Water and Land Value in Italy

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Abstract. Irrigation water in Italy, as in all Mediterranean countries, is of great importance for soil productivity and, therefore, its presence has a high impact on its value.

Irrigation water is not just a factor of production but its availability has generated new territorial systems, significantly different from those that would have developed in its absence; subsequently, these systems have evolved from traditional agricultural to industrial and tertiary ones.

The article presents research aimed at estimating the effect of the presence of irrigation water on the value of agricultural soils. The assessment was carried out by hedonic approach using the quotations (Average Agricultural Values) of the soils carried out by the provincial commissions, established pursuant to Article 41 of the Presidential Decree of 08/06/2001 No. 327, to determine the compensation for expropriation for public utility. The study briefly illustrates the hedonic method and its use in the evaluation of water resources and presents some econometric models developed to identify the contribution of water availability to the value of the soil.

Keywords: Water · Land value · Hedonic land pricing

1 Introduction

Since ancient times, the availability of water for agricultural and civil uses has been of great importance in Italy, as in all Mediterranean countries. As a matter of fact, the first examples of artificial use of water for agricultural production in the peninsula date back to the Etruscan civilization. However, it is thanks to the Benedictine monks that, around the year one thousand, it began to improve and spread to central and northern Italy. Subsequently, the Renaissance lords and the pre-unification States promoted important irrigation works, especially in northern Italy. At the end of the nineteenth century, in Italy, there were about 1.5 million hectares equipped for irrigation, but the real explosion of irrigation took place in the first half of the last century, thanks to the virtuous combination of adequate national laws (RD 1775/33 and LN 215/33) and local collective initiatives

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(Reclamation and Irrigation Consortia). In less than a century, the area equipped for irrigation doubled, reaching almost 3.1 million hectares [1]. The massive expansion of irrigation in the last century took place essentially to respond to the growing demand for agricultural products from a very high population compared to the little fertile land available. Currently, there are nearly 400,000 farms involved in irrigation, equal to 25% of the total amount [2]. The regularly irrigated area exceeds 2.4 million hectares (19%), while that equipped for irrigation is over three million hectares [3]. Overall, it has been estimated that irrigation involves 11 billion cu. m. of water [2].

Irrigation has not been, and is not, just a mere factor of production but, by profoundly modifying the production techniques, the use of the soil and its productivity, it has actually generated new agricultural and territorial systems, significantly different from those that would have been developed in its absence. In addition, the availability of irrigation has led to the adoption of investments that have changed, along with profitability, also the landscape and the value of the soils.

Soils are a complex primary production resource whose market value depends on multiple factors. Therefore, by observing the variation in the value of soils as a function of their characteristics, which also include the presence of irrigation water, it is possible to derive the contribution to the market value.

The hypothesis underlying the adopted method (Hedonic Land Price) is that buyers and sellers of agricultural land are able to evaluate the effect of the various characteristics of the soil on future profits and that this effect is incorporated into the purchase and sale value. In this case, the values reflect market preferences for the particular productive characteristics of the soils.

The evaluation of the effect of the presence of irrigation water was carried out starting from the quotations of agricultural land carried out by the provincial commissions established pursuant to Article 41 of the Presidential Decree 327/2001 for the determination of the expropriation compensation for public utility: the Average Agricultural Values (AAV). The AAV of a soil is determined "taking into account the crops actually practiced on the land and the value of the building structures legitimately built, also in relation to the operation of the farm, without evaluating any possible or actual use other than agricultural", DPR 327/2001 art. 40–42. Basically, the AAVs, although not market prices, are conditioned exclusively by agricultural production characteristics and, therefore, can be assimilated to capitalization values of the income deriving from cultivation.

The use of AAVs, compared to other sources, has some advantages:

1. they are available for the whole national territory in a homogeneous way;
2. they refer only to agricultural use and, therefore, are not influenced by urban rents;
3. they refer to codified and transparent economic and productive conditions;
4. they are available for homogeneous territorial areas (Agricultural Regions).

The contribution is divided into four parts.

The first and second are dedicated to a concise description of the theoretical approach and the hedonic method. The third explores its use in assessing the impact of irrigation water on land values and illustrates the characteristics of the data.

