Water Policy and Sustainability of Irrigated Farming Systems in Italy

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Paper prepared for presentation at the XIth *congress of the EAAE*

(European Association of Agricultural Economists),

'The Future of Rural Europe in the Global Agri-Food System.', Copenhagen, Denmark in:
August 23-27, 2005

WATER POLICY AND SUSTAINABILITY OF IRRIGATED FARMING SYSTEMS IN ITALY

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Abstract

The objective of this paper is to provide an analysis of the sustainability of irrigated agriculture in Italy in the context of CAP reform and Water Framework Directive. The work combines scenario analysis, multicriteria mathematical programming simulation models and economic, social and environmental indicators. Five irrigated farming systems were considered: cereals, rice, fruit, vegetables and citrus. The results show the diversity of Italian irrigated farming systems and the trade-off between socio-economic and environmental performance. This highlights the need for a differentiated application of the Water Framework Directive, balancing water conservation and rural development objectives.

1. Background and objectives

Agriculture is one of the main sectors involved in water management, at least in Mediterranean countries. Irrigation accounts for about 50% of total water use in Italy. In spite of the increased irrigated surface, the use of water in agriculture decreased in relative and absolute terms during the 1990s, due to the concurrent effects of improved irrigation technology and shortages of water during this period (with frequent droughts during the summer, often leading to a halt in water distribution). Irrigated agriculture accounts for about 27% of usable farmland, 30% of farms and about 50% of total agricultural production. Around 60% of Italian agricultural exports are produced by irrigated agricultural methods (Bazzani et al., 2003; 2004). According to forecasts, future water requirements in agriculture are expected to stabilise around the present level of consumption (Massarutto, 2001).

In perspective, major changes in the regulatory context concerning water management are expected by the implementation of the Water Framework Directive (WFD) (60/2000). However, it has received relatively little attention in Italy up until recently. Although a number of documents about water and irrigation do exist, they are heterogeneous, poorly updated and methodologically varied (INEA, 2000; Massarutto, 2001). In theory, the water management principles proposed by the WFD (WATECO, 2002; Massarutto, 2002) could bring about major changes in irrigation management. Major concerns derive not only from the implementation of the WFD, but also from the interplay between water and agricultural policy, that could affect the wide range of economic, social and environmental performances of irrigated systems.

The objective of this paper is to provide an analysis of the sustainability of irrigated agriculture in Italy in the context of agriculture and water policy scenarios. The work builds on the combination of simulation models and economic, social and environmental indicators. In commenting the results, it also aims at devising future research needs in the field of the economics of water use in agriculture, taking into account the present stage of application of the WFD.

2. WFD implementation challenges and irrigated agriculture

The WFD is intended to represent the reference norm for water management in Europe. One distinguishing feature of the directive is the strong role assigned to economics in reaching environmental and ecological objectives. The WFD calls for the application of economic principles such as the polluter pays principle and the full cost recovery. It also emphasizes the role of economic tools (such as cost-effectiveness analysis) in the policy design process and calls for the consideration of economic instruments (such as volumetric pricing) for efficiently achieve good water status objectives.

The main elements of the economic analysis are included in Articles 5 and 9 and Annex III, but economics also play an important role in the political decision-making process surrounding the formulation of environmental objectives for water bodies (Article 4). In 2004, river basins (should) have been characterized following the Article 5, with the assessment of the economic significance of water use and the current level of cost recovery. In the next years, work will concentrate mostly on the selection of a cost-effective programme of measures to reach the environmental objectives in the WFD (Article 11 and Annex III). Programs of measures have to be identified and defined by 2008. The subsequent assessment of the level of cost recovery and incentive pricing according to Article 9 will be based on the costs of the necessary measures, including environmental and resource costs. If total costs are considered disproportionate, environmental objectives can be lowered or delayed (Article 4).

This brings in a multiplicity of issues for irrigated agriculture. First of all, opportunity costs of different uses have to be balanced and traded off. Agriculture is not in a particular good position as it is frequently the higher water consuming and the least profitable economic sector. On the other hand, a true balance requires to take into account social and environmental effects that may play in favor as well as against agriculture. In facts, agriculture is also strongly involved on the quality side, as one of the major responsible for diffuse pollution from fertilizers, manure and pesticides.

