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Water management and irrigated agriculture in Italy: multicriteria analysis of alternative policy scenarios

F. Bartolini[a], V. Gallerani[a], M. Raggi[b] and D. Viaggi[a,*]

[a]*Department of Agricultural Economics and Engineering, University of Bologna, Viale Fanin 50, 40127, Bologna, Italy.*
**Corresponding author. Tel.: + 39 051 2096114, Fax: + 39 051 2096105. E-mail: davide.viaggi@unibo.it*
[b]*Department of Statistics, University of Bologna, Via delle Belle Arti 41, 40126, Bologna, Italy*

Abstract

Irrigated agriculture in Europe is facing major changes, due to the reforms of the Common Agricultural Policy and the coming into force of the new Water Framework Directive (60/2000). The objective of this paper is to evaluate the perceived outcome of different scenarios from the point of view of different stakeholders, as an instrument to support policy in the sector of irrigated farming. The methodology is based on the multicriteria analysis of water and agricultural policy scenarios and is applied in five study areas in Italy. The pay-offs for different stakeholders differ greatly between scenarios. Basic contrasts between farmer-related and environmental/water institutions are emphasised when facing different futures. This shows that greater coordination is necessary to provide consistent policies and appropriate incentives to farmers.

Keywords: Agriculture; Common agricultural policy; Irrigation; Multicriteria analysis; Scenarios; Simulation; Water Framework Directive

1. Introduction and objectives

Among natural resources connected to agriculture, water is undoubtedly one of the most prominent and strategically relevant, particularly in Mediterranean countries. In this region, irrigation is the most important water using activity and a major determinant of the economic, social and environmental sustainability of agriculture. In most cases, it is also tightly connected to the economic and social viability of whole food chains (e.g. citrus and vegetables).

The policy context of irrigated farming is facing major changes in the European Union (EU), due to the 2003 reform of the Common Agricultural Policy (CAP) and the forthcoming policy changes due to World Trade Organization (WTO) negotiation, as well as the coming into force of the new Water Framework Directive (WFD) (60/2000).

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The 2003 CAP reform focuses on the decoupling of payments from production, environmental cross-compliance and increasing the role of rural development measures. Altogether, it emphasises the multifunctional role of agriculture, already introduced with the Agenda 2000 reform, highlighting the need to promote policy options that reconcile natural resource management with competitive food and fibre production, in the attempt to match the whole range of societal goals related to agriculture. The approach of the 2003 CAP reform is expected to be strengthened in the future, as a further wave of reforms characterised by a major commitment to market liberalisation is expected by 2013, after the current WTO round of negotiation.

On the other hand, the WFD places a strong emphasis on new policy concepts and instruments. This includes the application of Polluter Pays Principle (PPP) and (Full) Cost Recovery (FCR), as well as volumetric pricing as a preferred instrument aimed at producing incentives towards more efficient use of water.

While both CAP and WFD regulations state the objective to promote a better integration of natural resource management and economic activities, specific objectives may frequently be in contrast. This is particularly true for water use which is managed traditionally by rather specific institutions able to mediate between a number of conflicting stakeholders and goals. In Italy, for instance, irrigation is managed by Reclamation and Irrigation Boards (RIBs), historically oriented towards land reclamation and water provision, mainly with the historical aim of improving agricultural production.

Bartolini *et al.* (2007) analysed the problem using microeconomic programming models to simulate the impact of joint water and agricultural scenarios on selected Italian irrigated systems. The outcome of the scenarios was measured through a set of economic, social and environmental indicators. This paper takes the analysis further by applying multicriteria analysis to the outcome of the simulation of Bartolini *et al.* (2007). The objective is to develop and test a methodology aimed at giving an aggregate evaluation of the perceived outcome of different scenarios by different stakeholders. This allows identification of convergencies and divergencies in attitudes to policy action under different contextual conditions, and may provide a tool to support the analysis of feasibility of institutional and policy changes required in the sector of irrigation and irrigated farming, to face the changing economic and policy context.

The structure of the paper is as follows: in section 2 the connection between water use and irrigated agriculture is discussed; in section 3 the methodology is illustrated, while in section 4 the case studies and data sources are presented; the results are illustrated in section 5; finally, some policy implications are discussed in section 6.

