Integrated participatory modelling of irrigated agriculture: the case study of the reorganisation of a water management system in Italy

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Abstract

The paper presents an application of the new version of the 'Decision Support for Irrigated agriculture' DSIrr designed to integrate water and agricultural policy analysis and to support participatory decision process. The tool is a scenario manager for bio-economic farm models considering climatic, agronomic, hydraulic, socio-economic and environmental aspects. The paper offers some insight on the decomposition approach adopted to integrate economic analysis at different scales by illustrating a case study conducted in Italy to support an ex ante evaluation of a water management system reorganisation. Reduce water consumption is a strategic objective which pricing policy cannot address given technical constraints. The replacement of the existing low-efficiency irrigation system could be the solution, but the recover of cost creates an affordability problem. Results suggest that a dual network, integrating agricultural and rural urban sectors, represents a real challenge for the Irrigation Board since this option meets the environmental goal and pass the economic sustainability test.

Key words: Water, Agriculture, Economic analysis, Modelling and tools, Participatory process

1. Introduction

The 2000/60/EC Directive, known as Water Framework Directive (WFD), defines the basic principles of sustainable water policy in the European Union (EU) and aims at reaching a “good status” for all water by 2015. The Directive requires a planning approach at the river basin scale which economic analysis should inform and support (WATECO, 2002). By 2010, Member States must ensure that water pricing policies provide adequate incentives for users to use water resources efficiently and that the different water uses contribute enough to the recovery of the costs of water services[1]. Policies and actions concerning the regulation of land use, environmental protection and the sustainability of economic and social development are to be pursued by optimising resource management in the respect of the minimum acceptable flow, increasing the availability of surface water for the various uses, safeguarding the quantitative and qualitative equilibrium of the groundwater, planning the demand in order to ensure the future water budget, favouring innovation in production processes and technologies in order to reduce water consumption, water pollution and soil degradation. Such actions should be assessed in terms of cost and benefit and the existence of disproportionate cost checked.

Agriculture is a significant user of water resources in Europe, accounting for around 30% of total use, this is particularly true in southern Europe where water is a fundamental agricultural input and irrigation accounts for over 50% of total demand. At EU level, irrigated agriculture is perceived as one of the main responsible for negative impacts on the environment. On this basis agriculture has been identified as a key sector in WFD implementation. The Common Agricultural Policy (CAP) has undertaken a severe reform process and the so called Fischler reform introduced in January 2005 represent the final step. It moves in the direction of a decoupled policy with internal prices more in line with the world market, which means lower prices for most commodities, and farm income support

[1] The principle of recovery of the costs (CRP) of water services, including environmental and resource cost,

in the form of direct single farm payment (SFP) to compensate for the previous reduction. Eco-conditionality integrates environmental concern into the CAP which recognises that agriculture has a key role to play in preserving the countryside and natural spaces and in the vitality of rural life. The new Rural Development policy 2007-2013 with the land management-environmental axis provides measures to protect and enhance natural resources and offers the greatest opportunity since water is one of the three level priority areas (2.2). The measures available under axis 2 should be used to integrate these environmental objectives and contribute to the implementation of the agricultural and forestry Natura 2000 network, to the Göteborg commitment to reverse biodiversity decline by 2010, to the WFD objectives and to the Kyoto Protocol targets for climate change mitigation, but all axes offer many opportunities to increase agricultural environmental sustainability. The incoming 'Health check', the planned review of the EU's agricultural policy in 2008, should reinforce this process.

The WFD requires an integrated participative water resources policy, which high quality computer based tools (ICT-tools) should support (HarmoniQuA, 2006; Borowski and Hare, 2007; Matthies et al., 2007). In order to synthesize available knowledge in this field the European Union has conducted a large-scale concerted action called "Harmonized Modelling Tools for Integrated Basin Management" (Harmoni-CA). The action aims at defining a guided use and methodologies of harmonized ICT-tools supporting the design of River Basin Management Plans and WFD implementation. Tools embedding economic modules are particularly needed to support an integrated policy analysis which assume particular relevance in the context of the joint application of CAP reform and WFD (Heinz et al., 2007). The 'System for Environmental and Agricultural Modelling; Linking European Science and Society' SEAMLESS, an EU FP6 Integrated Project, is one of the most impressive response (Bezlepkina et al., 2007) but many other tools exist, for a recent review see Bazzani (2007).

