the Global Sustainability scenario.

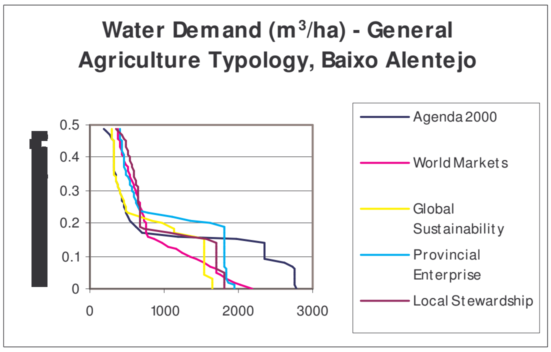
The water demand functions in the extensive agriculture typology exhibits a very elastic behaviour. Indeed, the highest efficacy of water pricing is reached at low prices. This is particularly notorious on the world market scenario in which a water price of 0.05€/m^3 would cause the reduction of 84% of the water consumption (a 16.7% saving per each cent of Euro), and a water price of 0.10 €/m^3 would be responsible for the 94% reduction (on average 9.4% saving per cent).

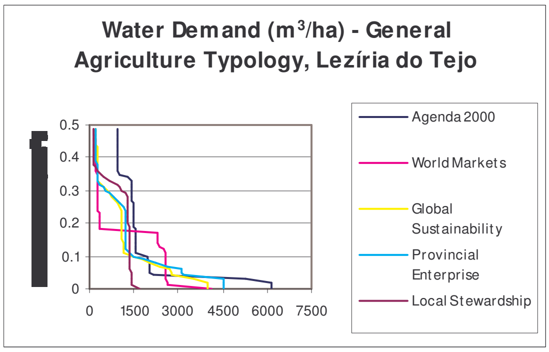
As far as the aggregated results are concerned, in Baixo Alentejo the Agenda 2000 situation exhibits a high water demand and not very elastic in the first steps of water pricing. In fact, the most significant water savings are comprised between 0.14 €/m^3 and 0.17 €/m^3. The water demand in the World Market scenario has the opposite evolution, with a very responsive behaviour since low water prices. Other scenarios have in between evolutions, presenting a maximum demand for water below 2000 m^3/ha at null water prices; the most significant reductions are registered for the water price interval of 0.15 - 0.20 €/m^3.

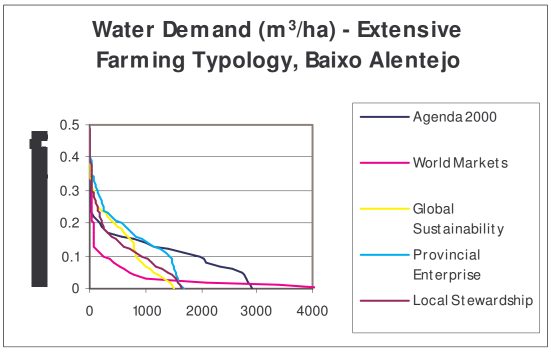
At the resemblance of the previous case, the aggregated water demand function for the Agenda 2000 in Lezíria do Tejo is initially characterised by higher consumptions. It is in this policy situation that the highest water savings are to be expected. It is worth mentioning that the water demand in the Local Stewardship scenario is almost inelastic until the water price of 0.28 €/m^3.

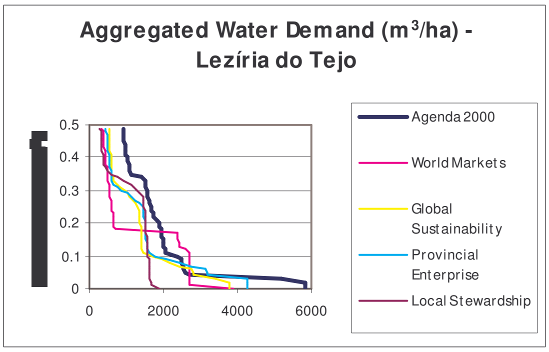


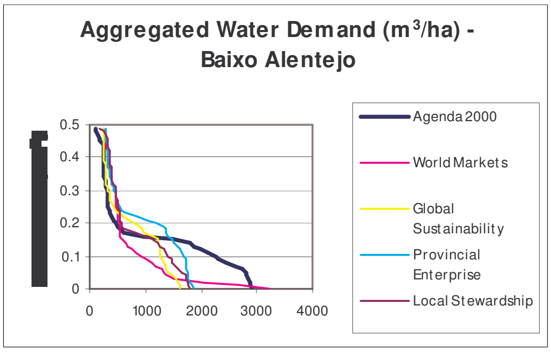












Figures 2-8. Water Demand Functions

AGRICULTURAL INCOME

In the vegetable typologies of both regions the highest farm income is reached on the Global Sustainability and Provincial Enterprise scenarios. The evolution of farm income in the vegetable typologies follows similar trends in all scenarios. The average distance between the best and the worst policy situations is of 1545€/ha in Baixo Alentejo and of 1920€/ha in Lezíria do Tejo. Most prospective scenarios seam to predict higher income performances than those achieved on the Agenda 2000 situation.