2. Water management and agriculture in Italy

CAP in the EU and Italy is promoting a “multifunctional” role for agriculture. Agriculture is increasingly seen as an activity producing a complex set of interconnected outputs to be evaluated (at the same time) with economic, social and environmental perspectives. For this reason, it is also considered somehow an exception compared to other economic sectors (Cardwell, 2004). The traditional role of agriculture is to secure food and fibre production, and this role is still central in connection to food safety and food security issues. Socially, agriculture is viewed as a sector able to maintain local culture, employment and population in otherwise abandoned areas. Environmentally, agriculture is seen as a major player in resource management. Positive externalities are attributed to the sector, such as upkeep of landscape and related services. However, it is also often accused of producing negative externalities, including externalities related to water quantity (e.g. water abstraction) and quality (e.g. nitrogen emissions).

Within the current vision of agriculture there is an emphasis on careful management of environmental externalities. Since the end of the 1980s there have been specific policies to reduce negative externalities and to increase positive externalities produced by agriculture. These policies are strengthened by the latest policy reforms (arable crop payments in 2003 and rural development schemes in 2005), with the introduction of compulsory environmental cross-compliance and with the strengthening of payments for voluntary agri-environmental measures.

In Italy and other Mediterranean countries, farming is also a key node in water management. Agriculture is the main water-using sector, with a share around 50% of total water use, due mainly to irrigation. In addition, agriculture has major impacts on water quality through non-point pollution, in particular due to fertilisers, pesticides and manure. In Italy in 2003, 30% of the total agricultural area was irrigated, with significant growth in the last decade. The share of irrigated area is very heterogeneous between regions, ranging from 9% of Marche, to 67% of Lombardia (ISTAT, 2007). For some crops (e.g. orchards, vegetables and flowers) virtually 100% of the total cultivated area is irrigated. More than half of Italian agricultural exports are from irrigated crops.

The distribution of irrigation water in Italy is mainly managed by RIBs, which are associations of farmers that control the management and distribution of water resources over a certain area. Water use regulation is based on a complex system of rights, whose structure is very much locally-specific. Water pricing usually works through area-based tariffs aimed at covering RIBs' costs, without any statutory role of providing incentives for water saving. There are some examples of volumetric pricing, associated with the most recent pressure pipe distribution systems, in which water measurement is possible.

The introduction of WFD could bring major changes for irrigated farming. Though the application should be strongly differentiated at the local level, according to river basin criteria and the newly formed hydrographic districts, some major economic criteria are the same for all countries.

The first is the principle of FCR, according to which the user of water should bear all the costs of water provision. The WFD states that the FCR should be taken into account, not necessarily covered. However, from an agricultural perspective, even relaxed FCR, could cause a net increase of water prices, as currently in Italy only a part of running costs for water provision are borne by the final users.

A second major principle introduced is the PPP, according to which, water users should also bear the environmental cost of water use. This justifies the fact that environmental costs are included in the Full Cost (FC), together with financial and resource costs.

Finally, WFD recommends the use of economic instruments, such as volumetric pricing, for water regulation.

Altogether, the price structure should cover the costs of water provision, the resource cost of water and (possibly) the environmental cost of water use, while, at the same time provide incentives to reduce both water use and pollution (WATECO, 2003).

The WFD provides for a gradual implementation of these concepts and allows for motivated derogations. In fact, volumetric water pricing and FCR are considered major principles for the sustainability of water systems, but are seldom applied for efficiency or equity reasons (Dinar & Subramanian, 1997; OECD, 1999; Massarutto, 2002).

From a policy perspective, an important issue is the coordination between CAP and WFD, to provide consistent incentives to farmers (Bazzani *et al.*, 2004a). As already mentioned, agriculture is characterised by a high degree of public intervention. CAP provides strong incentives to farmers that, depending on the farming system involved, may play for or against the objectives of the WFD, both in terms of quality and quantity control. For example, coupled payments of irrigated crops have promoted irrigation in some areas. On the other hand, decoupled policies, as proposed by the 2003 CAP reform, may reduce incentives for irrigation, so affecting the ability of cost recovery by water delivery institutions.