DSIrr: a scenario manager for bio-economic farm models

The 'Decision Support for Irrigated agriculture' (DSIrr) is a prototype not commercial tool designed to integrate water and agricultural policy analysis, originally created in the context of the EU WADI project (Berbel and Gutierrez, 2005) has now reached the second release. The program follows the integrated modelling paradigm which represents a well applied area of research to deal with environmental problems (Argent, 2004; Atwood et al, 2000; Jakeman and Letcher, 2003).

DSIrr is a scenario manager for bio-economic models which can be used as a Decision Support (DS) in participatory process (Bazzani 2005a and 2005b, Bazzani et al. 2005). The DS reproduces choices taken by actors (i.e. farmers), who interact in institutional settings market and policy driven, and assesses aggregate impacts in the social, economical and environmental dimensions. The program adopts a hierarchical approach to describe the agricultural sector, in the new release the decomposition module to scale down the idrographic reference unit (i.e. the basin) to the farm level has been completely rewritten. At farm level DSIrr analyses the conjoint choice of crop mix, irrigation, technology and employment as an optimization problem. The farm models adopt a primal representation of technology, which allows the use of available technical information concerning

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should be adopted in accordance with the polluter-pays principle (PPP) (Articles 9 & 13 and Annex VII).

physical quantities of inputs and outputs, and takes into account the production of externalities as part of the output (Gomez-Limón and Riesgo, 2004; Mejias et al., 2004).

This approach entails to analytically quantify the utilisation of water, chemicals, labour and machinery and their costs, considering different agricultural systems and farm types and favours the quantification of a set of indicators covering different dimensions of sustainability (OECD, 2001). For the economic dimension: farm net income (INC), calculated as the difference between the value of gross output and all expenses including depreciation; agricultural contribution to gross domestic product (GDP), estimated as the difference between total revenue and intermediary consumption; subsidies (SUB) representing transfers to the agricultural sector. The social dimension is assessed by agricultural employment (LT), disaggregated in family and extra family. For the environmental dimension: land use is described in term of cultivated surface by crop (SUR), the number of species (CRO) offers some insight on the ecologic variability, soil cover (SOC) addresses the soil erosion problem. A nitrogen (NIT) pressure indicator, measured as the quantity of nitrogen used, which can be refined calculating a balance can be quantified. The same approach can be adopted for chemicals and energy. A group deals with water: irrigated surface (SIR) quantifies the percentage of irrigated land on total land, water quantity (WQ) is the total demand, water value (WV) assess the farmers' willingness to pay for the resource, while irrigation techniques (IT) are described by type and distribution.

All models are implemented in GAMS (General Algebraic Modelling System) (Rosenthal, 2006), while the graphical user interphace (GUI) is written in Visual Basic and runs under Windows. A modular structure enables a continuous development of the program. The tool can be linked to other models on both sides: taking agronomic data in input and feeding other models. Release 2 has been designed to be used in participatory process following the NetSyMoD approach (Network Analysis – Creative System Modelling – Decision Support) for managing the involvement of stakeholders by building conceptual models (Giupponi and Moiso, 2007).