The fourth is dedicated to the development of econometric models at an aggregate level (national), by geographical area (Northern, Central and Southern Italy), by crop used and to the discussion of the results obtained.

Finally, some concluding remarks are proposed.

2 Water and Land Value

The land value as a function of its profitability (income value) can be assimilated to an investment value by a farmer. This places the value on a different level from that of the current market value which can also be influenced by aspects other than those considered by the agricultural entrepreneur, such as those due to urban rents connected with the potential transformation to civil uses (residential, industrial and commercial). That said, the agricultural plot value derives from the rent collectable through land property and embedded investments.

Indeed, with reference to agricultural land, the value is calculated with the following equation:

$$V_a = \frac{B_f}{r_{cf}} = \frac{R_f + K_f \cdot r_f}{r_{cf}} \quad (1)$$

Where

V_a Value of agricultural land;
B_f Land benefit (income resulting from the land property);
r_{cf} Land incomes capitalization rate;
R_f Ricardian land rent;
K_f Value of land investments;
r_i Price-earnings rate of land investments.

Equation (1) shows that the value, at least in lands with low investments (extensive latifundia), is due to the rent, which is to say to the revenue deriving from the mere property. Indeed, in the past, it was connected to the privilege of landowners, which derived from the possession of the most productive lands, and prospered thanks to the work of the rural population.

The availability of irrigation water affects the income of the owner (B_f) of the soil both in terms of size and composition.

In particular, the presence of water influences "natural" productivity and, therefore, the "pure land rent" (R_f) but also conditions the presence of (fixed) land investments (K_f).

To assess the impact of water availability on the value of soils in Italy, it is necessary to investigate the ways in which the producer has available water for irrigation, which are different from those in use in other countries, such as the USA, where the water is a normal production factor that can be purchased in a special market.

In Italy, water can be considered a public state property and can be used through a specific authorization, its amount is often fixed and commensurate not with the quantity of water available (which may vary according to the seasonal weather and climate) but to the potentially irrigable surface. The cost of irrigation water, therefore, can be broken down into three components: the first, fixed, is equal to the contribution that the owner of the land must pay to the consortium that takes care of the derivation of water from the river and delivery to the company; this cost is fixed and commensurate with the total annual management cost of the consortium and the benefit brought to farmers. The second is the cost incurred by the farmer for the distribution of irrigation water and can be further divided into a variable cost commensurate to the volumes of water distributed and a fixed amount relating to any fixed systems incorporated into the company grounds.

Therefore, the impact of water availability on the value of an agricultural fund can be evaluated using the following equation:

$$V_w = \frac{B_f^c}{r_{cf}^c} - \frac{B_f^s}{r_{cf}^s} = \frac{R_f^c + \left(K_w + K_{f \neq w}\right) r_i}{r_{cf}^c} - \frac{R_f^s + K_{f \neq w} r_i}{r_{cf}^s} \tag{2}$$

Where:

- V_w Value of water;
- B_f Land benefit with (c) and without (s) irrigation water;
- r_{cf} Land incomes capitalization rate with (c) and without (s) irrigation water;
- R_f Ricardian land rent with (c) and without (s) irrigation water;
- K_w Value of irrigation investments;
- r_i Price-earnings rate of land investments.

Assuming:

$$r_{cf}^c = r_{cf}^s = r_i = r_{cf} \tag{3}$$

Equation (2) becomes:

$$V_w = \frac{R_f^c - R_f^s}{r_{cf}} + K_w \tag{4}$$

Therefore, the effect of the availability of irrigation water on the value of the soil is given by the capital value of the Ricardian rent difference produced and by the value of the irrigation investments incorporated into the soil.