Water is one of the main factors affecting the economic, social and environmental performances of agriculture. For example, in many Mediterranean areas water availability is the main constraint to agricultural production. The availability of funding for irrigation infrastructure has acted to increase agricultural water use, while water policy has encouraged savings. The same to a large extent applies for pollution control problems, such as nitrogen leaching.

The present needs for more cost effective policies call for greater coordination between water and agricultural policy. However, policy coordination also requires institutional change and the management of possible conflicts among different stakeholders. To this end, the whole range of effects of water-agricultural policy objectives and the whole range of economic, social and environmental goods produced by agriculture must be considered.

A wide analysis of policy scenario effects on irrigated farming systems in southern Europe has been recently developed (Berbel & Gutierrez, 2004; Manos *et al.*, 2006; Riesgo & Gómez-Limón, 2006; Bartolini *et al.*, 2007)[1]. These studies mainly simulated the effects of different scenarios and yielded results in a range of economic, social and environmental indicators. The evaluation of these indicators, however, can differ greatly depending on the stakeholder interested. In this paper we attempt to advance by formalising the evaluation that each stakeholder may give of the effects of different scenarios. For this purpose, we follow up on the results of the previously mentioned papers, by developing a multicriteria analysis of indicators from scenario simulation in the case of Italy, particularly building on Bartolini *et al.* (2007).

3. Methodology

The approach used here is to compare the evaluation (utility) of different scenarios given by different stakeholders, through the following rationale:

$$U_{i,j} = f_i(g_j(s_j))$$

where:

$U_{i,j}$ = utility of scenario j for stakeholder i;
f_i = utility function;
$g_j(s_j)$ = vector of indicators describing the performance of irrigated farming systems in the scenario j;
s_j = vector of parameters describing scenario j.

[1] All of these studies were based on the experience of the EU project WADI (EVK1-2000-00057). See Berbel & Gutierrez (2004) for more details.

The computation of $g_j(s_j)$ was the main task of Bartolini *et al.* (2007). This paper focuses on $U_{i,j} = f_i(\cdot)$, by estimating and comparing the evaluation of different scenarios by different stakeholders through multicriteria techniques.

The empirical methodology used in this paper develops in the following steps:

1. identification of future scenarios concerning the socio-economic context at large, with particular attention to agriculture and water policy; scenarios are distinguished into a baseline scenario (that works as reference) and several alternative scenarios;
2. modelling of selected farm types/farming systems through multi-objective mathematical programming and computation of farm adaptation to each scenario;
3. computation of a set of derived indicators showing the effects of farm adaptation on a range of economic, social and environmental factors;
4. multicriteria analysis of derived indicators to assess the degree of "satisfaction" of different stakeholders from different scenarios;
5. analysis of the relationships between the utility of different stakeholders.

Steps 1–3 were developed in Bartolini *et al.* (2007) and only essential empirical elements are recalled in the next section. Their results are a numerical estimate of the vector $g_j(s_j)$. Steps 4 and 5 are the focus of this paper.

In step 4, to summarise the results quantified by the sustainability indicators, a multicriteria analysis (Romero & Rehman, 2003) has been set, taking the point of view of the different stakeholders.

The value of the utility of each scenario is expected to be different for each stakeholder and is given by the weighted sum of indexes obtained from indicators, each one multiplied by the related weight:

$$U_{i,j} = \sum_k w_{i,k} u_{i,j,k}$$

where:

$w_{i,k}$ = weight of indicator k, for stakeholder i;
$u_{i,j,k}$ = utility of indicator k, in the scenario j, for stakeholder i.

The result is the expected utility of each stakeholder from each scenario.

Operationally, this approach requires the following sub-steps:

4.1 transformation of indicators into socio-environmental quality indexes;
4.2 measurement of weights for each stakeholder and for each indicator;
4.3 measurement of probability of each scenario;
4.4 calculation of the overall socio-environmental quality of the results of each scenario.

In step 5, the analysis of the relationships between the utility of different stakeholders uses three connected approaches. First, we carry out a simple comparison of $U_{i,j}$ of different scenarios/stakeholders, following the rationale that:

- the greater $\Delta U_{i,i',j} = U_{i,j} - U_{i',j}$ (with $i' \neq i$), the higher the possibility of divergencies and conflicts in that scenario;
- the greater $\Delta U_{i,j,j'} = U_{i,j} - U_{i,j'}$ (with $j' \neq j$), the higher the preference for scenario j compared to j', and the greater the possibility of policy action to achieve that scenario.

