Integrated Irrigation Water policies: Economic and Environmental Impact in the "Renana" Reclamation and Irrigation Board, Italy

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Jel classification: Q25, C61

Abstract

This study was laid out in the "Renana" reclamation and irrigation board, in the Italian region of Emilia Romagna (northern Italy). Its objective was to evaluate the current and future possible policies adopted or to be adopted in order to spur a rational planning and decision making in water management and to give valid scientific answers to the local decision makers. A mathematical stochastic model was designed and implemented using data collected from farms in the area and other local sources. These policies are mainly based on modifying water quantity, the irrigable area, and the flat water tariffs. Finally all these changes are also analyzed in the presence of a volumetric water tariff designed by the European Water Framework Directive (WFD). Results have shown how fundamental it is to improve distribution efficiency of the channel system in order to increase irrigated land, for the positive socio-economic and environmental impacts on the territory. However, the introduction of a volumetric tariff could be an effective tool to control water demand expected to augment due to such policy measures, depending on yearly water availability; it could be very profitable to the RIB which will increase returns.

Key Words: Emilia Romagna, Renana Reclamation and Irrigation Board, Decision making, Water Management, Distribution Efficiency, Stochastic modeling, Water Pricing, Water Framework Directive.

Résumé

Cette étude a été réalisée auprès de l'Office de mise en valeur et de l'irrigation "Renana", dans la région italienne Emilie Romagne (dans le nord de l'Italie). L'objectif était d'évaluer les politiques actuelles et les politiques futures qui pourraient être adoptées afin d'encourager une planification et une prise de décisions raisonnées en matière d'aménagement de l'eau et de proposer des solutions scientifiques appropriées aux décideurs locaux. A cette fin, un modèle mathématique stochastique a été mis au point et appliqué en s'appuyant sur des données collectées au niveau des exploitations de la région ou à partir d'autres sources locales. Ces politiques reposent essentiellement sur la modification de la quantité d'eau, de la surface irrigable et des taux forfaitaires. Ces modifications sont successivement analysées en prenant en compte la tarification volumétrique de l'eau élaborée dans le cadre de la Directive Cadre sur l'Eau (DCE) de l'Union Européenne. Les résultats ont confirmé l'importance d'améliorer l'efficience de distribution du système de canalisation pour accroitre la surface irriguée, vu les effets socio-économiques et environnementaux positifs générés sur le territoire. Toutefois, l'introduction d'un tarif volumétrique pourrait représenter un outil efficace pour contrôler la demande d'eau qui est censée pouvoir augmenter, suite à l'adoption de ces mesures, selon la disponibilité annuelle d'eau. Ceci pourrait représenter un avantage très significatif en terme de rentabilité pour l'Office de mise en valeur et de l'irrigation « Renana » qui réussirait ainsi à accroître ses recettes.

Most-clés: *Emilie Romagne, Renana Office de mise en valeur et de l' irrigation, Prise de décisions, Aménagement de l'eau, Efficience de distribution, modélisation stochastique, Tarification de l'eau, Directive Cadre sur l'Eau.*

1. Introduction

Increasing problems of water scarcity and drought across Europe clearly indicate the need for a more sustainable and integrated approach to water resource management, which refers to activities that aim to coordinate humans' goals with the conditions (ecological, hydrological) of water systems (Kallis *et al*., 2004). Agriculture is by far the biggest water user, accounting in Europe for around 24% of the total water use, and can reach up to 80% in the Southern part (EEA, 2009) used mainly for irrigation. In this sense sustainable and integrated management of irrigated agriculture drastically influences the successful management of water resources.

In Italy, where about 50% of total water is used in agriculture (Zucaro and Pontrandolfi, 2005), management of irrigation is coordinated by entities called "Reclamation and Irrigation Board" (RIB). Born on a private and voluntary basis due to the free initiative of groups of farmers, the RIBs operate in order to guarantee drainage of waters, the protection of soils, the protection of water and natural resources, and to manage the irrigation and the valorization of the territory. They are responsible for the implementation and management of irrigation systems by ensuring both maintenance and operation and thus developing the irrigation of farms located in their scheme.

In the last few decades several factors – climate change, population growth and policy drivers- increased the pressure on water resources and difficulties and complications are rising in the management and planning task especially because water resource planning and management require a full range of options (Kallis *et al*., 2004) and a wide view of surrounding issues.

A lot of studies in the water sector have been done at farm level to give efficient tools for decision making. Discrete stochastic modeling, linear programming and multi-criteria decision making models (Blanco Fonseca, 2007; Saraiva and Pinheiro, 2007; Gómez-Limón and Riesgo, 2005; Noeme and Fragoso, 2004; Varela Ortega *et al*. 1998) are the most used tools. However, a few of them were laid at a large scale (Raggi and Viaggi, 2009; Viaggi *et al*., 2009; Dono and Severini, 2008; Scardigno and Bazzani, 2008).