As policy instruments are concerned, agriculture is strongly characterized by a number of technical and institutional peculiarities. For example, most of water distributed for irrigation is unmetered. Water distribution is widely controlled by organizations that are managed by farmers or where farmers have a strong role. In the past, irrigation has been strongly subsidized through public funding of water transport infrastructures.

3. Methodology

The methodology is based on the following steps:

- identification of representative farm types in each area;
- modelling of farm types;
- definition of agricultural and water policy scenarios;
- simulation of the impacts of different scenarios on farm's performance;
- aggregation of the results.

Farm typologies in each study area were selected on the basis of Cluster Analysis on data from a representative sample of farms, validated through interviews with local experts. Each cluster has been modelled separately and the results aggregated at a later stage.

The methodology adopted for simulation is based on mathematical models coupled with agri-environmental indicators. Multi-Attribute Utility Theory (MAUT) approach is adopted (Ballestero and Romero, 1998), in the form proposed by Sumpsi et al. (1996), Berbel and Rodríguez-Ocaña (1998), Berbel and Gomez-Limon (2000).

Models were calibrated using primary data collected from the surveyed farms and validated against the actual behaviour of farms seen as a combination of farming activities (rotation and irrigation choices).

Constraints include standard constraints such as land, labour, commercial constraints and rotations. Labour constraints have been constructed by period (for more details about the modelling approach and the disaggregated results, see Berbel and Gutierrez, 2005).

Once constructed and validated against the Agenda 2000 situation with benchmark values referred to 2001, the models were fed with the data coming from the scenario analysis. Scenarios have been developed adapting general world wide scenarios to the Italian situation, particularly as far as specific environmental conditions, productive features, quality strategy and self-sufficiency issues are concerned.

Prevailing values and the level of governance are recognised as the two main driving forces behind possible futures. Their various combinations give four main scenarios:

- world market (WM);
- global sustainability (GS);
- provincial agriculture (PA);
- local community (LC).

World market describes a scenario characterised by a high degree of liberalisation, where decisions are taken through market mechanisms at the global level. In the provincial agriculture scenario, choices are guided by markets, but they work on a regional scale. In the other two scenarios, decisions are taken on the basis of community values, which may work at the global (global sustainability) or local (local community) levels (Berkhout et al., 1998; Kroll and Treyer 2001; Berbel et al., 2002). Agenda 2000, as implemented in 2001, has been taken as a benchmark for comparing scenarios.

The time horizon for scenario definition was set to 2010. Firstly storylines were developed, followed by the quantitative definition of prices and other parameters. The prices and technical coefficients adopted were calculated with the aid of experts. Altogether, more than 100 parameters were defined, combining consistent futures of agricultural and water policy (OECD, 1999).

Altogether, by crossing farm types with scenarios, 55 long-term models were produced. For each of them, results have been parametrised on water price, thus giving the water demand curve and the trend of all indicators as a function of water prices. The indicators illustrated in this paper were calculated using the water prices that where considered most likely in each scenario.

The models were developed using GAMS as the optimisation software and, in the case of fruit and cereals, using a DS called DSIRR (Bazzani, 2005).

The impacts of different scenarios are quantified through a set of economic, social and environmental indicators developed on the basis of OECD (2001) (table 1).

Table 1. Selected indicators.

Area	Selected indicators
Economic balance	Farm profit
	Farm contribution to GDP
Social impact	Farm employment
	Seasonality
Biodiversity	Genetic diversity
Water use	Water use
Nutrients and pollutants	Nitrogen balance
	Pesticide risk

Indicators express the impact per hectare of usable farmland, thus making them comparable among farms and among different countries.

The most obvious indicators are those pertaining to the consumption of water, the emission of nutrients and the use of pesticides, as they are directly related to the pollution of water resources and appear more directly quantifiable at farm level.

Indicators of the economic viability of farming can also be used to assess the possible effects of water policies on the economic sustainability of agriculture (that is, on farm income). Moreover, the social aspect of agriculture is revealed in particular by farm employment and other related indicators.

Farm profit is calculated as the difference between the value of gross output and all expenses, including rent, depreciation and farm household labour. This indicator is one of the key indicators of the sustainability of agricultural systems, and is designed to measure the financial viability of farming. If financial returns are consistently negative, then any farming system will be unsustainable.

This indicator has to be distinguished from household income, which can be supplemented by non-agricultural activities and/or by summing up revenue from different productive factors employed on the farm (labour, capital).