Secondly, the results for the scenarios different from the baseline have been aggregated following an expected utility rationale. All stakeholders involved are assumed to be risk neutral:

$$U_i = \sum_j \pi_j U_{i,j}$$

where π_j is the probability attributed to each scenario;

U_i = expected utility of stakeholder i.

In a further stage, we try to formalise the similarity of attitudes across stakeholders by calculating correlation coefficients of $U_{i,j}$ across scenarios:

$$\rho = \frac{\mathrm{Cov}_{U_i U_{i'}}}{\sigma_{U_i}\sigma_{U_{i'}}}$$

where:

ρ = Pearson's correlation coefficient;

$\mathrm{Cov}_{U_i U_{i'}}$ = covariance between utilities of different stakeholders;

σ_{U_i}, $\sigma_{U_{i'}}$ = standard deviation of utilities of different stakeholders i and i'.

The methodology allows the identification and quantification of changes of pay-offs and incentives associated with possible futures. The information obtained is used to review the present policy framework related to irrigated agriculture and to discuss possible paths of development.

4. Case studies and data sources

We start the methodology illustrated above by the definition of five scenarios (step 1), with reference horizon 2010, identified as: (a) Agenda 2000, (b) World Market, (c) Global Sustainability, (d) Provincial Enterprise, and (e) Local Stewardship.

Agenda 2000 is the baseline scenario, built on prices, agricultural policy and farm characteristics at 2001, assuming they remain the same up to 2010. World Market describes a scenario characterised by a high degree of liberalisation, where decisions are taken through market mechanisms. This scenario is the closest to the actual trend in policy reforms expected by 2010. In the Provincial Enterprise 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 Stewardship) levels.

For each scenario, two water price options are considered: (a) present price and (b) double the present price.

To perform steps 2 and 3, farm level mathematical programming models are used. Specifically, the model is a multiobjective optimisation model derived from traditional linear programming farm models (Hazell & Norton, 1986) with attached economic, social and environmental indicators. It simulates how the farm would adapt to changes in context under different scenarios (Sumpsi *et al.*, 1996; Bazzani *et al.*, 2004b).

Five irrigated agricultural systems have been selected as case studies: a cereal system in Lombardy (Northern Italy); a rice system in Emilia Romagna (Northern Italy); a fruit system in Emilia Romagna; a vegetables system in Apulia (Southern Italy); and a citrus system in Sicily (Southern Italy).

These farming systems have been selected as representative of the main Italian irrigated crop specialisations, as well as of different geographical and climatic conditions in Italy.

The cereal farming systems are mainly extensive (maize, wheat, protein and fodder crops), in an area with plentiful water availability. The rice system is characterised by high water use and a very policy-dependent crop (historically strongly supported by EU payments). The fruit system mainly involves the cultivation of peaches, wine grapes and kiwi fruit, and is very profitable in an area with average water availability. The vegetables system also has high profitability but is in an area with low water availability, and is mainly dependent on the market of one single crop (tomato). Finally, the citrus system is highly dependent on water in an area with strong water scarcity and is again based mainly on a single crop (orange).

A more detailed description of the system and the specific characteristics of each area are given in Gallerani *et al.* (2004).

The basic information required for this paper, the indicators that measure systems' performance in different scenarios, are presented in Bartolini *et al.* (2007, see Tables 7–11). As previously described, the numerical values of such indicators are elaborated here using multicriteria analysis.

In the multicriteria analysis, the first sub-step (4.1, normalisation) has been carried out through the use of "quality functions". Quality functions are assumed to be linear from the minimum to the maximum. Minimum values correspond to 0 and maximum to 1 for indicators for which a higher value is preferred, while the reverse has been made for indicators for which a low value is preferred. For indicators that can take negative values, the minimum has been assumed to be equal to the lower level occurring throughout scenarios.

In sub-step 4.2, four different set of weights have been identified that correspond to the following stakeholders: farmers; agricultural policy makers; water policy makers; environmental policy makers.