Therefore, the objective of this contribution, specifically addressed to local decision makers, is to analyze water management issues at the local level, taking into consideration the quantitative aspects arising in a water scarcity context and with the implementation of the CAP and the WFD. Speci-

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fically, we are tempting to assess the impacts on water resources demand, farmers' income and RIB's receipts, of water management policies that integrate both supply and demand measures.

2. Material and Methods

Our case study is located in the "Renana" Reclamation and Irrigation Board (RIB) in Emilia Romagna, an Italian region situated in the low plain of the Po River Basin District.

The Po river is the largest Italian river basin district and one of the main and very fertile agricultural areas where economic development and urbanization growth are determining increasing pressures on water resources (AdBPo, 2009). Regional water allocated to irrigation represents 58.09% of the total surface water extraction in the region (PTA, 2006).

Renana RIB occupies mainly territories in the province of Bologna. The total area considered is 119,129 ha of which about 68,000 ha on hills and mountains (Fig. 1). In the area there are around 3,000 farms, approximately half of which being irrigable through systems managed by the RIB and occupying an irrigable surface of about 68,500 ha some 15,000 ha of which are irrigated. On the basis of the expected reliability of water available for irrigation, the irrigable area is divided into three areas differing in the type of water delivery that can be either continuous or discontinuous, namely: pressurized and continuous delivery (7,170 ha), gravity and continuous delivery (54,560 ha) and gravity and discontinuous delivery (6,900 ha).

The territory of the Consortium is grown with cereals – wheat and forage – (69%), permanent crops (21%) – mainly specialized orchards and vineyard –, and the remaining 10% with vegetable crops. The main source of water is the Emilia Romagna Channe[1] (in Italian: Canale Emilia Romagnolo (CER)) with a potential of 16.85 m^3 s^{-1}, making an approximate amount of 75.84 MCM available for irrigation. Nevertheless, a lot of losses in the distribution channels are reported due mainly to seepage and the effective water distributed to farmers is estimated around 33.03 MCM.

A tariff is paid per hectare of irrigable land. It depends on modalities of water delivery: it is 14.7 € ha^{-1} for irrigable surface by gravity and discontinuous delivery, 26 € ha^{-1} for irrigable surface by gravity and continuous delivery, and finally 52.7 € ha^{-1} for irrigable surface under pressure and continuous delivery.

In the recent years many factors are creating important pressures on water resources and the reclamation and irrigation

Figure 1 - *The administrative map of Emilia Romagna.*

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[1] Emilia Romagna Channel is an association of public right, a board of second level responsible for the planning, implementation and management of the irrigation system. It includes a research unit and technical assistance for the optimization of water resources in a sustainable development context. Through a derivation from the Po river, it serves an area over 3000 Km2, characterized by its significant agriculture, livestock, industry, urban and tourism activities.

boards have to deal with an increasing water demand and a reduced availability. The increase of regional water stress observed in the last few decades is mainly correlated to:

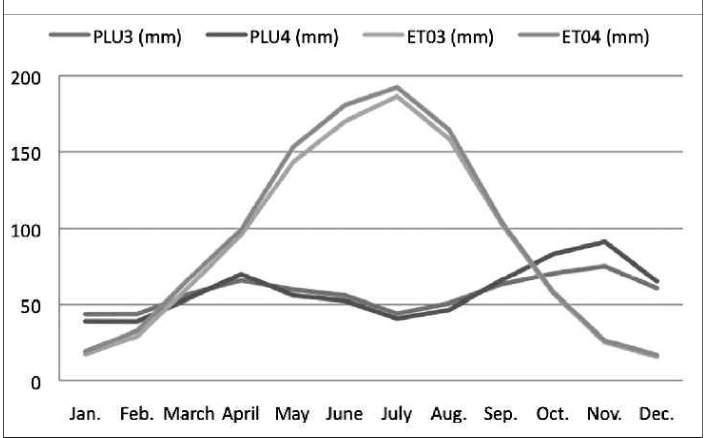
- Climatic changes and the effect of rainfall's decline and irregularity in precipitations, complicated by the total losses in the irrigation network, currently estimated around 26% (INEA, 2007; Brizzi, 2006). Climatic data (CER, 2009) for the period 1999-2009 shows that rainfall decreased in summer with respect to the period 1951-1998 and it increased in winter while evapotranspiration increased for the same compared periods (Fig. 2).
- Population growth increasing at a rate varying between 0.85 and 1.71% in the last decade (Emilia Romagna, 2010) and allocating around 25.65% of the total regional water use for urban purposes (PTA, 2006), and a developed economic sector considered the third in Italy, with a GDP per capita of 32,255.7 € (Emilia Romagna, 2010), requiring increasing amount of resources and creating competition between different water use sectors.
- Policy drivers such as the Common Agricultural Policy (CAP) moving agricultural sector towards sustainability and the Water Framework Directive (WFD) requiring the achievement of good quantitative and qualitative status of water resources and imposing new concepts in the water management like "Full Cost Recovery" as a guiding rule for the implementation of volumetric water pricing.