The farm model

The farmer's problem is cast as a constraint maximization and it can be formalized as follows:

$$\max_{\{X,W\}} \text{INC}=\sum_{c}\sum_{i}\sum_{s}\left\{X_{c,i,s}\left[p_{c,i}\,q_{c,i,s}\left(wr_{c,i,s}\right)+su_{c}-vc_{c,i,s}\right]\right\}+\mathit{farmpaym}-\sum_{k}\sum_{l}\sum_{p}W_{k,l,p}wp_{k,l,p} \qquad (1)$$

subject to:

…

$$\sum_{s}\sum_{c}\sum_{i}X_{c,i,s}ir_{c,i,s}\leq\sum_{l}W_{k,l,p} \quad \forall k,p \qquad (2)$$

…

where indices represent: *c* crop, *i* irrigation level, *s* type of soil, *k* water source, *l* water provision level, *p* period. To distinguish between variables (endogenously determined) and parameters (exogenously fixed) the former are written in capital letters: *INC* income (€), $X_{c,i,s}$ activities[2] (ha), $p_{c,i}$ crop market price (€/t), $q_{c,i,s}(wr_{c,i,s})$ crop production as function of water (t), $wr_{c,i,s}$ crop water requirements (m^3), su_c coupled subsidies (€), *farmpaym* farm payment (€), $vc_{c,i,s}$ variable costs (€), $W_{k,l,p}$ water consumption (m^3), $wp_{k,l,p}$ water price (€/m^3), $ir_{c,i,s}$ crop irrigation requirements (m^3).

In equation 1, representing farm income objective function, production *q* is expressed as a function of water and irrigation costs are kept apart, in this way it is possible to derive a farm *water demand function* (3) via parametrization of the resource price or quantity.

$$W = f\left(wp;Q\right) \tag{3}$$

The previous function determines the quantity of water *W* demanded by a farm in a certain period as an inverse function of its price *wp*, given the farm production possibilities and characteristics *Q*.

Each farm is described by a specific model characterized by a set of equations and proper coefficients. Among the constraints land, labour, financial capital and water availability, as well as crop rotations, commercial and policy aspects, are considered.

An application: an assessment of the reorganisation of a water management system

The case study

DSIrr has been applied in the context of the Italian case study of the EU-MEDA project ISIIMM to a pilot area located in the North-East of Italy in the Alto-Adriatico River Basin. Water is becoming a critical issue in the basin, where up to a recent past the resource has been abundant, due to changes in climate, rain distribution and socio-economic conditions. Water saving represents now a major problem, since conflicts among uses and environmental pressures have reached a critical level In the area a reorganisation of the water management system is foreseen to favour the replacement of the existing low-efficiency irrigation system, based on a network of open channels favouring farm surface irrigation, with a new one integrating pressure pipes and sprinkler irrigators at farm level. The network transformation could reduce water losses around 15-20%, while the adoption of modern irrigation techniques could offer an additional contribution to save water. The study is referenced in Giupponi and Moiso (2007).

Figure 1 presents a flow chart of the evaluation procedure adopted, which aims to assess future trends in land use, water demand, farm income, employment and environmental pressures under different scenario and to analyze water pricing policies to support cost recovery. The methodology includes two main stages. In the first one, the relevant data to describe the existing situation are collected, a qualitative analysis is conducted to identify the likely scenarios for CAP and WFD, key issues are discussed with stakeholders and experts. In a second one, a modelling exercise is conducted to explore the impacts of alternatives actions under different scenario via simulation. This latter stage is in fact an

[2] An activity is a crop characterized by the production process, i.e. fertilization, irrigation, …, mathematically is a vector with the input/output coefficient.

iterative procedure which have been repeated more times.

Data collection integrates census data (ISTAT, 2000), other official regional data, with private sources represented by the water board archives, farmer and producer association records and the results of an *ad hoc* survey conducted by the FEEM[3] team in 2005 in the area. According to the adopted methodology the root, the higher level of the tree, corresponds to the catchment, branches identify homogeneous group, leaves represent production units. In this case the higher level is represented by the river sub-catchment, a quite homogeneous area for soil quality, climate condition, environmental constraints, administrative aspects[4], water availability and management, only one Reclamation and Irrigation Board (RIB) is active.