Table 1. Weights attributed to different stakeholders.

Type of impact	Indicator	Farmer	Agricultural policy maker	Water policy maker	Environmental policy maker
Economic balance	Farm profit	0.5	0.34		
	Farm contribution to GDP		0.33		
Social impact	Farm employment	0.5	0.33		
Landscape and biodiversity	Genetic diversity				0.33
Water use	Water use			0.5	0.33
Nutrients and pollutants	Nitrogen balance			0.25	0.17
	Pesticide risk			0.25	0.17

Table 2. Results of multicriteria analysis by scenario and stakeholder, assuming present water price.

		Farmer	Agricultural policy maker	Water policy maker	Environmental policy maker
Cereals	A2000	1.00	1.00	0.12	0.41
	WM	0.32	0.37	0.35	0.51
	GS	0.40	0.48	0.49	0.60
	PE	0.72	0.76	0.30	0.53
	LS	0.55	0.67	0.27	0.51
Rice	A2000	1.00	1.00	0.14	0.39
	WM	0.26	0.29	0.61	0.62
	GS	0.65	0.69	0.56	0.70
	PE	0.88	0.91	0.31	0.52
	LS	0.87	0.91	0.21	0.44
Fruit	A2000	1.00	0.95	0.01	0.32
	WM	0.54	0.55	0.20	0.42
	GS	0.54	0.60	0.17	0.37
	PE	0.72	0.73	0.15	0.39
	LS	0.77	0.84	0.07	0.37
Vegetables	A2000	0.86	0.86	0.15	0.34
	WM	0.71	0.74	0.00	0.33
	GS	0.96	0.97	0.21	0.43
	PE	0.82	0.84	0.09	0.35
	LS	0.55	0.62	0.32	0.50
Citrus	A2000	0.67	0.78	0.00	0.17
	WM	0.43	0.46	0.35	0.56
	GS	0.51	0.52	0.68	0.70
	PE	0.42	0.38	0.20	0.38
	LS	0.49	0.59	0.92	0.78

A2000 = Agenda 2000; WM = World market; GS = Global sustainability; PE = Provincial enterprise; LS = Local stewardship.

Weights are an estimate of the importance of each indicator. They are a very important issue in multicriteria analysis, as they are a clear determinant of the results. However, they also prove difficult to evaluate. In this paper we use an indirect approach to weight elicitation. Instead of directly asking stakeholders for weights, the authors organised a workshop where results of the simulations were presented and discussed in a round table by stakeholders. At the end, interpreting the discourse of each stakeholder, each author gave a score to each indicator that he/she thought could represent the position of each stakeholder. Weights were then averaged across participants and the result discussed until a consensus was achieved. Weights are assumed to be the same in all case study areas.

The probability of each scenario (sub-step 4.3) was asked during interviews with 12 representatives of different agriculture-related stakeholders from different parts of Italy. The same interviews also supported the definition of scenario description and parameters in Step 1 of the general methodology.

The list of indicators used and related weights elicited for multicriteria analysis are given in Table 1.

The probabilities identified for each scenario were World Market = 0.45; Global Sustainability = 0.33; Provincial Enterprise = 0.11; Local Stewardship = 0.11.

Table 3. Results of multicriteria analysis by scenario and stakeholder, assuming double the present water price.

		Farmer	Agricultural policy maker	Water policy maker	Environmental policy maker
Cereals	A2000	0.77	0.80	0.53	0.68
	WM	0.26	0.32	0.48	0.59
	GS	0.34	0.43	0.65	0.66
	PE	0.66	0.70	0.40	0.60
	LS	0.47	0.59	0.39	0.48
Rice	A2000	0.82	0.84	0.31	0.44
	WM	0.15	0.18	0.46	0.52
	GS	0.59	0.63	0.56	0.70
	PE	0.80	0.83	0.31	0.52
	LS	0.76	0.80	0.32	0.47
Fruit	A2000	0.90	0.86	0.12	0.38
	WM	0.46	0.48	0.23	0.44
	GS	0.45	0.53	0.22	0.38
	PE	0.63	0.65	0.19	0.41
	LS	0.66	0.75	0.09	0.39
Vegetables	A2000	0.74	0.75	0.15	0.34
	WM	0.57	0.62	0.00	0.33
	GS	0.84	0.87	0.21	0.43
	PE	0.68	0.72	0.15	0.40
	LS	0.40	0.49	0.36	0.52
Citrus	A2000	0.54	0.45	0.61	0.64
	WM	0.45	0.39	0.87	0.75
	GS	0.50	0.34	0.91	0.78
	PE	0.50	0.35	0.87	0.75
	LS	0.49	0.35	0.92	0.78

A2000 = Agenda 2000; WM = World market; GS = Global sustainability; PE = Provincial enterprise; LS = Local stewardship.

