The Evolution of the Agri-Environmental Policies and Sustainable Agriculture

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Abstract

Sustainable agriculture implies the exploitation of natural resources now, without compromising the natural resources stocks for the future generations. In the context of the paper, agricultural sustainability takes place at the interface between agriculture and the environment. The focus is on the interplay between farming systems and agri-environmental policies. Agricultural policies have major impacts on soil and water quality and on bio-diversity. Support commodity price policies have lead to serious problems of water pollution; high levels of soil erosion; nitrate losses and lost of bio-diversity. The semi decoupeted income support policies and the introduction of the agri-environmental schemes under the 1992 CAP reform were the first attempts to correct the negative aspects of the production-orientated policies. For the first time farmers were regarded as countryside and landscape keepers and as environmental conservationists. Under the 2000 Agenda similar emphasis was given to the sustainability of agriculture.

The objective of this paper is to evaluate the impact of the different agri-environmental policies on typical farming systems and consequently their effects on water pollution, soil erosion and bio-diversity/landscape. A bio-economic model, integrating a mathematical programming model and crop growth simulation model, is applied to estimated the changes in the levels of nitrogen leaching and soil erosion, and in the degree of bio-diversity under the current and proposed agricultural policy scenarios. The following farming systems are studied: dryland cereal farming systems (intensive and extensive), livestock and irrigated farming systems using conventional and conservation farming technologies. The results show

The results show that the main changes on water pollution, soil erosion levels and bio-diversity are mainly due to changes in price and arable compensatory payments. The agri-environmental measures are more important as farm income source than as a policy instrument to influence environmental parameters.

Key-words: Sustainability, Agri-environmental Policies, Bio-economic Model and Conservation Farming Technologies

1. Introduction

Sustainable agriculture implies the exploitation of natural resources now, without compromising the natural resources stocks for the future generations. In the context of the paper, agricultural sustainability takes place at the interface between agriculture and the environment. The focus is also on the interplay between farming systems and on bio-diversity, water and soil quality.

Soil degradation, in particular soil water erosion, has been associated with cereal production and the use of tillage practices not suitable to the soil characteristics. However, recently, in marginal areas, soil degradation has been associated with land abandonment. In these abandoned areas, a lost of bio-diversity has also been observed as result of extinction of wild life habit created by low input agriculture. In addition, agriculture has a major effect on the quality of both surface and ground water not only because of nutrients (mainly nitrate and phosphorus) run off, but also because of the use of plant protection products. Whereas soil nutrient mining has been a problem in developing countries, in the developed world an overapplication of nutrients occurs as result of the relatively low cost of fertilisers which has lead some farmers to use them in amounts far in excess of plant needs and the capacity of soil to hold nutrients.

The introduction of sustainable technologies have shown successful results, even in less favoured areas, as it is the case of the use of no-till farming practice in very poor soils in Brazil which have been converted into very productive agricultural lands (Barghouti and Hazell, 2000). The integrated nutrient management approach which has the objective of both increasing crop production and safeguard the environment for the future generations integrates both organic and inorganic plant nutrients to obtain higher or maintain crop yields and soil fertility, preventing environmental and soil contamination and degradation, and sustaining agricultural production for a long time.

Agricultural policies have major impacts on soil and water quality and on bio-diversity. In the Common Agricultural Policy (CAP), support commodity price policies have lead to serious problems of water pollution; high levels of soil erosion and lost of bio-diversity. Recently, agricultural policies have been concerned with both the negative impact of intensive agricultural practices on environment and the problem of land abandonment in areas in which agriculture is no longer competitive. Major measures have been proposed and implemented with the objective reversing this panorama. The semi decoupeted income support and the accompanying measures of the 1992 Common Agricultural Policy reform (EC regulation 2078/92) were the first attempts to correct the negative aspects of the production-orientated policies. For the first time farmers were regarded as countryside and landscape keepers and as environment conservationists. Even tough the overall objectives of these agri-environmental schemes are identical for every European Community country, different schemes have been defined and applied according to each EC country specificity. Moreover, within a country, several schemes have been only offered within specific areas and differentiated premiums have been awarded according to eligible areas. Under the Agenda 2000 similar emphasis was given to the sustainability of agriculture. A new CAP reform is programmed for the year 2006. One of the proposals completely will decouple agricultural subsidies from production, which will be award according to farmers' contribution to environment conservation and farm employment (Ministério da Agricultura, 2001).