Analyzing the points of strength and weakness of the water resources on the territory, as well as the opportunities and the threats, alternative priority actions to be undertaken were identified with the participation of the local decision makers such as:

- The improvement of distribution efficiency of channels.
- The improvement of reliability of irrigation network.
- The reform of the pricing policy with the introduction of a volumetric water tariff.

The model used in this study is a non-linear stochastic optimization model which maximizes a farmer's utility function subject to a set of resource, agronomic and economic constraints written in GAMS language (General Algebraic Modeling System). Yield and commodity price uncertainty as well as risk associated with the availability of irrigation water were found to be the main stochastic parameters to be considered in the model development process. Risk associated with price fluctuations and yield variability are taken into account in the objective function of the model, and are considered as an economic risk (Saraiva and Pinheiro, 2007; Gómez Limón and Berbel, 2000) and it is calculated using the mean-stanfard deviation analysis method closely related to the mean variance analysis (Hasell *et al*., 1986); risk associated with unreliable water supply is taken into account in the constraints part of the model and considered as a technical risk.

Figure 2 - *Monthly distribution of rainfall and evapotranspiration in Bologna.*



Statistical analysis of official data (FADN Database) and a field survey carried out on 47 farms allowed to identify and specify structural and economic characteristics of the local farms. All the data collected were discussed with different stakeholders to check them. Three farm typologies were identified: arable crops, vegetables and fruit trees farms, respectively (Tab. 1).

The aggregation of the single farms into one model to represent the complete scheme was done through blocks constituting the different typologies in the case study (Dono *et al*., 2008), thus the main difference between a block and another is the type of on-farm agricultural production. Each farm typology constituted a block at the district level respecting the percentages of crops produced in each farm and the percentage of rented land in each typology. The results from scaling up the data from the farm level to the district level give us the land use by crop as described in Table 2.

The objective function of the model is the maximization of the net farm income and the minimization of its variability (Eq. 1).

$$U = Z - (\varphi \times \sigma) \qquad (eq.1)$$

Where Z = *expected net income,* φ = *avversion coefficient* and σ = *standard deviation.*

The net farm income is defined as the difference between the gross margins and fixed and variable costs, except for the cost for the irrigation water (Blanco Fonseca, 2007). The result obtained is the remuneration to factors of production of the family, i.e. landed property, labor and capital.

$$\sigma = \sqrt{\frac{1}{K_1^{50}} \Sigma_K (ZK_K - Z)^2} \qquad (eq.2)$$

$$Standard\ deviation = \sqrt{\frac{1}{Number\ of\ statments} \sum_{number\ of\ statments} (Random\ Income - Expected\ income)^2}$$

Random incomes, calculated for each combination of yield and crop price level considered, take into account the variability over a certain number of years of the yield and the crop prices (Eq.s 3 and 4):

$$GM_{c,d,t,i} = (Y_{c,t} \times Pr_c - VC_c - IC_{d,t,i}) \times DI_{d,i} \qquad (eq.3)$$

$$Expected\ Gross\ Margin = (Expected\ Yield \times Expected\ Price \times Crop\ Variable\ Costs - Irrigation\ Variable\ Costs)$$

$$GM\_K_{c,d,t,i,kp,ky} = (Y\_K_{c,t,ky} \times \Pr\_K_{c,kp} - VC_c - IC_{d,t,i}) \times DI_{d,i} \qquad (eq.4)$$

Randon Gross Margin
= (Randon Yeald × Random Price × Crop Variable Costs - Irrigation Variable Costs)

Before using the model for policy analysis, its predictive capacity must be tested. There are no formal tests of vali-

Table 1. *Land use of representative farms.*

Main Crops	Surface (ha)	Surface (%)	Secondary Crops	Surface (ha)	Surface (%)
Arable Crops Farm					
Bread Wheat	8.59	10.57	Spring Onion	0.71	0.88
Durum Wheat	19.71	24.30	Autumn Onion	1.00	1.23
Maize	10.79	13.29	Grapevine	0.13	0.16
Sorghum	8.86	10.92			
Alfalfa	23.36	28.79			
Sugar beet	6.86	8.45			
Set aside	1.14	1.41			
Total	**79.29**	**97.73**	**Total**	**1.84**	**2.27**
Fruit trees Farm					
Main Crops	**Surface (ha)**	**(%)**	**Secondary Crops**	**Surface (ha)**	**(%)**
Peach	3.95	25.58	Bread Wheat	0.87	5.97
Pear	4.35	29.67	Durum Wheat	0.34	2.30
Plum	0.52	3.53	Maize	0.29	1.96
Grapevine	0.89	6.10	Sorghum	1.21	8.22
Apple	0.19	1.28	Alfalfa	0.76	5.19
Apricot	0.13	0.85	Potatoes	0.42	2.86
			Sugar beet	0.25	1.71
			Set aside	0.50	3.41
Total	**10.02**	**68.35**	**Total**	**4.64**	**31.63**
Vegetable crops Farm					
Main Crops	**Surface (ha)**	**(%)**	**Veget. Crops**	**Surface (ha)**	**(%)**
Durum Wheat	8.73	19.50	Potatoes	7.26	16.22
Bread Wheat	10.17	22.74	Spring Onion	3.67	8.19
Maize	2.50	5.59	Autumn Onion	2.42	5.40
Sorghum	0.78	1.74	**Total**	**13.34**	**29.82**
Sugar beet	7.71	17.22	**Secondary Crops**	**Surface**	
Soybean	0.70	1.56		**(ha)**	**(%)**
Set aside	0.25	0.56	Pear	0.57	1.27
Total	**30.84**	**60.92**	**Total**	**0.57**	**1.27**