3 The Hedonic Land Price Method

The hedonic method is based on the assumption that economic goods are aggregates of different characteristics whose status affects the market value [4]. If some of these characteristics are separable from the asset in question then they have their own market value. If, on the other hand, they are incorporated into the asset, they cannot be sold/purchased separately and have no individual prices. In the land market, for example, it is not possible to buy separately the texture of the land, the position or the agricultural hydraulic arrangement; in our case, it is assumed that the possibility of irrigation is not separable from the soil but is inherent in a place where it is available naturally or provided by an irrigation consortium. The hedonic method allows, starting from the market value of a private good, to estimate the implicit prices of the individual characteristics. The method has several variations and the best known, and most used, is the one that uses the price of the properties as a reference value. In particular, the hedonic land price estimates the value of the characteristics of landed assets (tangible and intangible), starting with the variations induced in their market price [5]. The hypothesis is that the different characteristics may affect the value of the land and, therefore, that the economic value of these characteristics can be traced back to the price differences of the soils, obviously without the effect of all other specificities. The hedonic approach has the advantage of being based on actual values, rather than on investigations of hypothetical choices or production simulations.

Rosen [6], who assumes a competitive market and, therefore, provides for the simultaneous estimation of supply and demand functions, rigorously formulated the theory on which hedonic methods are based. Originally, the approach was developed to estimate the consumer's rent deriving from attributes of consumer goods and was subsequently adapted by Palmquist [7] to the demand for factors of production.

From a theoretical point of view, the problem can be illustrated by considering a producer with an availability of resources equal to y and with a company described by a vector of technical characteristics (a), who uses its resources by choosing a soil, defined by a vector of characteristics $z = (z_j)$, and by a level of expenditure x in other factors of production.

The problem that the producer must solve is the maximization of the following production function:

$$MaxP = f\left(z_j, x, a\right) \;\; with \;\; x + v(z_j) \leq y \tag{5}$$

where $v\left(z_j\right)$ represents the value (V) of the soil as a function of its productive characteristics, that is the hedonic function to be estimated.

The solution of the previous model is obtained when the weighted marginal productivity of all the factors of production used in the production process are equalized, including the production characteristics of the fund (z_j).

$$\frac{dP/dz_j}{dv/dz_j} = \frac{dP/dx}{dV/dx} \tag{6}$$

The value of a land can, therefore, be expressed by the present value of the income (B_f) that it can provide over time (t) given a certain discount rate (r):

$$V = f\left(z_j\right) = \int_0^{\infty} B_f(z_j) \cdot e^{-rt} dt \tag{7}$$

Or, with reference to constant, discontinuous annual, deferred and unlimited income:

$$V = f\left(z_j\right) = \frac{B_f(z_j)}{r} \tag{8}$$

The value of a certain z characteristic will be commensurate with the contribution made to the income. In other words, under perfectly competitive market conditions, the value of the characteristic will be equal, in the case of a factor of production, to the value of its marginal profitability.

The estimate of the value function of the private good is normally obtained by applying the statistical method of multiple regression to a significant sample of goods sold. By using this method, the market value (V) is related to a series of explanatory variables that represent the different characteristics of the asset itself.

In this way, each characteristic of the asset is associated with a parameter (β_j) of the function which, having satisfied the conditions illustrated above, represents its implicit price and, consequently, the impact on value. By adopting a linear function, we have that:

$$V = \alpha + \sum\nolimits_{j=1}^{k} \beta_j z_j + \varepsilon \ \ with \ \ \beta_j = dV \big/ dz_j \tag{9}$$

In other words, β_i represents the implicit marginal price of one unit of the characteristic z_i. If, as in this case, the characteristic (presence of irrigation water) is represented by a dummy variable (0/1), β_j represents its total value per unit of surface.

The hedonic method presents, alongside undoubted potential, some limitations attributable to compliance with a series of rather restrictive hypotheses [8] which, if not verified, can compromise the quality of the estimates.

First, it is assumed that the market is in equilibrium, that is, that the supply of goods with a certain characteristic is equal to the corresponding demand. Second, which all combinations in the characteristics required by the market are available on the market. Freeman [8] envisions the market as a vast warehouse with various baskets (the complex goods), each filled with various combinations of characteristics. The buyer chooses among the available baskets the one that maximizes its utility (production), in other words, the one that contains a combination of characteristics such that their weighted marginal utilities (productivity) are equal. Third, the reference market must have good transparency on the prices and characteristics of the goods sold and there must be no transaction costs. Fourth, all observations come from a homogeneous market. The presence of a segmented market will result in clearly different supply and/or demand functions and, consequently, in different marginal prices. Finally, prices must not be influenced by expected changes in the characteristic under consideration[1]. The real land market has undoubted limits compared to the prerequisites described above. However, the use of the AAV as a reference value allows these limits to be mitigated since the determination of these values is formulated for territorially homogeneous market segments and with reference only to agricultural productivity. Finally, they are formulated starting from a deep knowledge of the land market which, in this case, can be defined as substantially transparent.