Farm contribution to GDP has been estimated as the value added produced at farm level i.e. the difference between total revenue and intermediate consumption. Thus it is a measure of the contribution of the farm to economic wealth, and it also takes account of items that are subtracted as costs when we consider farm income/profit only.

Farm employment is defined as agriculture's share of total civilian employment. The OECD proposes farm employment as a contextual indicator designed to measure the importance of agriculture in providing employment within the context of the national economy. Furthermore, farm employment can provide a measure of the social implications of agriculture in terms of the provision and distribution of income. As such, it is one of the main indicators of the social importance of agriculture. It may be defined as the total amount of labour requested by the farm, and is hence a measure of the total employment guaranteed in the farming sector.

A **seasonality index** quantifies the distribution of labour over the year. It is related to the kind of work needed (e.g. peak periods call for the employment of external, often non-local labour, sometimes poorly qualified).

Genetic diversity is the total number of crop varieties/livestock breeds that have been registered and certified for marketing for the main crop/livestock categories. This indicator represents the simplest form of biodiversity indicator. For our purposes, this indicator has been equated with the number of species of crop/livestock present on the farm.

Water use is intended as the required amount of irrigation water measured at the farm gate (and thus includes all waste and inefficient use on the farm) and in this simple form is a clear measure of water use in agriculture. Water consumption as a function of water price *wp*, given farm production potential and characteristics Q, can be seen as the farm's demand for water:

$$W = f(wp; Q) \tag{1}$$

Nitrogen balance is the physical difference (surplus/deficit) between nitrogen inputs and outputs from an agricultural system, per hectare of agricultural land. This is the main form for calculating the surpluses of nitrogen that are a potential risk for the environment. It could also be considered the main indicator of the impact of farming on the environment as far as groundwater quality is concerned.

All nitrogen put into cultivated soil is considered to be input, while the harvested production is considered as output. The difference is the net amount of nitrogen that, over one year, is released into the environment (air, soil, water). It could be positive, thus indicating a surplus, or negative, thus pointing to a deficit.

The value of nitrogen balance, and of other nutrient and pollutant indicators (I) when required, is calculated as the difference between input and output at the farm gate:

$$I_k = \sum_i \sum_j s_i x_{ij} c_{jk} - \sum_i \sum_z s_i y_{iz} d_{zk} \qquad (2)$$

where:

s_i = surface of crop i;

x_{ij} = amount of input j per hectare of crop i;

c_{jk} = amount of indicator k (pollutant/energy) per unit of input j;

y_{iz} = amount of output z produced by crop i;

d_{zk} = amount of indicator k (pollutant/energy) per unit of output z.

The **pesticides risk indicator** adopt the following basic OECD structure:

$$Pesticide\ risk = \frac{exposure}{toxicity} * area\ threatened \qquad (3)$$

where exposure depends on the quantity of pesticide in the water and may be calculated in many different ways, including scoring. Toxicity may be intended as the quantity of pesticide needed to kill 50% of a given population of organisms exposed to the pesticide. The area threatened is the area affected by the presence of the pesticide. The value of the index c_{jk} for pesticides is calculated as follows:

$$c_{jk} = \sum_t a_{jt} \frac{1000000}{DL\,50_t} \qquad (4)$$

where: a_{jt} = amount of active matter t by unit of input j and $DL50_t$ = lethal dose 50 of the active matter t. The indicator represents the weight (in kilograms) of the population of rats, 50% of which would be killed by 1 kg of the input.

4. Description of study areas

The paper is based on the analysis of some of the main agricultural systems in Italy where irrigation is a relevant feature. The methodology has been applied to five irrigated agricultural systems. For the purposes of this study, an agricultural system is taken to be a form of farming defined by a given crop combination and located in a given river basin. The river basin is identified with the Reclamation and Irrigation Board (RIB) to which the system belongs. According to this definition, the irrigated system represents a way of farming, in a homogenous territory, which is combined with others in different proportions depending on the specific area.

The irrigated farming systems for which models have been created are as follows:

1. cereal system: Mantua - Lombardy - Northern Italy (RIB Fossa di Pozzolo);
2. rice system: Ferrara – Emilia Romagna - Northern Italy (RIB I Circondario Polesine di Ferrara);
3. fruit system: Ravenna – Emilia Romagna - Northern Italy (RIB Romagna Occidentale);
4. vegetables system: Foggia - Apulia - Southern Italy (RIB Capitanata);
5. citrus system: Syracuse - Sicily - Southern Italy (RIB Piana di Catania).