Table 2 - *Land use in the RIB.*

	Ha	%
Arable Crops	82,454.61	69.21
Maize	9,275.84	7.79
Bread Wheat	14,964.91	12.56
Durum Wheat	19,561.28	16.42
Alfalfa	16,436.76	13.80
Sorghum	9,027.27	7.58
Sugar beet	10,816.51	9.08
Set aside	2,108.44	1.77
Soybean	515.47	0.43
Vegetable crops	11,913.62	10.00
Potatoes	6,362.81	5.13
Autumn onion	2,404.42	2.02
Spring onion	3,146.39	2.64
Fruit trees	24,760.77	20.78
Peach	9,077.12	7.62
Pear	10,946.75	9.19
Plum	1,736.76	1.46
Grapevine	2,243.71	1.88
Apple	453.86	0.38
Apricot	302.57	0.25
Total	**119,129.00**	**100.0**

dation for mathematical programming models (Hazell and Norton, 1986; Norton *et al.*, 1978), but measures of goodness of fit can be used to check how closely the model predicts the levels of areas planted, production, prices and levels of input use (Schmid and Sinabell, 2005).

The Constant Relative Risk Aversion coefficient was used also for calibration purposes (Howitt *et al.*, 2002 and Heckelei, 2002) since the risk preference of the decision maker is usually not available for the modeler. We solved the model for different values of the coefficient in a range between 0 and 1.65. The selected value, equal to 0.35, is the value that better calibrates the model (Teague *et al.*, 1995; Hazell, *et al.*, 1983).

To validate the model we used the percentage absolute deviation (PAD) parameter (Blanco et al., 2008; Hazell and Norton, 1986 and Norton *et al.*, 1978) between observed and predicted values (Eq. 5). Where:

$$PAD = \sum_{i=i}^{n} \left| X_i^o - X_i^p \right| \div \sum_{i=i}^{n} X_i^o$$

where X_i^o is the observed value of the variable and X_i^p the predicted value.

3. Model constraints

The objective function is subject to two main groups of constraints: the first one regards total and rented land, family labor, rotation and land use constraints; the second one concerns water availability.

In the first group, the land constraints fix the upper limit of total and rented land availability, where the total land should be 119,129 ha as a maximum value which is relative to the total surface of the RIB only 62,557 ha of which are owned and the rest could be rented. The family labor is constrained by the total labor availability equivalent to 80 hours per hectare a year. We have also the rotation constraint for an identified set of arable crops that cannot be produced for two consecutive years on the same land. In addition, there are constraints regarding vegetable crops and maize: vegetable crops should not exceed the mean vegetable crop land use in the surveyed farms because of soil inadaptability to such type of crops, and maize production is fixed since it is associated to the livestock activity present in some farms.

The second group of constraints concerns irrigation water. Irrigation water availability depends on the modality of water delivery in the different areas of the RIB. Given the discontinuity in some distribution modalities, water consumption in each area under different modalities must be lower than the product of the land surface by water availability per hectare multiplied by water availability probability (Tab. 3).

4. Simulation scenarios

Four different scenarios were considered:

Water Management 1 (WM1): this scenario considered an increase in the irrigated area served with a pressurized and continuous delivery system coupled with an amplification of distribution efficiency of channels and a reduction of the flat water tariff.

Water Management 2 (WM2): this second scenario considered an augmentation of the irrigated area served with a pressurized and continuous delivery system coupled with an increase in distribution efficiency of channels and an increase in the flat water tariff.

Water Management 3 (WM3): this scenario considers the changes applied in scenario WM1 associated to different levels of volumetric water price.

Water Management 4 (WM4): this final scenario simulated the changes of scenario WM2 coupled with different levels of volumetric water price.