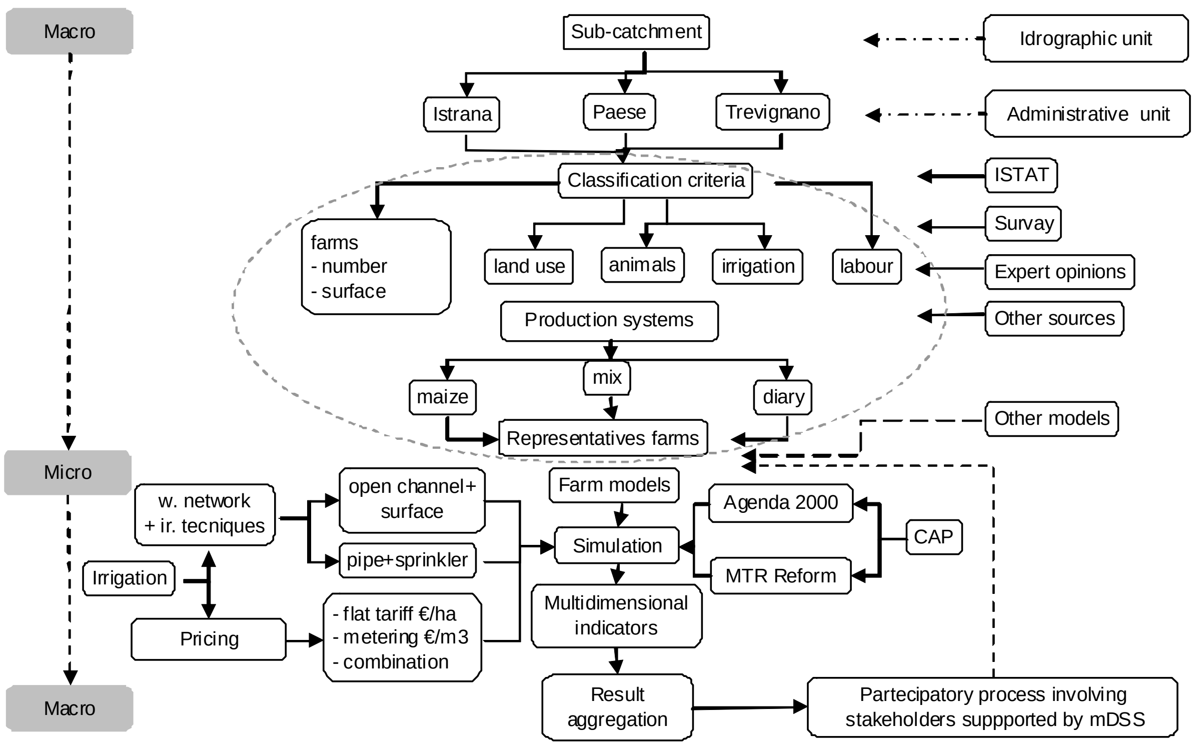

Figure 1 Flow chart of the evaluation procedure

Table 1 photographs the lower levels of the tree describing the agricultural sector. Among the 1523 existing farms the family type is dominant but important differences exist considering land use, farm size and the presence of animals. Three agricultural systems have been clustered: the first includes farms specialized in cereals (maize) and other annual crops; the second mixed farms with annual crops and vineyards; the third diary farms. Each system has been further articulated by considering farm size, being other characteristics not discriminative. In this way eight representative farm types have been identified. Table 1 reports cultivated surface, farm number, average farm size and group weight.

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[3] The 'Fondazione Eni Enrico Mattei' FEEM is the Italian partner in the EU ISIIMM project.

[4] The area comprehends three administrative units represented by the Municipalities of Istrana, Paese and Trevignano, all in the Veneto Region.

Table 1 The agricultural tree

System	Farm	Group surface (ha)	Farm number (n)	Farm size (ha)	Group weight (w)
CEREAL	Small	912	599	1.52	20.97%
	Medium	490	74	6.62	11.28%
	Large	458	23	19.91	10.55%
MIX	Small	834	549	1.52	19.22%
	Medium	550	83	6.63	12.67%
	Large	239	12	19.92	5.50%
DIARY	Small	561	168	3.44	12.92%
	Medium	299	15	19.93	6.89%
TOTAL		4343	1523		100.00%

ISTAT data reveals that in this area only 10 crops are relevant, covering about 95% of the cultivated land. Crops and systems are further characterized in Table 2: not all are irrigated, winter cereals are rain fed. Maize, with over 60% of the surface, represents the principal cultivation and it is articulated in silo-maize for animal feeding and other varieties with different cycle. Crops are characterized by specific water and labour requirement, physical production and cost[5]. Water-yield functions, which quantify the crop response to water in terms of production quantity, are based on available data (Giupponi and Fassio, 2007).