The main features of the study areas, and the way in which case studies have been selected, are illustrated in table 2 and the main characteristics of the sampled farms in table 3.

Table 2. Main features of the five study areas.

	Agricultural systems				
	Cereal Lombardy	**Rice Emilia Romagna**	**Fruit Emilia Romagna**	**Vegetables Apulia**	**Citrus Sicily**
Water supply	Po river	Po river	Emilia Romagna Canal	Dams, Ofanto river, private wells	Dams, Simeto river, private wells
Water distribution system	Open canals	Open canals	Pressure pipes + Open canals	Pressure pipes	Pressure pipes
Irrigation system	Mobile wings, automatic sprinkler	Flood system, infiltration	Drip irrigation	Drip irrigation	Drip irrigation, sprinkler
Water price	0.09 euro/m^3	0.02 euro/m^3	0.15 euro/m^3	0.09 euro/m^3	0.18 euro/m^3
Prevailing tariff system	Surface based	Volumetric	Volumetric	Volumetric	Volumetric
Agricultural surface in the RIB (ha)	48137	91085	193359	143000	98000
Agricultural surface of the system considered (ha)	27919	11582	21675	25740	14700
Main crops	maize, soy, sugar beet	maize, soy, sugar beet, rice	peach, nectarine, wine grape	durum wheat, tomato, broccoli	orange

Table 3. Main characteristics of the sampled farms.

	Agricultural systems				
	Cereal Lombardy	**Rice Emilia Romagna**	**Fruit Emilia Romagna**	**Vegetables Apulia**	**Citrus Sicily**
Area in the sample (ha)	1105	6093	6086	913	187
Number of farms in the sample	26	86	1479	120	16
Average farm size in the sample (ha)	42.5	70.8	4.1	7.6	11.6
Methodology for the identification of farm types	Interviews with local experts	Cluster analysis and interviews with local experts	Cluster analysis	Cluster analysis	Data from previous surveys and interviews with local experts
Number of typologies modelled	1	2	4	2	2

The cereal system case-study (1) is characterised by the relative ready availability of water. It represents a variety of extensive farming, traditionally based on average to high water use and

benefiting from considerable public support. The sample includes 26 farms belonging to one farm type.

In the rice system case-study (2) water is readily available, but there are also strong agronomic constraints due to peaty soils that require the cultivation of rice, over at least half of the area, in order to maintain those soil characteristics compatible with farming. For this reason, such a system is representative of the vulnerability of farming in high water-consuming, but economically marginal, areas. A sample of 86 farms was collected and sub-divided into two farm types, each characterised by a different soil type (peaty, non-peaty).

The case-study featuring the fruit system (3) mainly involves the cultivation of peaches, wine grapes and kiwi fruit. The fruit system is traditionally considered one of the most profitable and strong farming systems in the country. In fact, it is a system producing high added value, it is backed by a strong marketing organisation, and mostly involves co-operative working. Altogether, 4 farm types were modelled out of a sample of 1479 farms, differing in farm size, household structure and management style, crop mix.

The vegetable system case-study (4) features a combination of high-income tomatoes (for canning), and highly-subsidised traditional crops such as non-irrigated durum wheat. The development of high value-added crops, such as tomatoes and other vegetables, is counterbalanced by a strong environmental impact. Irrigated agriculture is highly dependent upon the availability of water. The sample consists of 120 farms sub-divided into 2 farm types, one based on tomato-durum wheat and the other cultivating a wider range of vegetables.

Finally, the citrus-fruit case study (5) involves a highly-specialised, intensive system. It is representative of the rich, but fragile, agricultural systems of certain Mediterranean areas, and is heavily dependent upon water availability (farming is not possible without irrigation) and with a very high level of water consumption, located in a context characterised by significant social problems and a high level of unemployment. The citrus-fruit farming system is characteristic of the region where oranges constitute the main crop. The sample included 16 farms, articulated into 2 farm types, differing basically according to farm size (3 ha vs. 15 ha).

5. Results

5.1. *Cereals - Lombardy*

Results of the simulations are reported in table 4.

Table 4. Cereal system: impact indicators per scenario (absolute value and percentage variation from Agenda 2000).