4 Irrigation Water and Land Value

As previously illustrated, the effect of the presence of water for irrigation on the value of the soils was estimated using an econometric approach by relating the AAV of the soils

[1] For example, if the values of the soils in an area reflect the expectations of introducing irrigation resulting from a consortium investment, the implicit prices obtained with the Hedonic method underestimate the current economic value of the presence of irrigation.

and the possibility of irrigating them. As a matter of fact, the hedonic analysis could also be applied to rents. If the market values reflect the rents, it doesn't matter is one uses rents or values. In Italy, the rental of agricultural land is highly regulated and current rents cannot be considered "market" rents and, therefore, it is appropriate to refer to the values of the land and not to the rents.

Obviously, if the market value exceeds the present value of future income deriving from the fund (land benefit), the value of the land does not reflect agricultural productivity, but incorporates future income from non-agricultural uses. In this case, the market values of the soils cannot be used to derive the value of the productive characteristics. The use of the AAV allows to reduce the distorting effect of extra-urban annuities.

In the literature there are not many contributions on the evaluation of irrigation with this approach, although in recent years there has been a growing interest, perhaps due to the greater availability of market data, the growing conflicts around the uses of the water resource and the possible effects of climate change.

To our knowledge, the first articles that explore the possibility of using the values of agricultural soils to estimate the value of irrigation water date back to the late 1950s with Renshaw [9] and Milliman [10]. In particular, Milliman observes how the assessment of water resources is particularly complex to estimate directly (budget approach) since water is often allocated with mechanisms other than that of the market. The indirect estimate, on the other hand, collides with the lack of adequate market information. Hartman and Anderson [11], relying more on the value of soils as the basis for estimating the value of irrigation and analyzing the effect of a federal irrigation project in Colorado on the sales values of 44 farms, identified a positive effect on the value of the soils of the availability of irrigation water. Twenty-five years later, Crouter [12], drawing inspiration from earlier works by Brown et al. [13] and Anderson [14], carried out similar evaluations with reference to 53 companies in Colorado, confirming the positive effect of the quantities of water available on the value of the soils and, at the same time, the difficulties of activating an efficient irrigation water market due to the high transaction costs.

Torell, Libbin and Miller [15] investigated the effects of a drastic reduction in the amount of water derived from the Ogallala Aquifer in the western United States, noting a consequent decrease in the market value of soils from 30 to 60%. King and Sinden [16], in a study aimed at identifying the main factors affecting the market value in New Wales and South Australia, found that the proximity of the soil to a river, with the consequent possibility of irrigation, is positive but not significant. On the contrary, Faux and Perry [17] focused on the value of irrigation water in Oregon in relation to the productivity of the soil: in the most productive lands the value of water is equal to about three € cent/cu. m. while, in the less fertile ones, the value drops to less than one € cent.

Arias [18], in the province of Leon in Spain, estimates that the value of irrigated arable land is about three times that of non-irrigated arable land while in the meadow it is about double. The value ratio in the Chalkidiki region, a typical rural area in Greece, is equal to two [19] and rises to 2.7 in the Great Plains region of the USA [20].

Petrie and Taylor [21] evaluated water use permits in Georgia starting from the effect of their restriction on the market values of farms. They found that the difference in values between irrigated and non-irrigated soils becomes significant after the introduction of a moratorium on the issuance of new water derivation permits and that the difference is approximately 30% (1,240 €/ha).

Thompson and Johnson [22] estimate the impact of irrigation on the market value of soils in Nebraska at about 290 €/ha, much lower than that estimated by the "Annual Residual Rent Method" according to which it would be worth about 600 €/ha. The difference, according to the authors, lies in the higher rate of capitalization with which the income from irrigated land is discounted compared to non-irrigated land, due to the uncertainty affecting the future availability of water for irrigation.