5. Results

Summary indexes, derived as weighted sums from indicators (after normalisation) with present price of water show the different evaluation that the stakeholders give to different scenarios (Table 2).

The impact of different policy scenarios from the point of view of farmers is clear; Agenda 2000 is the best scenario for all of the systems. For cereals and rice, World Market is by far the worst. For fruit, World Market is still the worst, but is equalled by Global Sustainability; Local Stewardship is worst for vegetables and Provincial Enterprise worst for citrus.

This judgment is basically confirmed for agricultural policy makers, while things are much more complex for water policy makers and environmental policy makers. In both cases, Agenda 2000 is never the best solution and is often the worst. Depending on the area, either Global Sustainability or Local Stewardship is the best scenario.

These results justify a preference of water and environmental stakeholders for sustainability scenarios, putting pressure on agriculture to incorporate environmental values into policies and practices. On the other hand, agriculture stakeholders have incentives to resist change in this direction. All groups,

Table 4. Results of multicriteria analysis, assuming present water price.

		Farmer	Agricultural policy maker	Water policy maker	Environmental policy maker
Cereals	A2000	1.00	1.00	0.12	0.41
	Future	0.41	0.48	0.38	0.54
	Diff.	−0.59	−0.52	0.26	0.13
Rice	A2000	1.00	1.00	0.14	0.39
	Future	0.52	0.56	0.51	0.61
	Diff.	−0.48	−0.44	0.38	0.23
Fruit	A2000	1.00	0.95	0.01	0.32
	Future	0.58	0.62	0.17	0.39
	Diff.	−0.42	−0.33	0.16	0.07
Vegetables	A2000	0.86	0.86	0.15	0.34
	Future	0.79	0.82	0.11	0.39
	Diff.	−0.07	−0.04	−0.04	0.05
Citrus	A2000	0.67	0.78	0.00	0.17
	Future	0.46	0.48	0.50	0.61
	Diff.	−0.21	−0.29	0.50	0.44

A2000 = Agenda 2000; Future = weighted average of alternative scenarios; Diff. = Difference between expected utility from future scenarios and Agenda 2000, i.e. (weighted) average expected utility.

however, have incentives to resist changes toward market liberalisation. This scenario may be pursued by other stakeholders external to this analysis, for example on the ground of higher economic efficiency, but could provide incentives for collusion against its development by agriculture and environmental stakeholders.

With a water price equal to double the present one, all indicators are lower for farmers and agriculture policy makers, but strongly higher for water and environmental policy makers (Table 3).

Table 5. Results of multicriteria analysis, assuming double the present water price.

		Farmer	Agricultural policy maker	Water policy maker	Environmental policy maker
Cereals	A2000	0.77	0.80	0.53	0.68
	Future	0.35	0.43	0.52	0.60
	Diff.	−0.42	−0.37	−0.02	−0.08
Rice	A2000	0.82	0.84	0.31	0.44
	Future	0.43	0.47	0.46	0.57
	Diff.	−0.39	−0.37	0.15	0.13
Fruit	A2000	0.90	0.86	0.12	0.38
	Future	0.50	0.54	0.21	0.41
	Diff.	−0.40	−0.32	0.09	0.03
Vegetables	A2000	0.74	0.75	0.15	0.34
	Future	0.65	0.70	0.13	0.39
	Diff.	−0.09	−0.05	−0.03	0.05
Citrus	A2000	0.54	0.45	0.61	0.64
	Future	0.48	0.36	0.89	0.76
	Diff.	−0.07	−0.09	0.28	0.12

A2000 = Agenda 2000; Future = weighted average of alternative scenarios; Diff. = Difference between expected utility from future scenarios and Agenda 2000, i.e. (weighted) average expected utility.