Scenario	Economic Balance		Social Impact		Biodiversity	Water use	Nutrient and Pollutants	
	Profit	Farm contribution to GDP	Farm employment	Seasonality	Genetic diversity	Water use	Nitrogen balance	Pesticide risk
	€/ha	€/ha	hours/ha	index	index	m³/ha	Kg/ha	index
World Market	-176,27	504,17	25	0,05	5,00	490	-34	4797
	-293%	-52%	-42%	-67%	-17%	-41%	-12%	1%
Global sustainability	-141,01	675,48	25	0,00	5,00	242	-27	4241
	-255%	-36%	-41%	-100%	-17%	-71%	9%	-11%
Provincial Enterprise	25,67	871,29	29	0,01	6,00	557	-33	4789
	-72%	-17%	-32%	-93%	0%	-33%	-9%	1%
Local stewardship	-84,23	958,08	31	0,00	6,00	618	-33	4787
	-192%	-9%	-28%	-100%	0%	-26%	-9%	1%

All scenarios yield economic results that are worse than Agenda 2000; WM and GS show the worst situation. Moreover, farm employment decreases strongly, with a reduction of up to 42% in the case of the WM. This reduction involves the expulsion of external labour from the farm, with the seasonality index falling to zero in most cases. The use of water varies strongly according to crop profitability, mainly as a function of public support and water price. The greatest reduction (-71%) is seen in the case of GS, but the other scenarios would also witness a reduction of at least 30%. Environmental indicators are basically stable across scenarios, with variations mostly limited within the 10% range.

On a regional scale, the aggregate economic impact could be important for the agricultural sector, since the system is a widespread one. But from a global economic and social point of view, the impact may be considerably less relevant. Labour is likely to shift to other sectors, at least in the medium term, as the area has quite low unemployment (about 4%). In addition, even if the competition for resources, particularly for land and water, among the different sectors is strong, it is socially desirable to maintain and defend to some extent the agricultural activity, even in the worst scenarios.

Under all the scenario considered the most important positive effect is the fall in water consumption. The area used to be relatively rich in water, but water saving is becoming a crucial issue. Saving water in general may contribute towards increasing water availability in key periods, particularly for the most profitable crops (e.g. melons and water melons and other vegetables); this shift could increase efficiency in water use.

Few significant environmental improvements have been made in this area, where the main problem remains nitrogen pollution from fertilisers (on average 121 kg/ha per year) and manure. Pesticides have a comparatively less significant impact (6 kg/ha per year of active matter, 11 of total products) due to significant reduction occurred over the last decades.

5.2. Rice – Emilia Romagna

The economic results are strongly affected by the hypothesis on public subsidies within each scenario, (especially subsidies for rice, but also for other COP crops) (table 5).

Table 5. Rice system: impact indicators by scenario (absolute value and percentage variation from Agenda 2000).

	Economic Balance		Social Impact		Biodiversity	Water use	Nutrient and Pollutants	
	Profit	Farm contribution to GDP	Farm employment	Seasonality	Genetic diversity	Water use	Nitrogen balance	Pesticide risk
Scenario	€/ha	€/ha	hours/ha	index	index	m^3/ha	Kg/ha	index
World Market	-609,36	355,49	11	0,07	2,40	2144	-40	679
	-3571%	-67%	-57%	-41%	-46%	-71%	3%	38%
Global sustainability	-307,87	836,31	20	0,10	5,00	4130	-75	304
	-1755%	-23%	-23%	-11%	12%	-44%	-81%	-38%
Provincial Enterprise	-72,81	1057,26	23	0,12	4,61	6018	-61	470
	-339%	-3%	-14%	-1%	3%	-19%	-48%	-5%
Local stewardship	-80,86	1106,14	23	0,13	4,00	6097	-32	432
	-387%	1%	-12%	9%	-11%	-18%	22%	-12%

In particular, profits and GDP fall dramatically in the WM scenario. The percentage decrease is the worst among annual crop systems. Profit strongly negative, makes the cultivation of this particular system no longer sustainable.

All scenarios show a reduction in the use of labour. This is not a particularly relevant feature, as the level of labour employed in this system is already very low.

Water use is always reduced. Other environmental results appear to be somewhat contradictory. Generally speaking, the strong percentage variations (plus or minus) are made less relevant by the absolute value of pollution, which is remarkably low on the whole.