Table 2 Crops by farming system

Crop	Irrigated (yes/no)	Surface (Ha)	Farming system		
			Cereal	Mix	Diary
Set-aside		63	x	x	x
Barley		10	x	x	x
Durum wheat		79	x	x	
Soft wheat		399	x	x	x
Maize medium cycle	x	2664	x	x	x
Maize long cycle	x		x	x	x
Silo-maize	x	47			x
Soya been	x	177	x	x	x
Alfa Alfa	x	418			x
Pastures and meadows	x	385			x
Vineyards	x	101		x	
Total		*4343*			

Three scenarios have been identified in open discussions with the stakeholders and experts, defined: agricultural, preserving the existing destination with flat tariff only to support cost recover;

[5] Data on production quantity and price, subsidy, cost, labour and water requirement are available by the author.

urbanization where rural area is subtracted to agriculture; sustainable development where water pricing based on metering would be applied.

Results

The models have been calibrated and validated against the observed situation with reference to 2005 when Agenda 2000 represented the policy regime. Water, distributed in open channels with a predefine calendar, is abundant and do not constrain production choices. A flat tariff of 80 Euro/ha enforces the RIB cost recovery and farmers adopt surface irrigation[6]. This technique requires a lot of labour, operators must accurately prepare the field and manually allocate water when available working day and night, but has little financial cost since farmers provide labour and energy requirements are low. The estimated land use looks very similar to the observed one; variations in percentage are in the range 0.2-8.9%. Main differences are in wheat, but these disparities reduce considering that durum and soft varieties compensate each other.

Calibrated the models the scenario simulation was conducted. Results are reported in Table 3. It should be emphasized that the figures quantified via the simulation should be interpreted more in relative than in absolute terms, relative comparison are safe since all the information is generated with the same methodology, using a common dataset and the same models in all the scenarios. In the upper section aggregate result at macro scale are reported, below average unitary result.

Table 3 Results by scenario

	Indicator:	**SUR**	**WP**	**INC**	**LT**	**SOC**	**WQ**	**WAR**	**SIR**
	Unit	Ha	€	€	€	%	m3	€	Ha
Adopt	scenario	Aggregate result (000)							
no	agr	4.34		4657.76	763.11	0.56	27019.52	347.38	3.71
	urb	3.57		3836.70	598.00	0.56	22214.21	285.85	3.06
yes	agr	4.34		3376.29	675.66	0.55	17692.75	607.93	3.52
	urb	3.57		2825.86	525.91	0.55	14504.82	500.23	2.88
	wsu	4.34	0.03	2985.13	671.94	0.50	12860.69	993.13	3.52
	ssu	4.34	0.05	2778.12	666.95	0.50	7723.57	993.07	3.03
		Unitary average result							%
no	agr			1072.64	175.74	0.56	6222.37	80.00	0.85
	urb			1083.77	167.36	0.56	6217.03	80.00	0.86
yes	agr			777.53	155.60	0.55	4074.49	140.00	0.81
	urb			790.87	147.19	0.55	4059.43	140.00	0.81
	wsu		0.03	687.45	154.74	0.50	2961.71	228.71	0.81
	ssu		0.05	639.78	153.59	0.50	1778.67	228.70	0.70

In Table 3 all scenarios refer to the CAP reform, subsidy are now decoupled and a single farm payment adopted, cross-compliance is compulsory. The first row (agr) describes the new regime with

[6] Considering the type of soil surface irrigation is assumed having 50% efficiency.