Table 6. Correlations of utility of different stakeholders.

	Farmers	Agricultural policy makers	Water policy makers	Environmental policy makers
Farmers	1	0.957*	−0.512*	−0.439*
Agricultural policy makers		1	−0.623*	−0.533*
Water policy makers			1	0.956*
Environmental policy makers				1

*Significant at $P < 0.01$.

Not surprisingly, this reflects incentives to pursue water price increases for water and environmental policy makers, and to resist such increases for farmers and agricultural policy makers. In most cases, however, the relative utility of different scenarios for the same stakeholder does not change significantly compared to the current water price.

Tables 4 and 5 show the results of expected utility from the aggregation of scenarios other than Agenda 2000; i.e. the sum of the scenario's utility weighted by the probabilities assigned to each scenario.

With the present price, future scenarios lead to worsening for farmers and agricultural policy makers in all systems, with negligible changes only in the vegetables system. On the contrary, water and environmental policy stakeholders would have a net improvement of utility, again with the exception of vegetables. This result explains actual trends, where water and environmental stakeholders show strong commitment to change, putting pressure on agriculture. On the other hand, agriculture stakeholders have incentives to resist change. With double the present price of water, the results are generally similar, though the differences between Agenda 2000 and future scenarios are attenuated. There is an exception for cereals, where future scenarios are expected to be worse than Agenda 2000 for all stakeholders.

The analysis of the correlations of utility of different stakeholders (Table 6) formalises and emphasises the potential for coalitions and conflict concerning irrigated systems highlighted above.

The interests of farmers and agricultural policy makers, in particular, are strongly positively correlated in the different scenarios and systems considered. As expected, the same applies to water and environmental policy makers. On the other hand, the position of agriculture-related versus water and environmental-related parties are negatively correlated. This confirms the existence of basic conflicts between agriculture and the environment concerning management of water resources. Also, this justifies some collusion between farmers and their policy makers in preserving the sector's viability through policies where the environment is somehow protected, without prejudging the profitability of agriculture.

6. Discussion and policy implications

The scenario analysis highlights relevant differences in the potential futures of irrigated farming and the variety of reactions of Italian farming systems in adaptation to the policy and market context. Facing these scenarios, different stakeholders show conflicting objectives and incentives.

The quantitative analysis carried out through the multicriteria evaluation of the results of different scenarios match with the real life experience, where increasing pressures for change are being exerted by water and environmental stakeholders to make agriculture comply more directly with environmental objectives.

The perception of scenarios by different stakeholders may encourage action to adapt or to affect futures. While global scenarios are outside the range of decision making of the stakeholders considered here, they may nevertheless adapt or affect scenario evolution at the local level.

Different scenarios may encourage different action by different stakeholders. In particular, Global Sustainability and Local Stewardship may moderate requirements for additional water and environmental regulatory activities. Conversely, World Market may encourage a strong policy reaction to meet environmental stakeholders' objectives.

However, the main message here is that, particularly in the World Market scenarios—a "radicalisation" of the present trend—all stakeholders considered would have interest in (possibly common) actions to counteract the effects due to market and agricultural policy forces.

Facing divergent attitudes towards the future, the issue of institutional coordination appears of strategic importance for irrigated systems to shift from a largely subsidised, production-oriented agriculture, towards a more environmentally and cost-responsible sector.

In this respect, RIBs may have a major role, since they already connect most of the stakeholders considered in this paper. This role could possibly be developed to achieve a higher "institutional efficiency", i.e. the ability to be a more cost-effective and proactive node of the system.

The contemporaneous application of WFD and the 2003 CAP reforms can be viewed as a major opportunity to advance in this direction, through a re-discussion of the relationship between agriculture, natural resources and social objectives, and by providing the institutional basis for effective planning at the river basin level.

The methodology showed how simulation model results can be developed to interpret decision-making processes in the policy arena. This approach has the potential to go further, by directly offering support to the decision-making process. The main improvements required to become operational, however, concern the timeliness and policy updating of scenarios and output indicators, and a more transparent and generally usable methodology for the elicitation of weights. Both these aspects suggest useful streams of further empirical research.

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