The impact would strongly affect the area under analysis, with results depending largely on soil characteristics. The distinguishing factor of this area is that it consists largely of peaty soil situated below sea level, the land having been reclaimed during the last century. Peaty soils mean that at least half the surface is cultivated with rice, and hence there will be a limited capacity to adapt to changing scenarios, as a consequence of the inherent agronomic constraints. When this crop is no longer profitable, given that it is not possible to change the crop mix, then farmland may be gradually abandoned or the area may be partially reconverted to wetlands. The study showed that the rice system can only survive if provided with some form of public support; otherwise, it tends to be abandoned.

There could be considerable environmental benefits from abandoning cultivation in this area, which is characterised by relatively high pollution (90 kg/ha per year of nitrogen and 10 kg/ha per year of active matter of pesticides, 21 kg/ha per year of total products), but they would probably be much less important than other side effects such as the problems of water control.

Even though the present farming system is based largely on subsidies, such subsidies are justified by the wide array of services that the system produces for society as a whole. The present system allows for the sustainability of farming in the area and its contribution to environmental sustainability as a sort of tacit by-product of agricultural activities. The most desirable scenario would involve a more explicit consideration of the actual role of the farming system in delivering public goods within the area, and a combination of CAP, rural development and water policy designed to respond to local social objectives. One possible result could be a major "re-naturalisation" of the area. Given the singularity of the area, this could also be acceptable as a local response to the WM scenario. The alternative is the progressive abandonment of land, starting with the worst soil.

5.3. *Fruit – Emilia Romagna*

The system is basically stable and able to match most of the scenarios without any major changes in the crop mix (table 6).

Table 6. Fruit system: impact indicators by scenario (absolute value and percentage variation from Agenda 2000).

Scenario	Economic Balance		Social Impact		Biodiversity	Water use	Nutrient and Pollutants	
	Profit	Farm contribution to GDP	Farm employment	Seasonality	Genetic diversity	Water use	Nitrogen balance	Pesticide risk
	€/ha	€/ha	hours/ha	index	index	m³/ha	Kg/ha	index
World Market	-916,05	2044,58	185	0,00	8,23	991	65	23003
	-208%	-34%	-22%	-100%	-9%	-23%	-2%	-26%
Global sustainability	-1026,21	2645,86	214	0,00	7,35	1045	64	24108
	-245%	-14%	-10%	-100%	-19%	-19%	-5%	-22%
Provincial Enterprise	-687,73	2672,90	212	0,00	8,40	1028	67	25999
	-131%	-13%	-11%	-96%	-7%	-20%	0%	-16%
Local stewardship	-712,78	3485,91	229	0,00	10,27	1088	67	32277
	-139,85%	13%	-4%	-100%	14%	-15%	0%	4%

The more significant changes concern profitability and the contribution to GDP resulting from price changes across scenarios. However, relatively significant changes in profit can be misleading: if farmers accept a certain degree of under-payment of family labour, as they do at present, incentives are never going to lead to an abandonment of fruit farming, even when profits are strongly negative. As a consequence, the system retains most of the labour it employs even in the worst scenarios (WM).

Water usage is already highly efficient, as it is based mainly on drip irrigation, and all scenarios are characterized by a slight further reduction in water use. The amount of water used does not change significantly, however, at least in the case of those farms with a crop mix based only, or mainly, on fruit. Clusters with a relevant percentage of annual crops display greater changes, usually characterised by a shift from irrigated to rain-fed annual crops. Once this adaptation has taken place, nevertheless, the water demand curve becomes rather rigid.

Other indicators show contrasting results in different scenarios, but no change is particularly significant. Environmental impact is strong, and remains relatively stable across scenarios.

On the whole, alternative scenarios and different possible approaches to water policy are likely to have minor effects on the fruit system. This result is common to most fruit farming in Emilia Romagna, but is not true of all irrigated fruit systems, which are relatively common in other parts of the country as well. In particular, in many areas fruit farming is more strongly based on irrigation (e.g. the kiwi system in the hills of Romagna, the apricot systems in the South) and/or does not benefit from the favourable environmental conditions in this area. In such cases, the impact on profitability would have a much stronger effect on the sustainability of fruit farming.

Environmental improvements would be desirable in the area, which lies within a region with relatively high pollution, despite efforts to reduce pesticides in recent years and to introduce more natural forms of pest management and organic farming methods. Present pollution pressures are 90 kg/ha per year of nitrogen and 10 kg/ha per year of active matter of pesticides (21 kg/ha per year of total products). However, the low reactivity of the system means that few benefits are to be expected whatever policy were adopted.