Table 1 shows and compares the agri-environmental schemes applied to Portugal under Regulation (EU) 2078/92 and under the Rural Development Regulation (EU) 1257/99. Summarily, the new schemes of Group I has the objective of reducing the negative environment externalities of agriculture. They are related to the use of very toxic pesticides; intensive fertilisation in irrigated production systems; and the use of very erosive tillage practices in dryland production systems.

The aim of the agri-environmental schemes of Group II is to preserve the landscape and the traditional rural environment in terms of their natural, recreation and tourist values. The measures of Group III are associated with the conservation of traditional agricultural lands in remote areas, which are very important for a large number of wildlife species. Group IV measures have the objective of conserving natural ecosystems located within agricultural lands, which play an important ecological role. The conservation of low productivity autocnes livestock races is the objective of the Group V measures.

The objective of this paper is to evaluate the impact of different agri-environmental policies on typical farming systems and, consequently, their effects on water pollution, soil erosion, bio-diversity/landscape and farm income. The remainder of this paper is organised as follows. Section 2 is devoted to the analytical framework. A bio-economic model, integrating a mathematical programming model and a crop growth simulation model, used to estimate the environmental impacts, and the farming systems is described in this section. Section 3 presents and discusses the results, which show the changes in the levels of nitrogen leaching and soil erosion, and in the degree of bio-diversity under the current and proposed agricultural policy scenarios. Finally, concluding remarks and policy implications are discussed in Section 4.

2. Analytical framework

Agricultural production causes a number of specific environmental problems, primarily related to the use of land (soil degradation) and industrial inputs (fertiliser and pesticides) but also contributes to some general environmental problems (bio-diversity/landscape).

In general terms, the major factors affecting soil erosion are climate, soil, topography, and land use. Many models have been developed to predict soil erosion and environmental impacts from agricultural systems for different environments. Some of them are empirical models, based on the identification of statically significant relationships between the variables, others are stochastic, generating a synthetic sequence of data from the statistical characteristics of the sample data, and others are physically-based, which use mathematical equations to represent the fundamental hydrological and erosion process. The best known and most utilised empirical model is the Universal Soil Loss Equation developed by Wischmeir and Smith (1978). Others examples of different models are CREAMS (Chemicals runoff and erosion for agricultural management systems) developed in the USA by Knisel (1980), AGNPS (Agricultural Non-Point Source Model) developed by Young *et al.* (1989), PI (The Productivity Index) developed by Pierce *et al.* (1983), EPIC (Erosion/Productivity Impact Calculator) developed by a team from the US Department of Agricultural Research Service (Williams *et al.*, 1982) and ANSWERS (Areal Non-Point Source Watershed Environmental response Simulation (Beasley *et al.*, 1980).

Table 1 - Agri-environmental Schemes under (EU) 2078/92 and (EU) 1257/99 Regulations