In the general agriculture and extensive typologies of Baixo Alentejo, water price increases create income curves progressively more steeped; initial price increases lead to higher income losses then the following ones. In the general agriculture typology, the variation between maximum and minimum values of farm income varies from 287 €/ha to 185 €/ha, being the average distance of 224€/ha. In addition, the average farm income reduction per each water price increase of one cent of Euro – on the price segment below the 0.15 €/m^3 – varies from 15.2 €/ha (World Markets) to 27.7 €/ha (Agenda 2000).

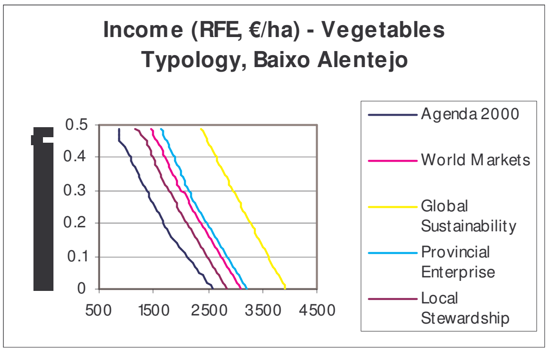
The implications of the agricultural policy in the economic sustainability are also clearly shown for the case of the general agriculture farming system of the Lezíria do Tejo region. The variation of farm incomes imputable to the agricultural policy scenarios varies from 417 €/ha (0.31 €/m^3) to 546 €/ha (at the end of the parametrization). The most significant income losses due to the water price increase are registered in the Agenda 2000 situation with an average reduction of 36.7 €/ha per cent of Euro increase in the first 0.1€/m^3 segment and 18.3 €/ha in the second.

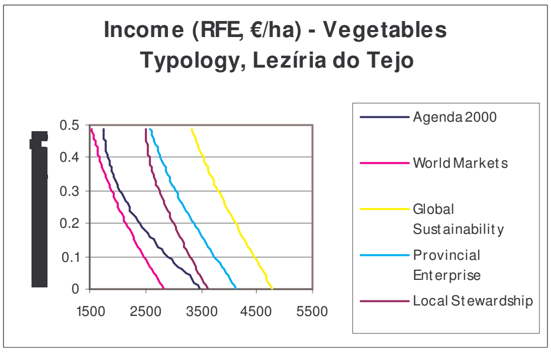
Based on the model results, changing exclusively the agricultural policy would originate farm income losses in cereal based farms such as the extensive typology; these losses would be particularly accentuated in the case of the liberalization of agricultural markets. The economic viability of irrigation in this farming system faces a severe challenge due to the implementation of the WFD. For all situations of active agricultural policy, water prices comprised between 0.22 €/m^3 (Agenda 2000) and 0.34 €/m^3 (Provincial Enterprise) would cause irrigation to be reduced to less than 5% of the area, dragging farm incomes to levels close to those of rain fed agriculture.

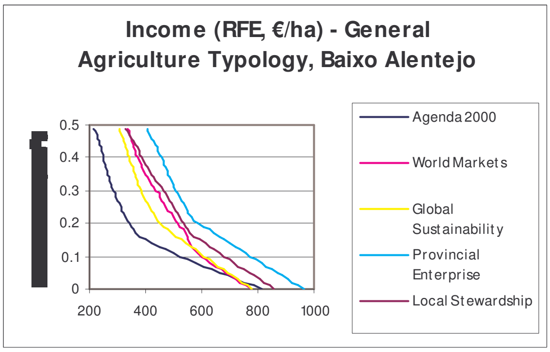
In what concerns the aggregated farm income in Baixo Alentejo, it is possible to note that most simulation scenarios present similar evolution trends. The Agenda 2000 exhibits the less steeped (higher decreases) curve of all scenarios, and lower results are only found in the agricultural liberalization scenario for water prices below 0.12 €/m^3; in this last scenario it should be highlighted that the contribution to the GDP is always the highest of all scenarios (the difference between RFE and GDP corresponds to the public amount allocated to direct subsidies). In other scenarios, the weight of public funds has often a contribution of more then half of the farm income.