5.4. *Vegetables - Apulia*

The economic results vary according to the scenarios, as a result of variations in the amount of public support for, and in the prices of, durum wheat, counter-balanced by the changing cost of raw materials, including water (table 7).

Table 7. Vegetables system: impact indicators by scenario (absolute value and percentage variation from Agenda 2000).

Scenario	Economic Balance		Social Impact		Biodiversity	Water use	Nutrient and Pollutants	
	Profit	Farm contribution to GDP	Farm employment	Seasonality	Genetic diversity	Water use	Nitrogen balance	Pesticide risk
	€/ha	€/ha	hours/ha	index	index	m^3/ha	Kg/ha	index
World Market	75,77	2384,37	100	0,09	3,75	2496	91	112756
	-85%	-8%	9%	1178%	7%	14%	27%	18%
Global sustainability	514,04	2881,98	92	0,03	3,10	2145	74	71084
	5%	11%	1%	261%	-12%	-2%	4%	-26%
Provincial Enterprise	369,62	2597,45	92	0,03	3,10	2253	78	111536
	-24%	0%	1%	261%	-12%	3%	9%	17%
Local stewardship	-132,11	2147,12	85	0,00	3,00	1852	63	57599
	-127%	-17%	-7%	-100%	-14%	-15%	-12%	-40%

In fact, the WM and the LC scenarios give the worst economic results. GS would allow for moderate environmental concern, but also the valorisation of high quality local products, and as such would yield the best results in terms of profit and GDP. The differences among scenarios are more evident in terms of profit, while the agricultural contribution to GDP tends to be relatively stable. Farm employment also tends to be rather stable, showing the system's ability to cope with market trends in different scenarios. Biodiversity is also rather stable.

The lowest results for water use are those in the LC scenario (where water prices are higher), while the WM seems to encourage increased use, due to the low price of water together with a reduction in the relative profitability of rain-fed crops (durum wheat).

Similar trends can also be seen with regard to environmental issues concerning nitrogen and pesticides. WM and PA cause an increase in pollution, while the other scenarios show significant reductions.

On the whole, the impacts are likely to be of average importance on a regional scale. On the one hand, variations in the main indicators are not particularly strong. On the other hand, the system in question is located within an area characterized by a serious problem of unemployment, where any source of income is potentially important.

Moreover, in spite of its stability, the vegetable system relies very much on tomatoes grown for industrial use, instead of a balanced mix of crops, which in turn exposes it to the risk of excessive specialisation. Furthermore, the production of such tomatoes provides important raw materials for the food processing industry. In the face of such issues, there seems to be little likelihood of seeing any reduction in pollution, as the region is characterised by an average use of nitrogen fertilisers and the low employment of pesticides, 60 kg/ha per year and 7 kg/ha per year of active matter (13,7 of total products), respectively.

As regards water, while it is possible to use water pricing as a way of regulating its use, nevertheless this option needs to be considered against the risk of bringing down incomes in one of the few agricultural systems still capable of making a significant contribution to the local economy.

5.5. *Citrus Fruit - Sicily*

All the scenarios show the structural weakness of this agricultural system (table 8).

Table 8. Citrus system: impact indicators by scenario (absolute value and percentage variation from Agenda 2000).

	Economic Balance		Social Impact		Biodiversity	Water use	Nutrient and Pollutants	
	Profit	Farm contribution to GDP	Farm employment	Seasonality	Genetic diversity	Water use	Nitrogen balance	Pesticide risk
Scenario	€/ha	€/ha	hours/ha	index	index	m³/ha	Kg/ha	index
World Market	-859,44	618,70	78	0,00	1,64	1190	60	43062
	52%	-82%	-85%	-100%	64%	-75%	-65%	-12%
Global sustainability	-496,58	-116,68	1	0,00	1,00	0	9	14533
	72%	-103%	-100%	-100%	0%	-100%	-95%	-70%
Provincial Enterprise	-2814,20	2170,31	449	0,00	1,47	3739	137	40379
	-56%	-36%	-16%	-100%	47%	-21%	-21%	-17%
Local stewardship	-525,27	-144,12	1	0,00	1,00	0	8	13495
	71%	-104%	-100%	-100%	0%	-100%	-95%	-72%