Agri-Environmental Schemes under Regulation (EU) 2078/92				**Agri-Environmental Schemes under the Rural Development Regulation (EU) 1257/99**			
Groups	**Objectives**	**Schemes**	**Application**	**Groups**	**Objectives**	**Schemes**	**Application**
I	Reduction of the polluting effects of agriculture through rational use of pesticides and promotion of organic farming.	A1. Recommended Pest Control A2. Integrated Crop Protection A3. Integrated Crop Production A4. Organic Farming	National National National National	**I**	Protection and improvement of environment, soil and water quality	A1.Recommended Pest Control A2.Integrated Crop Protection A3.Integrated Crop Production A4.Organic Farming A5.Soil Improvement and Erosion Control A6.Extensive Forage Production Systems A7.Reduction of Nitrogen Leaching	National National National National National Regional National
II	Extensification and/or maintenance of the traditional agricultural systems	B1.Maintenance of Traditional Extensive Multi-Crop Systems B2.Dryland Extensive Cereal Production Systems B3. Grass Production in Wetlands B4.Extensive Forage Systems B5.Traditional Olive Production B7.Terraced Vineyards of Douro Region B8.Orchards of Regional Varieties B9.Traditional Dryland Orchards B10.Traditional Dryland Almond Trees B11.Holm-Oak Pasture Lands B12.Reconversion of Arable Land into Extensive Pastures B13.Endangered Local Livestock species	Regional Regional Regional Regional Regional Regional National Regional Regional Regional Regional Regional National	**II**	Preservation of landscape and traditional agricultural land	B1. Improvement of rural villages surroundings B2. Improvement of natural spaces for public use B3. Terraced vineyards of Douro Region B4. Recuperation and maintenance of traditional small agricultural production systems	National National Regional Regional
III	Conservation of resources and countryside landscape. Prevention of forest fires.	C1.Maintenance of Abandoned Forests C2.Maintenance of Abandoned Farm Woodlands C3.Preservation of Local Trees and Bushes Belonging to Ecosystems with High Biological Interest. C4.Maintain Arable Lands Inside Forests C5.Maintenance of Traditional Agricultural Systems in Environmental Sensitive Zones	Regional Regional National National Regional	**III**	Conservation and Improvement of the Natural High Value Cultivated Areas	C1.Traditional multi-crop production systems C2.Holm-oak grazing lands C3.Natural pastures with high flora value C4.Traditional olive production C5.Traditional orchards C6. Maintenance of small crop parcels C7. Environmental Sensitive Zone of Castro Verde C8.Other Environmental Sensitive Zones	Regional Regional Regional Regional Regional Regional Regional Regional
				IV	Conservation of natural Ecosystems within Agricultural Lands	D1. Conservation of small woodlands with high ecological value D2. Riparian zones D3. Conservation of wetlands	National National National
				V	Conservation of Genetic Bio-diversity	E1. Maintenance of autocnes races	National

Source: Ministério da Agricultura (1995, 2000)

Among the models described above, only the PI and EPIC models were designed to predict the crop productivity impacts of soil erosion. EPIC particularly generates data unique to a single combination of resource, climate, crop, rotation, tillage, and conservation practice and these particular features make it a suitable tool to investigate the impact of the changes in the farming systems (Godinho, 1997). However, all models referred do not consider the economic aspects of soil erosion prevention.

Several authors have analysed conservation issues by applying economic models at the sector level and on farm level. Different methodologies have been used, but mathematical programming models and specifically linear programming models, are the most widely applied. Examples in the literature are Miranowski (1984), Barbier (1994), Ribaudo *et al.* (1994), Schipper (1996), Godinho (1997) and Deybe (1998).

Considering the review of literature (that shows that farm level models can provide more detail about individual impacts than large-scale sector level models), and also that: 1) farming systems will change in response to the new policy measures under the old and new CAP policies; and 2) the levels of soil erosion, nitrates leaching and bio-diversity change with the change in the farming systems. A farm level bio-economic model, integrating a mathematical programming model and an agronomic crop growth model, is applied to estimate the environmental impacts of the different agri-environmental policies on typical farming systems of the Alentejo region of Portugal and consequently, their effects on water pollution, soil erosion, bio-diversity/landscape and farm income.