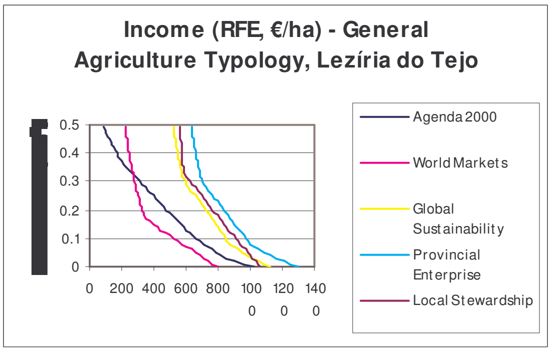
At the resemblance of the previous region, the aggregated farm income results in the Lezíria do Tejo region are lower in the Agenda 2000, only surpassed by the World Market scenario below the water price of 0.36 €/m^3. Nevertheless, the level of farm income is much higher in Lezíria do Tejo.

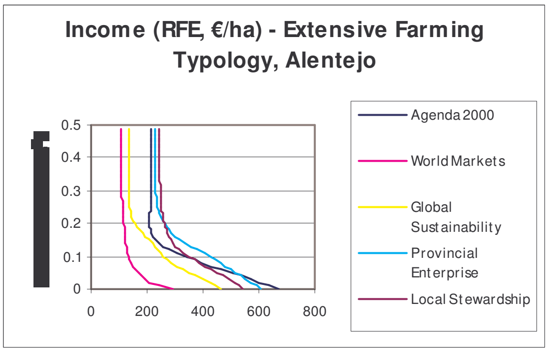
Although the farm income curves reveal the same general tendencies it is noticeable that subsidies vary greatly among scenarios. At the exception of the World Markets and Local Stewardship scenarios, the allocation of public funds almost increases by 150 €/ha during the first 0.10 €/m^3 increase of water prices. In the specific case of the Local Stewardship scenario, public support is only slightly affected by water pricing and maintained close to 462 €/ha.

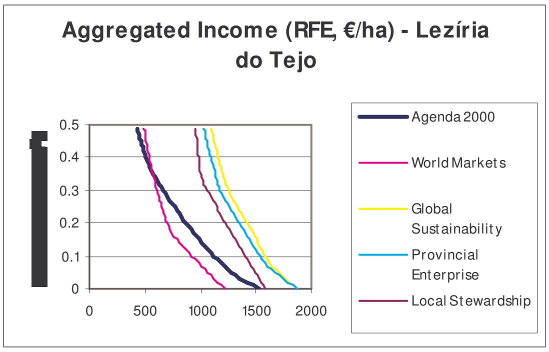


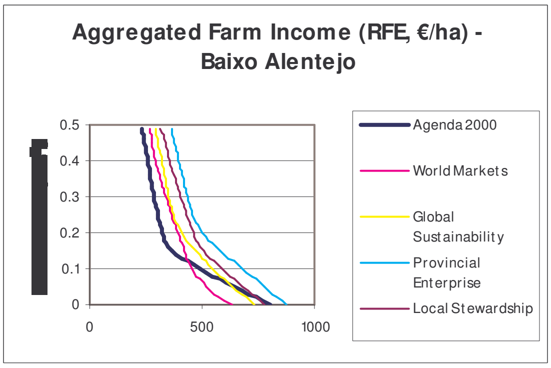












Figures 9-15. Farm Income

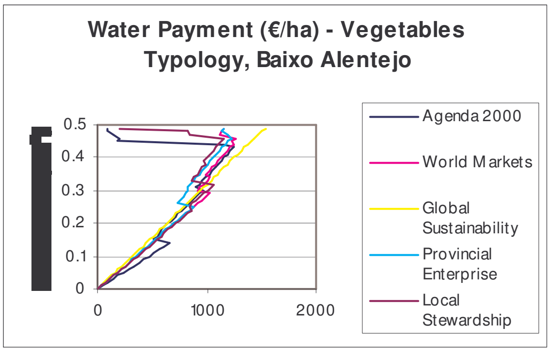
WATER PAYMENT

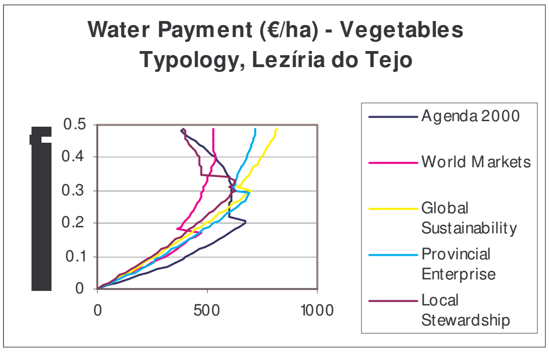
The general pattern of the water payment curves to (or water receipts of) a water management agency is firstly raised, accompanying the water price increases. This situation is maintained by a more than proportional growth of water prices than water demand reductions; that is, until high water prices imply a cutback of water demands. From this point on, the viability of irrigated crops is challenged, water demands are diminished, and water agency receipts are compromised.