In all simulations the gap between the total water availability of the RIB – which is around 75.84 MCM – and the water currently distributed to farmers – which represents 44% of the for-

Table 3 - *On-farm annual water availability (m^3 ha^{-1}).*

Probability (%)	Modality of Distribution		
	Pressurized	Gravity continuous	Gravity discontinuous
1/3	800 (m^3 ha^{-1})	800 (m^3 ha^{-1})	800 (m^3 ha^{-1})
1/3	800 (m^3 ha^{-1})	400 (m^3 ha^{-1})	0 (m^3 ha^{-1})
1/3	800 (m^3 ha^{-1})	200 (m^3 ha^{-1})	0 (m^3 ha^{-1})

mer (something like 33.04 MCM) – is reduced through: 1) improving the efficiency of the distribution channel system to get a total availability of 68.63 MCM representing 90.49% of the total water availability, and; 2) transforming the modalities of water distribution with the extension of the pressurized and continuous irrigation system over all the served area. As for the flat water tariff, in WM1 it will be 15% higher than the actual one and in WM2 15% lower. Further different levels of water tariff have been introduced from 0 to 2.2 Euro for cubic meter of water.

Figure 3 - *Change occurred in irrigated land.*

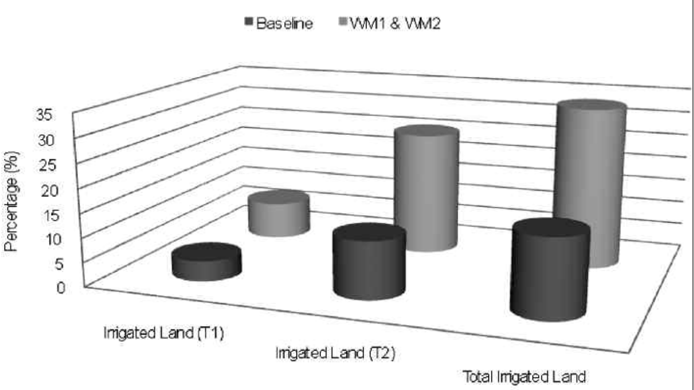
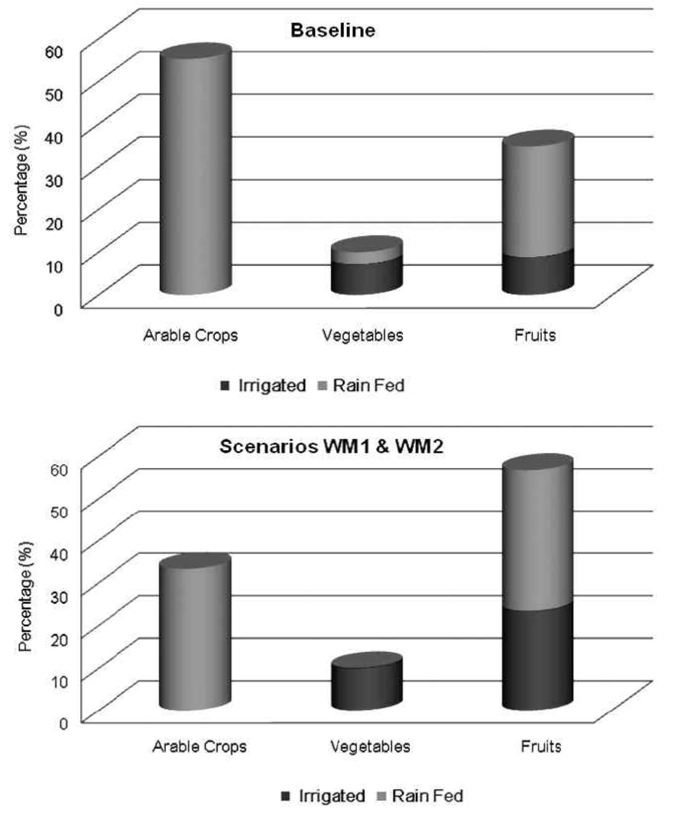


Figure 4 - *Changes in irrigated/rain fed cultivation between different groups of crops.*



A baseline scenario was also simulated reproducing the current situation with a full decoupling of CAP payments. In this condition, total cultivated land represents approximately 119,126 ha – 16.5% of which is irrigated –, a farmer's income of about 1,484 € ha^{-1} and water use by hectare of irrigated land equal to 1,684 m^3.

Results presented by scenario will include: agricultural land use, farmers' income, RIB's receipt, water demand and soil cover indicator, calculated as the number of days in a year that the soil (agricultural land) is covered with vegetation (OECD, 2001). The higher this indicator (above 50%), the lower the probability of erosion. Both water demand and soil cover are considered as environmental impact indicators.

5. Results and discussion

A first observation that deserves mentioning and that could interest the stakeholders, is the absence of any impact of tariff changes on the land occupation and irrigated area in the territory of the RIB. These changes however will impact slightly the income of farmers and RIB's returns as we will explain in the following paragraphs.