A linear programming model is formulated in order to examine the impact of the new policy instruments on the farming systems. This model is appropriate for the calculation of the implications of different resource endowments, different market conditions, and improved of new technology (Hazell and Norton, 1986). The level of soil erosion, water pollution and bio-diversity is evaluated with and without the current and new proposed policy instruments and price scenarios. For each farming system, the level of erosion and water pollution is estimated using EPIC, which was previously calibrated for erosion rates, water pollution and crop yields. Then, the levels of soil erosion, water pollution and the crop yields are included in the linear programming model. For each optimal solution of the bio-economic model, the total level of erosion, the water pollution, the degree of bio-diversity and the farm income are calculated. The farming system include dryland cereal farming systems (intensive and extensive), livestock (sheep and cattle) and irrigated crops using conventional and conservation farming technologies. Each farming system is supposed the to have a different effect on bio-diversity which is assumed to vary from level 1 - high degree of bio-diversity present in natural landscape-, to level 6 - low diversity degree, present in intensive farming systems. Further characterisation of the farming systems included in the model is presented in the Appendix 1.

The model is specified as follows:

$$Max\ E(\pi) = \sum_j \sum_a \sum_t \sum_b (p_j f(k_{(j,t)}) - C_k K_{(j,t)} + A_{(j,a,t)})\, X_{(j,a,t,b)}$$

$$s.a. \quad \sum_j \sum_a \sum_t \sum_b X_{(j,a,t,b)} \leq S$$

$$\sum_j \sum_t \sum_b X_{(j,a,t,b)} \leq D_a$$

$$K_{(j,t)} \geq 0;\ e\ X_{(j,a,t,b)} \geq 0;$$

where: *j,a,t* and *b* indicate the farming system, the compensatory and agri-environmental subsidies, the production technologies and the effect in bio-diversity, respectively (see appendix 1); *x* is the decision variable which defines the area (ha) occupied by the farming system; $f(k_{(j,t)})$ is the production function of *j* farming system according to the technology *t*; $K_{(j,t)}$ is the vector of the changing inputs used in the process of production of *j* farming system with technology *t*, C_k is the unit cost of the different variable inputs used; *pj* is the final price of products; $A_{(j,a,t)}$ is the parameter of the compensatory payments and the agri-environmental subsidies which are function of the farming system; *S* is the vector set of the available production inputs (land, labour and fixed capital); and *D* is the parameter to modulate the agri-environmental subsidies.

The objective function, Max E(π), is the maximisation of the gross margin or the short term revenue. It represents the return of the production systems to the land, fixed capital, permanent labour and management. This model was applied to two typical farms data of the Alentejo region of Portugal. One of the farms is representative of dryland farming systems and another is representative of mixed, irrigated and dryland farming systems.

3. Results

Table 2 shows the results obtained for the four different scenarios: base (1997 prices and subsidies), Agenda 2000 (2006 prices and subsidies), new proposal of CAP reform with and without agri-environmental subsidies (full trade liberalisation).

In the base scenario (CAP 1997) the predominant farming production systems in both farms are the intensive dryland with traditional technology and the semi-intensive dryland with sheep with reduced soil mobilisation technology. In farm 1, the innovative irrigation system (24.5% of land) occupies the all irrigated surface.

Price changes and alterations in agricultural subsidies in terms of Agenda 2000 (scenario CAP 2006), make it possible to foresee significant adjustments in the production plans of the two farms studied, which clearly move towards extensification of the agricultural production. In farm 1, the intensive dryland systems (61.7% of land) and the semi-extensive dryland with sheep (5.4% of land) are replaced by extensive dryland with native cattle (74.1% of land), which according to the new package of agri-ambiental measures (regulation 1257/99) benefits from support to extensive forage systems. In farm 2, the production plan changes in the same direction, with the extensive dryland system with native cattle occupying all the available land.

The adjustments in production plans of the two farms occurring under the Agenda 2000 scenario, make it possible to foresee a significant improvement in the environmental parameters. The nitrogen leaching are reduced from 45.3 and 36.8 Kg/ha to 29.5 and 16 Kg/ha, in farms 1 and 2, respectively. Soil erosion is reduced, slightly in the first case, i.e., changing from 2.74 to 2.17 tons/ha, and significantly in the second case, from 1.31 to 0.6 tons/ha. The reduction of soil erosion in farm 1 is related to the maintenance of an important area under the innovative irrigation (24.5% of the land). The level of bio-diversity of eco-systems also improves, changing from about 8% of the land classified in level 1 (which represents higher level of bio-diversity), to 76% in farm 1 and 100% of the land in farm 2.