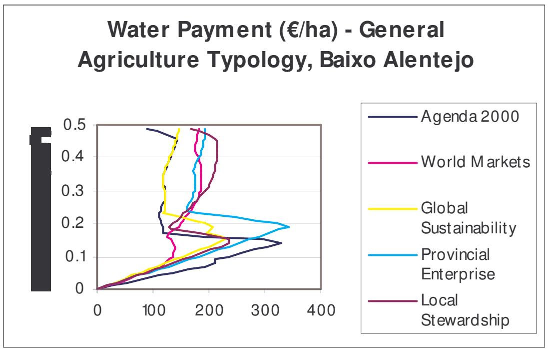
The water payment curves of the vegetable systems analysed reveal that these systems are able to resist well to water pricing, until extremely high water prices.

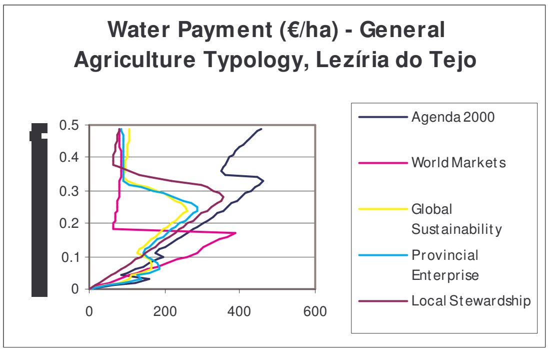
In the case of the general agriculture system of Baixo Alentejo there is a water price interval (from 0.14 €/m^3 to 0.24 €/m^3) associated to a very elastic behaviour. This originates a maximum point of water receipts followed by a severe diminishment. Water prices above these points not only contribute to impoverish farmers' income as do not lead to higher water agencies revenues. The extensive farming typology exhibits a very similar pattern; more pronounced and with cutbacks in water revenues at much lower water prices.

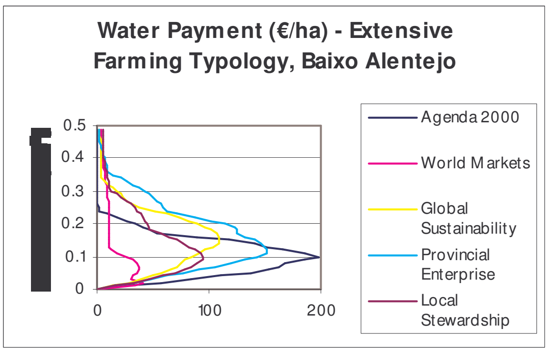
The water demand curves of most scenarios of the general agriculture typology of Lezíria do Tejo are greatly affected at early water prices. These "tail" illustrated water demand functions, particularly in the Agenda 2000 situation, are accompanied by a reduction on the water agency revenues. As soon as the water demand stabilises at the end of the tail the water receipts start increasing again.

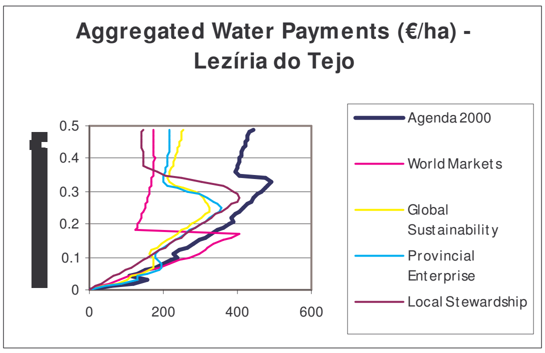


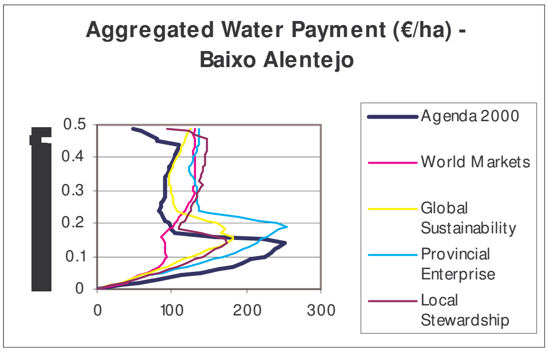












Figures 16-22. Farm Income

CONCLUSIONS

The implementation of a volumetric water tariff is conducive to the reduction of the water demand. Although results should be locally interpreted, it is possible to say that the final impact, at the farm level, on the variables analysed (income, water consumption, employment) depends as much on the agricultural scenario being considered as on the water price level.