Yoo et al. [23] investigate the effect of irrigation in relation to the degree of urbanization of agricultural areas in some areas of Arizona and find that, in absolute terms, the effect is greater in peri-urban areas (€ 15,000/ha against € 14,000/ha) while it is lower in percentage terms (28% against 58.5%).

Buck et al. [24] return to the difficulty of estimating the value of irrigation water and, using panel data on repeated farmland sales in California (San Joaquin valley), find that the capital value of the right of use incorporated in that of the land is equal to 6, 2 €/cu. m., so, if the owner has the perpetual possibility to use 2,000 m^3/year of water, the value of the land increases by 12,400 €/ha.

Swanepoel et al. [25] studied the value of irrigation water from underground sources in Phillis County in Colorado. The study found that the average value of is equal to 2.2 € cents/cu. m. but that it varies a lot depending on the depth of the supply wells (extraction cost).

Joshi et al. [26] studied the effect of access to irrigation in Nepal, highlighting that it affects the average value of soils by 46%; in addition, the presence of multiple sources of supply and a structured distribution system increase its effect.

Sampson et al. [27] estimated that the presence of irrigation affects the value of soils in the High Plains of Kansas to the extent of 53% and that the effect from 1988 to 2015 increased by 1%/year.

From the analysis of the main contributions published, some obvious trends can be identified:

1. the value of irrigation water seems to increase over time;
2. the value increases in the areas where it is scarcer and where the investments made to distribute it are greater;
3. the value increases where the most profitable crops are grown (horticulture and orchard);
4. the value increases in areas with greater urban development.

Ultimately, water availability is a very important factor in the enhancement of agricultural soils as it affects both the extent and variability of production.

5 Results

The evaluation of the effect of the presence of irrigation water on the value of the soils was performed using linear regression models with fixed effects:

$$V_i = \alpha_i + \beta_{1i} z_{1i} + \sum_{j=2}^{k} \beta_{ji} z_{ji} + \varepsilon_i \tag{10}$$

where:

V_i represents the AAV per hectare measured in the i-th territorial area;
z_{1i} the presence of irrigation water;
z_{ji} represents the value that the j variables (altimetry, location, crop, etc.) assume within the territorial area i;
β_{1i} represents the effect of irrigation on the soil AAV;
β_{ji} represent the effect of the other z_{ji} variables on the AAV, α_i represents a constant that expresses the effect on the AAV of the variables that have not been included in the model and that characterize the territorial scope i and ε_i represents the idiosyncratic error. The estimation of the parameters of these models (α_i and β_{ji}) is usually carried out with the least squares method.

The peculiarity of fixed effects models consists in the inclusion of as many constants αi as there are territorial areas considered (minus one) in order to avoid the distortions of the estimates caused by the possible omission of relevant explanatory variables. The constant will, therefore, capture the effect of all the factors that influence the AAV in the particular territorial area but which, due to the unavailability of the data, it was not possible to include in the database and, therefore, in the regression model.

The analysis was performed on both average data at a national level and on homogeneous geographical partitions (North, Center, South). The study by homogeneous partition of the database allowed to obtain models characterized by a greater interpretative capacity of the data used.

As mentioned above, the values of the soils were assumed to be equal to the average agricultural values (pursuant to art.16, LN 865/71) since, although they are not market values, they are transparent, they refer only to agricultural production characteristics, they are available uniformly throughout the national territory and for predefined crop types, they are averaged by agricultural region and therefore are more stable and little affected by specific contingent situations (urban rents). The evaluation involved a representative sample of all Italian regions (one representative province per region) for a total of 166 Agricultural Regions and 1368 municipalities.