no other change and represents the “base case”[7]. The cropping pattern does not include soya been, such crop highly subsidized under Agenda 2000 is not profitable with the new CAP. The second row (urb) represents the urbanization scenario where a reduction of 18% of cultivated land (SUR) is assumed. Farm income (INC) reaches here the highest value at farm level since marginal farm exit, but at macro level the situation reverse. Total water demand (WQ) and RIB revenue (WAR) show the same reduction, while labour drops (-22%). As far as concern land use the cereals would reduce keeping stable the others. The cost recovery by the RIB, should be according WFD as full as possible. In these scenarios, since water is distributed by open channel, raising flat water tariff represents a viable option; this could recover cost but no signals would be transferred to farmers to induce efficient behaviours and reduce consumption. The consideration of the polluter pays principle suggest to differentiate tariffs among crops and agri-techniques, to incentive or disincentive irrigation according to environmental performances of the agricultural process. This approach would incentive farmer to adopt good farming techniques, but the implementation of such policy has been recognized as highly complex and expensive due to the monitoring needs and the difficulties to differentiate tariff on objectives and sound basis.

The transformation of the irrigation network represents a real option to save water, it would reduce water consumption in agriculture by lowering losses at network level and by favouring a more efficient use at farm level since a shift from surface to sprinkle irrigation would be induced[8]. At farm level, cost would increase due to investment in irrigation technology and for higher energy consumption[9]. The substitution of labour with capital would increase labour productivity[10], but this would have no impact on cost since in most farms labour is an endogenous factor coming from the family. Furthermore the absence of alternatives, in agriculture and in other sectors, could make more severe under-employment; in fact the adoption of new crops, like vegetable or fruits which could benefit of the reorganization and increase employment and income, is not perceived as viable by the stakeholders. A lower farm net income is therefore one of the effects of the transformation, and this explains farmers’ opposition to the change. Incentive supporting the adoption of modern irrigation techniques minimizing the energy consumption in the Rural Development plans 2007-2013 and the disposal of water at farm gate at higher pressure could represent important solutions to keep irrigation profitable.

In the ‘agr’ scenario, water saving picks to 35%, flat tariff would rise to 140 €/ha increasing RIB revenue of 75%. Income due to higher cost would decrease of about 28%. Pressure pipes introducing measurability of water consumption at farm gate, enables the change of the tariff scheme and the adoption of volumetric pricing, this approach is highly recommended since it should induce a more efficient use of the resource (Joahansson et al., 2002; WATECO, 2002)[11]. Two price levels are

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[7] CAP reform reduced farm income, the single farm payment is lower than Agenda 2000 transfers; larger farms are most affected since modulation is explicitly considered.

[8] Efficiency would now be in the range 70% - 85%. Different types of sprinklers have been considered.

[9] Sprinkler irrigation is energy demanding and fuel represents the main source, this determines an increase of the variable cost at the current price of 0.5 Euro/kg. Higher fuel price could make irrigation even less profitable.

[10] The quality of the labour would be also higher thanks to the mechanization of irrigation.

[11] The metering pricing scheme encounters many difficulties in the agricultural sector in Italy since the resource is not considered a commercial good and existing legislation creates a special regime for water in agriculture:

considered, 3 and 5 Eurocents/m3, respectively in the scenarios called weak sustainability 'wsu' and strong sustainability 'ssu'. As expected the price reduces water demand of 52% and 71% respect to the reference level, multiplies water agency revenue by a factor of 2.86, has a strong negative impact on farm income -36% and -40%, reduces irrigated surface of 5% and 18%, and labour of 12% and 13%. In the urbanization scenario total water demand decreases of 46% mainly for the reduction of 22% in the total irrigated surface.

If water saving were the goal of the pricing policy, the price should be set higher than 3 Eurocents/m^3, but this is not the case since a strong reduction in demand comes from the network transformation and the irrigation technology improvement at farm level. Rising water price negatively impacts on farm income and this effect becomes progressively more and more severe, not just for the higher cost of the resource, but also for the substitution effect which would take place among crops. Considering land use, maize shows the stronger response to metering water pricing policy: total surface reduces from about 60% to 40% and high production long cycle varieties would be substituted by others with shorter cycle, being these latter characterized by an higher productivity of the resource. The final impact on income would be anyhow negative, due to the lower production and the higher cost. Rain feed crops would expand, soft wheat rising from 12% to 33%, while the surface covered by other crops would keep more stable.