In both scenarios WM1 and WM2 arable crops will lose about 39.72% in the land occupation with respect to the baseline that will be allocated to fruit production. Consequently, this will be followed by an augmentation of the irrigated land that will almost be twofold higher with respect to the baseline and it will represent around 33.39% of the total area of the RIB (Fig. 3). Irrigation occurs basically in the high value crops: vegetables and fruits. Approximately 77% of this land will be fully irrigated while only about 23% partially irrigated. The following chart will explain how the irrigated areas

Figure 5 - *Changes in RIB's returns and Farmers' Income.*

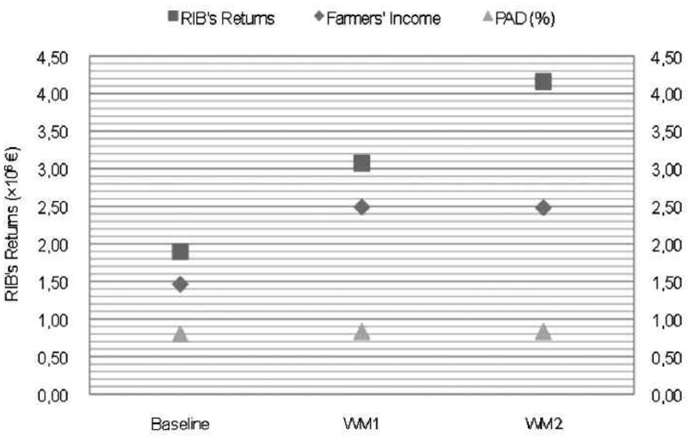


Figure 6 - *Changes in arable crops and fruits occurred with the volumetric water tariff.*

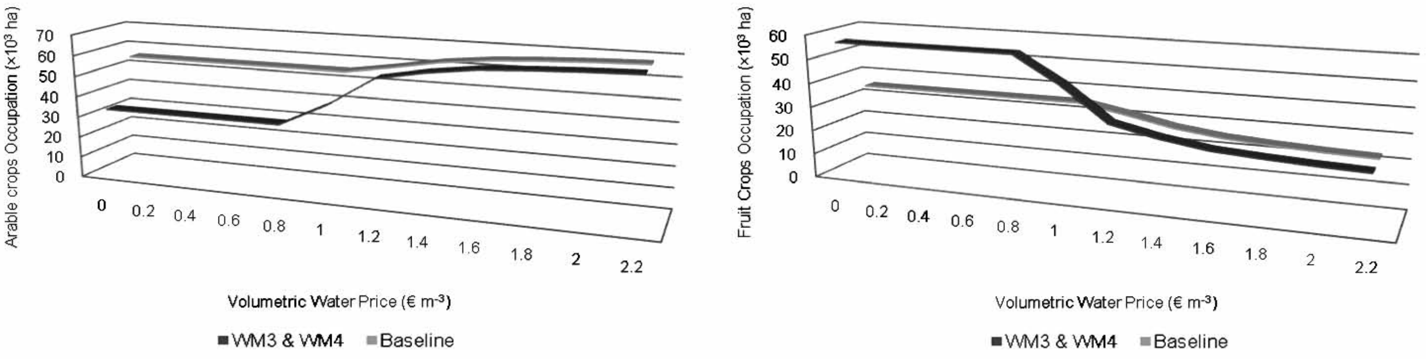
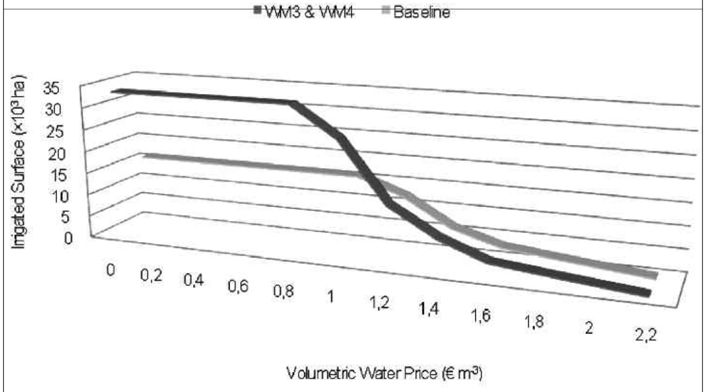


Figure 7 - *Decline in irrigated land due to the implementation of volumetric water tariff.*



by different techniques are distributed between different groups of crops (Fig. 4).

As for the economic impact, in WM1 scenario, farmers' net income increases by approximately 70.26% with respect to the baseline, while in the second case (WM2) it will raise to around 69.64%.

No significant negative environmental impacts resulted, yet no big improvements were achieved in these policies' simulations as to the calculation of the soil cover indicator got as the number of days in a year that the soil (agricultural land) is covered with vegetation (OECD, 2001). In both scenarios WM1 and WM2 this indicator is 83.37%, with a slight improvement of 3.30% with respect to the baseline, while the water use by hectare increases by only 2.75%. Therefore, a tradeoff exists in such policy scenarios between the economic impacts, farmers' income and RIB's returns, and the environmental impacts, especially the pressure on water resources.

Finally, the impacts of WM1 and WM2 on returns of the RIB, constituted by the water tariff paid by farmers, are about 62.01% higher in the first case and 119.14% higher in the second case compared to the current situation (Fig. 5).