Table 2 – Results

	Scenario of Agricultural Prices and Subsidies			
	CAP 1997	CAP 2006	Free Market (with subsidies)	Free Market (without subsidies)
Farm 1: Land = 300 ha; Irrigated =73,5 ha; Permanent labours = 4; Fixed costs=265.49 Euro/ha				
Farming Systems in % of Land:				
Innovative irrigation crops	24.5	24.5	-	-
Traditional irrigation crops	-	-	16.0	16.0
Innovative irrigated horticultural industrial crops	-	-	0.9	0.9
Intensive dryland with traditional technology	61.7	-	-	-
Extensive dryland with native cattle	-	74.1	83.1	83.1
Semi-extensive dryland with sheep and reduced mobilisation technology	5.4	-	-	-
Set-aside	8.4	1.4	-	-
Idle land	-	-	-	-
Environmental Parameters:				
Nitrogen leaching (kg/ha)	45.3	29.5	29.1	29.1
Soil Erosion (ton/ha)	2.74	2.17	0.93	0.93
Bio-diversity (% of land at level 1)	8.4	75.5	83.1	83.1
Bio-diversity (% of land at level 3)	67.1	-	-	-
Bio-diversity (% of land at level 4)	24.5	24.5	19.9	19.9
Economic Results (Euro/ha):				
Gross margin	576.86	419.98	160.88	122.91
Production	663.75	482.87	336.84	336.84
Subsidies	316.10	240.96	37.97	-
Agri-environmental subsidies:	5.00	34.60	37.97	-
Operating capital (Euro/ha)	402.98	303.85	213.93	213.93
Dual value of land (Euro/ha)	384.54	289.03	77.69	46.79
Farm 2: Land = 310 ha; Permanent labours = 3; Fixed costs=177.42 Euro/ha				
Farming Systems in % of Land:				
Intensive dryland with traditional technology	71.9	-	-	-
Extensive dryland with native cattle	-	100.0	100.0	100.0
Semi-extensive dryland with sheep and reduced mobilisation technology	19.4	-	-	-
Set-aside	8.7	-	-	-
Idle land	-	-	-	-
Environmental Parameter:				
Nitrogen leaching (kg/ha)	36.8	16.0	16.0	16.0
Soil Erosion (ton/ha)	1.31	0.60	0.60	0.60
Bio-diversity (% of land at level 1)	8.7	100.0	100.0	100.0
Bio-diversity (% of land at level 3)	91.3	-	-	-
Economic Results (Euro/ha):				
Gross margin	401.12	315.19	117.33	74.17
Production	290.48	152.63	152.63	152.63
Subsidies	324.38	241.02	43.16	-
Agri-environmental Subsidies:	19.19	43.16	43.16	-
Operating capital (Euro/ha)	213.74	78.46	78.46	78.46
Dual value of the land (Euro/ha)	378.74	262.85	65.00	34.27

Source: Model results (2001).

In the two scenarios for world trade liberalisation, with and without agri-environmental subsidies, it can be seen that in farm 1, the reinforcement of the extensive dryland with native cattle (83.1% of the land) and the reduction of the irrigated surface, are accompanied by the substitution of innovative irrigation by traditional irrigation (16% of the land) and by the introduction of a small area of irrigated horticultural industrial crops. These changes in the production plan contribute, significantly, to the improvement in the levels of soil erosion (0.93 tons/ha) and in the bio-diversity of the eco-systems, of level 1 of bio-diversity represent about 83.1% of the land. The solution of the model of farm 2, in terms of the production plan and environmental parameters is identical to that of the Agenda 2000 scenario (CAP 2006).