A great disparity within the agricultural sector emerges. The diary system shows a most rigid water demand; in this case, while pricing could be a good tool for budgetary considerations, it is unlikely that it would be effective in reducing water use or containing pollution. The annual crop systems shows instead a strong response to water price, but differences exist between the mixed system where income would be slightly affected due to the little incidence of irrigated crops, and the maize system which would experience a strong negative impact on income.

Policy recommendation

The study shows that the existing irrigated agriculture is quite inefficient but water pricing policy can do very little since technical constraints exist. The network transformation is the preconditions to the reorganisation of the water management system. Water saving would be a direct effect of the investment even without any pricing incentive scheme.

The significant investment, which should be undertaken to upgrade the existence water infrastructure, could be partially supported by the European Agricultural Fund for Rural Development (EAFRD) if the policy will be properly designed, but users should anyhow pay as requested by WFD at article 9. This could put at stake the economic sustainability of the agricultural sector since, even with the existing level of water tariff, in many situations net income cannot remunerate at market price farm assets (land and labour) and family labour. Therefore, a problem of affordability exists, which could impede the RIB to recover cost and this could take to the conclusion that the investment should not be done since public intervention cannot support the entire cost..

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farmers pay to the Irrigation Board a special 'contribution' which is requested for the services provided, which often have no link with real consumption.

A solution to this problem can be found in the allocation and the management of the saved water. Rights on the resource become central. According to the Italian low on water Irrigation Boards have rights, based on previous agreements with the public Authority, to use certain quantity of water and have to pay for this. These rights are under renegotiation; the expectation is that the quantity will be reduced to comply with the respect of the minimum flow required to maintain the river ecological integrity and with other WFD requirements, and the cost will rise. But in this case the reorganisation of the water management system, thanks to the reduction of the network losses and the lower irrigation needs due to the higher efficiency and the additional effect of a metering pricing policy, will anyhow create a surplus of water for the RIB[12]. Excluding to enlarge the irrigated area or to transfer water to another Region, the surplus of non-potable water of high quality could be diverted to new local uses. An option would be to sell water for environmental objectives, to reach water quality levels in rivers higher than the minimum standard or promoting other environmental services linked depending on water but this does not represent a viable solution. The existence of a urban sector insisting in the rural area represents, instead, a real option; such sector uses a lot of water to irrigate gardens, wash cars, fire prevention, or in similar activities and for this purposes consumes high quality potable water, derived from the public network or by abstraction, often illegal, from the water tableau. The cost requested to make the network capable to serve both sectors is not much higher than in the previous option[13].

The creation of a multi-sector water network represents a real challenge for the Irrigation Board. This solution could favour an affordable and balanced cost recovery, which could benefit from the higher willingness to pay generally associated with non agricultural uses; while the adoption of a combined tariff scheme, even keeping low the water price[14], could increase efficiency in the use of the resource, enhance the cost recovery by the RIB and would result acceptable by the actors. A dual network would represent a ‘win, win’ situation: the citizens would benefit of abundant water at a lower cost, the RIB could find additional resources, the financial pressure on the agricultural sector could be reduced, and the environment would be better preserved. The implementation of the regional Rural Development programme could make a vital contribution to the sustainability of this rural area ensuring that in a competitive economy a sustainable balance between urban and rural areas is maintained.