Profits are low or negative due to the labour-intensive nature of this kind of farming. Moreover, income is limited as the produce is sold "on the tree". Indeed, the system is never profitable, whatever the imagined scenario. The contribution to GDP is only positive in the PA and WM scenarios. The system may only be expected to continue producing citrus fruit, with no relevant changes compared with the present situation, in such cases, even if profits are strongly negative and water consumption very high. When citrus cultivation is no longer profitable, oranges may be replaced by a rain-fed crop mix based on durum wheat. Profit itself may even improve in some scenarios, but there will be considerable social consequences as the employment of labour plummets to almost zero.

The abandonment of citrus fruit farming would produce positive environmental effects (a reduction in nitrogen pollution and no further need for irrigation), but it would lead to major social problems and the marked alteration of the local landscape.

Altogether, all scenarios would have strong negative effects on the area. The worse scenarios, such as the WM, would lead to a reduction of more than 50% in employment in farming in the local area. The problem of the fall in employment would affect not only the farms themselves, but also workers hired by farmers to harvest the oranges, and the associated activities along the food chain. Compared with such social issues, the possible environmental benefits appear of little relevance. Sicily has a low level of nitrogen fertilizer use (40 kg/ha per year), while the use of pesticides is average (11,2 kg/ha per year of total products, about 7 kg/ha per year of active matter).

The analysis is more complex when it comes to water, as there is strong competition between domestic, industrial and agricultural users during the summer. The scenarios assume that domestic and industrial uses prevail.

However, the social importance of citrus farming could also lead to a more balanced pricing strategy. The possibility that citrus farming be gradually abandoned in the area is very hard to accept, even in the long term, due to transaction and reorganisation costs. The worst scenarios would probably lead to the gradual abandonment of farming, to be replaced in the long term by the more extensive cultivation of annual crops. It is likely that such a hypothesis would encourage policies for the conservation of the local environment and traditional farming, possibly coupled with greater efforts at improving water saving systems, for example through the construction and/or use of better irrigation systems.

6. Conclusions and recommendations

The application of the WFD will require the balance of conflicting interests on water use, related to different sectors and different areas. The adoption of economic concepts by the WFD emphasizes the necessity to achieve choices which are at the same time efficient and able to reach public consensus. This challenging task requires, in turn, adequate economic tools and proper policy instruments.

The present paper elaborates in particular on the agricultural water demand. The paper emphasises the variety of responses of different farming systems to water price and the complexities of farm reactions along the demand curves. These complexities are to be taken into account if the true opportunity cost of water in agriculture is to be estimated.

The range of sustainability indicators adopted, on the other hand, highlights the variety of possible side effects of water policy in terms of social and environmental impact, both upstream and downstream from agriculture.

In addition, scenario analysis emphasises the connection between water and agricultural policy. In fact, CAP and water policy show sometimes contradictory objectives (as in the case of irrigated cereals), while they appear synergic in other cases (such as that of rain-fed cereals combined with irrigated vegetables or fruit). A consistent policy design is requested, if undesired economic, social and environmental effects are to be avoided. This highlights the need for a more careful balance of water conservation and rural development objectives.

The results here presented should be better compared with the water supply side, in terms of financial, resources and environmental costs. Even the descriptive analysis of this issue included in this paper is sufficient to point attention on the possible strong conflict to be expected in the southern areas of Italy, where water is relatively scarce and costly (need of reservoirs, competing uses) while intensive farms have almost no alternative to irrigated crops.

Finally, matching demand and supply has to take into account infrastructural constraints, given by the existing distribution system. For instance, in many areas the water distribution network is based on open canals. In such cases, policy instruments requiring metering may be not socially profitable, due to the cost of metering, monitoring and the related transactions.

These considerations highlight the need for further research, first of all with the aim of assessing the true full cost of water in different circumstances. This should be complemented by a deeper enquiry into water policy design, taking into account alternative policy instruments, information structures and transaction costs; innovative forms of water management could be analysed, such as water markets, tradable permits, mixed instruments; other aspects of water policy, such as water recycling, the use of waste water and quantitative regulation aimed at dealing with drought periods, should also be considered. It also highlights the needs of a more detailed analysis of issues such as seasonality, water storage, conservation and transport as well as a broader view in terms of integrated analysis of other water uses.

Acknowledgements

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