The extensification of production and the consequent improvement in the environmental parameters are accompanied by successive reductions in the revenue, as the gross margin value demonstrates. In the case of farm 1, in which the gross margin in the base scenario was 576.86 Euro/ha, a reduction of 27% was registered in the scenario of Agenda 2000 and 72% and 79% under the two scenarios of the world trade liberalisation. Farm 2, with a gross margin of 401.12 Euro/ha, had reductions in the short term revenue of 21%, 56% and 82%, respectively. These revenue losses are due to the reduction in production value and subsidies, which are not sufficiently compensated by adjustments in the operating capital, due to adoption of changes in the production plans, showing inclusively, for the world trade scenario, that the competitiveness of the two farms is threatened in the long term, assuming the same farm structure, since the gross margin is less than the fixed costs.

The main changes, in terms of production plans, environmental parameters and revenue are more due to changes in the support system of agricultural markets, both by reduction of prices and customs rates and by compensatory payments, than to the new package of agri-environmental measures under Regulation 1257/99. The stability of production plans obtained in the two scenarios for world commerce liberalisation, with and without agri-environmental subsidies, somehow, creates doubts about the efficiency of these measures, however, its importance in supporting the revenue and land income is unmistakable. In these scenarios the difference in the gross margin and in the dual value of land, which is mainly due to the existence, or not, of agri-environmental subsidies, is 24% and 40% in farm 1 and 37% and 47% in farm 2, respectively.

4. Concluding remarks

This paper evaluated the impact of the different agri-environmental policies on typical farming systems and consequently their effects on water pollution, soil erosion and bio-diversity/landscape. A bio-economic model, integrating a mathematical programming model and crop growth simulation model, is applied to estimate the environmental impacts on two farms in the Alentejo region of Portugal.

The four different scenarios analysed (1997, Agenda 2000 and new proposals of CAP reform), lead to different results between farms. Price changes and alterations in agricultural subsidies in terms of Agenda 2000 (scenario CAP 2006), make it possible to foresee significant adjustments in the production plans of the two farms studied, which clearly move towards extensification of the agricultural production. These extensification of production and the consequent improvement in the environmental parameters are accompanied by successive reductions in the farm income, as the gross margin value demonstrates.

The main changes, in terms of production plans, environmental parameters and income are more due to changes in the support system of agricultural markets, both by reduction of prices and customs rates and by compensatory payments, than to the new package of agri-environmental measures under Regulation 1257/99. The stability of production plans obtained in the two scenarios for world trade liberalisation, with and without agri-environmental subsidies, somehow, creates doubts about the efficiency of these measures, however, its importance in supporting the revenue and land income is unmistakable.

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Appendix 1 – Characterisation of Farming Systems

Production System	Crops	Production Technology	Agri-Environmental Measure	Effect on Bio-diversity
Innovative Irrigated Horticultural industrial crops	broccoli × potato - melon broccoli × pepper - onion	Traditional soil mobilisation	does not apply	LEVEL 4
Innovative irrigation crops	industrial tomato - hard wheat - beetroot – sunflower	Traditional soil Mobilisation	does not apply	LEVEL 4
Traditional irrigation crops	corn - sunflower	Traditional soil mobilisation	does not apply	LEVEL 3
Intensive dryland	sunflower - hard wheat – soft wheat	No tillage Reduced soil mobilisation	Reg. 1257/99 measure A5.;	LEVEL 4
Semi-extensive dryland with sheep or cattle	fallow ground – hard / soft wheat - forage – natural pasture hard / soft wheat – forage – natural pasture	Traditional soil mobilisation No tillage Reduced soil mobilisation	Does not apply Reg. 2078/92 measure B2.; Reg. 1257/99 measure A5.;	LEVEL 2 LEVEL 2
Extensive dryland with sheep	forage - 6 years of natural pasture	Reduce soil mobilisation with traditional crossbred sheep	Reg. 1257/99 measure A5.;	
Extensive dryland with cattle	forage - 6 years of natural pasture	Reduced soil mobilisation with traditional crossbred cattle Reduced soil mobilisation with traditional native cattle	Reg. 2078/92 measure B13.; Reg. 1257/99 measure A5.;	LEVEL 1
Idle Land	Fallow	does not apply	does not apply	LEVEL 1

Source: Farms data (1997); Ministério da Agricultura (1995, 2000)