In scenarios WM3 and WM4, imposing a volumetric water tariff will have opposite effects on the territory, whereas arable crops increase (Fig. 6), the total irrigated area declines beginning with fruits (Fig. 7) and accordingly economic profits for both farmers and RIB will be reduced (Fig. 8). However, these changes occur in both baseline and water management scenarios in different trends because elasticity to water demand is different in each case. Indeed, it's easily shown in these graphs how rigid the response is in the baseline scenario and how it becomes more elastic in the water management scenarios e.g. fruit crops occupation that requires water begins to respond to a volumetric water above 0.6 € m^{-3} in the water management scenarios and the response is sharp while in the baseline the response is very smooth and happens at a volumetric tariff of around 1.2 € m^{-3}, albeit the quantity of this change that is much higher in the water management scenarios with respect to the baseline. These figures are supported with some numbers that explain the changes in the baseline and the water management scenario due to an increasing volumetric water

Figure 8 - *Changes in RIB's returns and farmers' income with the volumetric water tariff.*

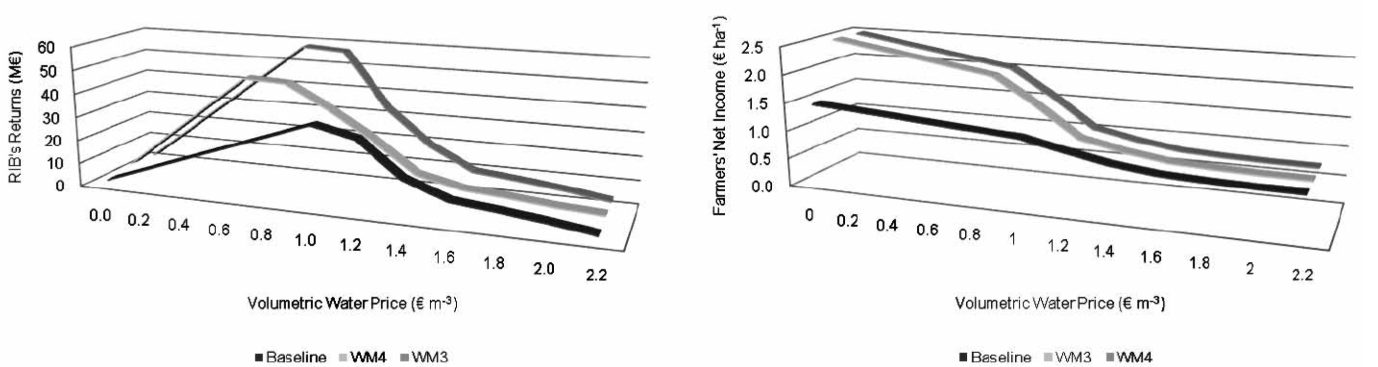
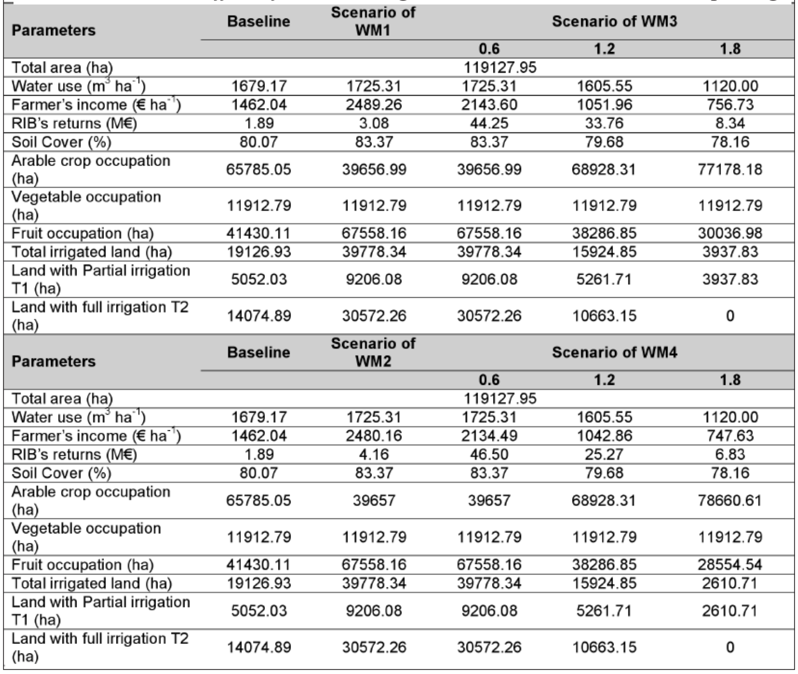


Table 4 - *Combined effect of water management scenarios and volumetric pricing.*