Conclusion

Integrated models and tools to support agricultural and water policy are widely applied around the world. Successful experiences clarify that such tools require multidisciplinary teams of well trained people and adequate data to be properly run. The choice of which tool to use is highly dependent on local circumstances, among which previous experiences in modelling, trained people and data availability are critical. The case study presented in this paper, dealing with the reorganisation of a

[12] Since the water saving due to the new system is about 35%, a reduction of 10% - 15% in the assigned quota would leave a surplus of 25% 20% of the initial allotment.
[13] A specific study deals with this issue.
[14] High water price could push actors, farmers and rural citizens, to increase illegal abstraction from the water tableau, which in the area is quite superficial, this would have negative impacts on the environment, as well as on the RIB cost recovery.

water management system in the North East of Italy, represents a successful story which could find further extension, in fact, while the case study deals with a specific situation where agriculture represents the main water user and the overall efficiency of the system is low, the methodology adopted can be easily applied in other contexts. DSIrr, the tested tool, can support different economic analyses to assess: trends in water demand according to different scenarios considering markets, agricultural policy, climate and other exogenous driving forces; the potential role of water pricing and of other water policies (e.g. environmental taxes, subsidies, quota, water markets); the impact of innovation in irrigation technology (e.g. shift from gravity to spray) and in agriculture (e.g. introduction of new varieties less water demanding or more resistant to plant diseases or water stress). What is really important is that the tool can assess the sustainability of proposed actions by combining qualitative local knowledge and preferences with up-to-date mathematical and simulation techniques, for these features it can be used as a flexible support to conduct a participatory evaluation process involving stakeholders as requested by WFD. DSIrr represents a bridge between science and policy by making operational methodologies and approaches based on the integration of agronomic, hydraulic, engineering and economic disciplines.

The case study confirms the importance of developing and sharing with stakeholders scenarios, as well as of eliciting knowledge and opinions about the proposed actions. To pursue this goal the evaluation process has been organized in two phases. Phase one comprehends quali-quantitative analysis and includes: data collection, identification of the relevant production systems, identification of the representative farms by production system, hierarchy decomposition and weights estimation, scenario definition. Phase two, representing the quantitative part of the modelling exercise, includes: models definition, and calibration, simulation by scenario, results interpretation and policy recommendations. The tool proved capable to reduces efforts, time and cost of the simulation phase generating results in an easily usable format for presentation and discussion with stakeholders. Two aspects deserve further attention: data collection and the use of the tool. A complete exploitation of the program potentiality requires the availability of good local agronomic and environmental data. In fact, while the methodology and the structural part of the models have a general validity and can easily be transferred, a correct description of agricultural practices and furthermore of environmental processes needs site specific information which should be collected case by case. The integration of different sources requires a multidisciplinary work involving local expertise. A second aspect is the ‘positive’ and not ‘normative’ use of the program in the process, DSirr has been presented, used and perceived as a simulation tool capable to explore possible evolution paths and to quantify how different components of the system could react to external driving forces under predefined scenarios, and not as an optimisation model dictating the optimal solution.

It is quite possible that WFD will increase agricultural production cost and farmers, who used to pay little for water, will lose from the implementation of the new policy. An extensive consultation and involvement of farmers in developing programs to create new opportunities can be critical in reducing political opposition to the reform; in the same way the design of compensatory scheme could help them through the transition and reduce the conflict. DSIrr and similar tools can be useful instruments to support discussion between experts and stakeholders, this aspect is possibly more important than exact predictions. Stakeholders’ involvement will be a key issue in the next future, tools by increasing a common knowledge base and by enhancing the integration of economics into water management and policy could support this process. A proper application will improve efficiency, effectiveness, and transparency of the planning process, favouring balanced solutions capable to achieve good water status with acceptable social impacts. Good practice in model development and application are requested and deserves sustained attention, in fact the credibility and the impact of the information and insight that modelling aims to generate are much dependent upon the quality of the modelling exercise. To bridge the gap to real-world decision processes the following recommendations are considered important: a multilevel approach in modelling integrating conceptual, qualitative and quantitative models should be adopted; participatory modelling involving end users and stakeholders in the modelling exercises should be implemented in order to enable all actors to understand and review the various assumptions and their implications for the modelling results; training and capacity-building activities are necessary at the local level; models and tools must be adapted to pre-established local approaches, and not vice versa; models and tools should be seen as ICT components of a structured, flexible approach.

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