For instances, Global Sustainability impact on farm incomes would be the most advantaging for regions producing vegetables, while Provincial Enterprise and Local Stewardship would stimulate farm income in cereal based agricultures.

Often, most variables under study only achieve worst results in the free-trade liberalization scenario then in the Agenda 2000 situation. If, on the one hand, it is certain that these results are constrained by scenario assumptions, on the other hand it is possible to anticipate that future agricultural policies may promote better living standards in rural areas.

In general, the water price increase leads to the loss of farmers' well-being and to the loss of farm income, and, often, reduces the demand for agricultural employment.

In economic terms, the summation of the farm income with the amounts spent with water consumption are always lower then the farm income at free water levels. There is a loss of receipts. The water price increase has several consequences, but it is safe to say that they always imply the reduction of farm income and agricultural employment. It is important to highlight that water price increase does not always imply increases in water agencies receipts.

In environmental grounds it should be highlighted that price increase leads to water demand reductions, and its best allocation among alternative activities, which is what this policy measure aims to reach. Second, in variable degree and depending on the typology/region considered, the water price increase leads to the use of lower levels of inputs such as nitrogen fertilisers and pesticides, therefore with less environmentally damaging potential.

Bearing in mind all that has been said, it is very necessary to find a compromise solution, from the political point of view, that accounts for all these dimensions in the best interest of the future of agriculture, of the reinforcement of its competitiveness, without ceasing to consider the possible implication for human desertification, rural development, on a regional/local context where agriculture is often the unique economic activity development propelling. Also, it is important to have in mind that each region is a case with its particular peculiarities so, policy generalization may cause irreversible damages in some regions although being the best policy for a specific region.

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Annex I

Table 4. List of activities simulated in Baixo Alentejo and Lezíria do Tejo regions

List of Activities	Baixo Alentejo			Lezíria do Tejo	
	Tipologia Hortícola	Tipologia Agricultura Geral	Tipologia Arvenses	Tipologia Hortícola	Tipologia Agricultura Geral
Alfalfa (Irrigated)		√	√		
Aples (Irrigated)				√	√
Aples (Rain fed)				√	√
Avena x Vicia (forage)	√	√	√		
Barley (Rain fed)				√	√
Broccoli (Irrigated)	√				
Carrots (Irrigated)				√	
Common Wheat (Irrigated)	√	√	√	√	√
Common Wheat (Rain fed)	√	√	√	√	√
Compulsory Set Aside	√	√	√	√	√
Cotton (Irrigated)	√	√	√		
Durum Wheat (Irrigated)	√	√	√	√	√
Durum Wheat (Rain fed)	√	√	√	√	√
Lettuce (Irrigated)	√			√	
Lolium Silage (Rain fed)	√	√	√		
Maize (Irrigated)	√	√	√	√	√
Maize (Silage, Irrigated)	√	√	√	√	√
Melon (Irrigated)	√	√		√	√
Oat (forage, Rain fed)	√	√	√	√	√
Oat (grain, Rain fed)	√	√	√	√	√
Olive Grove (Irrigated)		√	√		
Onions (Irrigated)	√			√	
Orange (Irrigated)	√	√	√	√	√
Pasture (Rain fed)	√	√	√	√	√
Peach (Irrigated)				√	√
Pear (Irrigated)				√	√
Pear (Rain fed)				√	√
Permanent Pasture (Rain fed)	√	√	√	√	√
Potatoes (Irrigated)	√			√	√
Rice (Irrigated)					√
Sorghum Forage (Irrigated)				√	√
Sorghum Silage (Irrigated)	√	√	√		
Sugar beet (Irrigated)	√	√	√	√	√
Sunflower (Irrigated)	√	√	√	√	√
Sunflower (Rain fed)	√	√	√	√	√
Sweet Pepper (Irrigated)	√	√		√	
Sweet Pepper (Irrigated)	√				
Tomato (fresh, Irrigated)	√			√	
Tomato (Proc., Irrigated)	√	√		√	√
Triticale (Rain fed)	√	√	√		
Voluntary Set Aside	√	√	√	√	√