Parameters	Baseline	Scenario of WM1	Scenario of WM3		
			0.6	1.2	1.8
Total area (ha)	119127.95				
Water use (m^3 ha^{-1})	1679.17	1725.31	1725.31	1605.55	1120.00
Farmer's income (€ ha^{-1})	1462.04	2489.26	2143.60	1051.96	756.73
RIB's returns (M€)	1.89	3.08	44.25	33.76	8.34
Soil Cover (%)	80.07	83.37	83.37	79.68	78.16
Arable crop occupation (ha)	65785.05	39656.99	39656.99	68928.31	77178.18
Vegetable occupation (ha)	11912.79	11912.79	11912.79	11912.79	11912.79
Fruit occupation (ha)	41430.11	67558.16	67558.16	38286.85	30036.98
Total irrigated land (ha)	19126.93	39778.34	39778.34	15924.85	3937.83
Land with Partial irrigation T1 (ha)	5052.03	9206.08	9206.08	5261.71	3937.83
Land with full irrigation T2 (ha)	14074.89	30572.26	30572.26	10663.15	0
Parameters	**Baseline**	**Scenario of WM2**	**Scenario of WM4**		
			0.6	**1.2**	**1.8**
Total area (ha)	119127.95				
Water use (m^3 ha^{-1})	1679.17	1725.31	1725.31	1605.55	1120.00
Farmer's income (€ ha^{-1})	1462.04	2480.16	2134.49	1042.86	747.63
RIB's returns (M€)	1.89	4.16	46.50	25.27	6.83
Soil Cover (%)	80.07	83.37	83.37	79.68	78.16
Arable crop occupation (ha)	65785.05	39657	39657	68928.31	78660.61
Vegetable occupation (ha)	11912.79	11912.79	11912.79	11912.79	11912.79
Fruit occupation (ha)	41430.11	67558.16	67558.16	38286.85	28554.54
Total irrigated land (ha)	19126.93	39778.34	39778.34	15924.85	2610.71
Land with Partial irrigation T1 (ha)	5052.03	9206.08	9206.08	5261.71	2610.71
Land with full irrigation T2 (ha)	14074.89	30572.26	30572.26	10663.15	0

tariff at the level of RIB's structure (crop occupation, water availability and irrigated land expansion) and at the economic level (farmers' net income and RIB's returns) and at the environmental outcome (Tab. 4).

6. Conclusions

The scope of this paper was to analyze irrigation water management issues of the Renana RIB located in Emilia Romagna in Italy, taking into consideration the quantitative aspects arising in a water scarcity context and some water policy measures implemented.

Through different simulations we tried to understand how different policies applied by the RIB would impact: (1) the development of the local agriculture that with an increased irrigation water availability and reliability becomes more productive and oriented to high value crop production, (2) the economic performance of farms where the net income could increase up to 70.26% with respect to the baseline, and (3) the financial sustainability of the RIB accountability that reaches high levels. By this means, we can offer to policy analysts some useful information upon which their future decisions may be built. The simulated policies are mainly based on modifying water quantity distributed to the farms, the irrigable surface equipped with different delivery systems and a reformed water pricing policies based on provisions included in the regional Water Protection Plan (WPP) as required by the European Water Framework Directive (WFD).

According to the achieved results, to preserve the profitability and the efficiency of the management, the Renana RIB, where water distribution network is mainly based on open canals with a little pressurized area, should increase the distribution efficiency in the system and the potential availability of water by reducing losses. This should be followed by an improvement of reliability of irrigation network on the territory as it proved to be beneficial from many points of views, and if worries exist regarding the huge amount of investments to be allocated, increased returns of the RIB could be used to cover investment costs.

As shown the introduction of a volumetric tariff as required by the WFD could be an effective tool to control water demand that will likely augment due to such policy measures. From another side a volumetric tariff could – at a certain level – contribute to the augmentation of RIB's returns without a significant negative impact on farmers' income. However, imposing a volumetric water tariff will – over a certain threshold –transform agriculture in the district into rain fed dominated by arable crops. Therefore, the optimal tariff would be the one that would control the demand to equal the resources availability and optimize farmers' income through the high value crops production. Thus, fixing a water tariff is a very sensitive issue that the RIB should take into consideration because the increase of such tariff could lead to a marginal cost of production higher than the marginal income and consequently water demand will fall drastically generating negative socio-economic impacts on both farmers and the RIB.

In addition, it resulted that amplifying the total water availability has effects on the rigidity of water demand i.e. the response of fruit crop occupation of the irrigated land and of farmers' net income and RIB's returns to volumetric water pricing is more elastic with respect to the baseline.

Furthermore, achieved results demonstrate the existence of a tradeoff between economic returns of the RIB, welfare of farmers and environmental impacts that must be carefully considered. For instance, to augment the RIB's returns, farmers' net income could slightly be reduced and from another side, increasing irrigation could be beneficial to the area up to a certain limit above which negative environmental and ecological impacts could become significant.

Finally, further studies are recommended firstly to better understand farms on the territory and farmers' behavior and secondly to understand the dynamic effects of different policy scenarios in the region, and to evaluate impacts of their implementation. A follow up study could be useful in order to elicit the cost-benefit value of different measures especially for solutions requiring metering to value if it would be worsen implementing it or it may be costly and not socially profitable.

7. References

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