The data used for the evaluation is:

- AAV of the Agricultural Region to which it belongs, distinguished by type of crop (lawn, arable land, orchard, vegetable garden) and by the presence/absence of an irrigation system (Source: Revenue Agency, 2013);
- Structure of agricultural activities: average size of farms; % of agricultural area with valuable crops; use of third parties (Source: VI Agricultural Census, 2010);
- Type and source of irrigation (Source: VI Agricultural Census, 2010);
- Geographical and climatic characterization: altimetric zone; hydro-climatic balance values (Source: ISTAT; Agrometeorological database of CRA-CMA);
- General economic characterization: agricultural labor; industry employees; service personnel (Source: VI Agricultural Census 2010; Industry, Commerce and Handicraft Census, 2011);
- Demographic characterization: population; population density (Source: Population Census 2011).

Overall, the variables taken into consideration provide a sufficient framework to outline the structure of the agricultural sector, the climatic and socio-economic characteristics of the territorial areas considered.

The average AAV of the most important crops from an economic point of view (arable land, orchard, vegetable garden and lawn) is around 40 thousand €/ha, with a maximum of 52 thousand €/ha in the north and a minimum of 20 thousand €/ha in the center (Fig. 1). The presence of irrigation significantly discriminates the AAV by introducing an average difference between irrigated and non-irrigated equal to 13.5 thousand €/ha. In percentage terms, this difference is higher in the center-south (60–80%) than in the north (39%) due to the known climatic differences.

The benefit produced by irrigation differs not only by geographic distribution (latitude), but also by the most widely practiced crops. On average, in areas where arable land predominates, the increase in value attributable to irrigation is approximately 27%. The maximum contribution is recorded for soils located in areas suitable for specialized crops: orchards (+35%) and vegetable garden (+82%). The contribution made to the value of lawn areas, which, even in the north, require high volumes of irrigation water, is also significant (+48%).

Basically, by comparing the AAVs in the different geographic areas it is clear that the contribution of irrigation to the value increases with the value of the crops grown and with the average value of the soils.

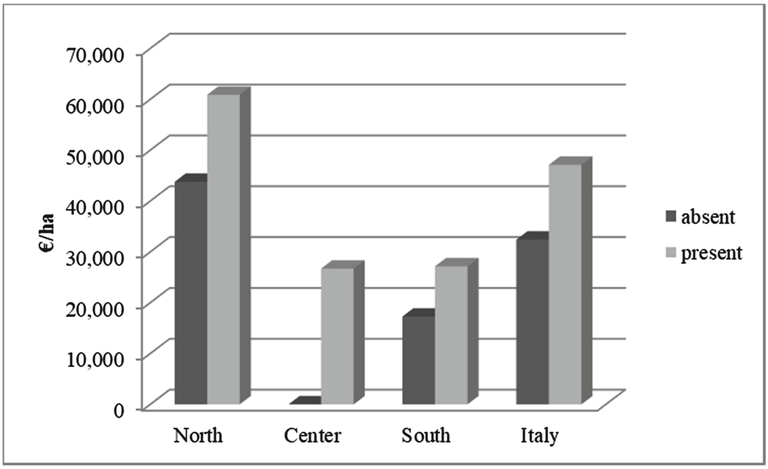

Fig. 1. Average Agricultural Value in the presence and absence of irrigation.

These first results are confirmed by the econometric analysis which identifies, net of all the other characteristics that may affect the land value, the contribution attributable to the possibility of irrigation in the sample of municipalities considered.

Two main investigations were carried out: the first to verify whether or not the contribution of irrigation to the agricultural value was statistically significant, the second to identify the factors that most affected this contribution, both in the first instance and interacting with other characteristics.

Analysis confirm that the AAV of the soils (Table 1) is significantly and positively influenced by the possibility of irrigation (+€ 9,520/ha), by the diffusion of irrigation at the local level and by the presence of a structured (consortium) water supply system. Irrigation plays a decisive role in the formation of value, especially in the presence of consolidated irrigation territorial systems.

The effect of advanced irrigation techniques (sprinkler or micro-irrigation) is apparently counterintuitive, perhaps due to their higher operating costs.

The value of the soils, in addition to the presence of irrigation, is significantly connected with the crops practiced: taking as a reference basis the value of the grass soils, arable crops involve an increase in value of 16k €/ha, horticultural ones of 18.8k €/ha and fruit crops of 31.2k €/ha.

The greater contribution of orchards to the value is due to the huge land investments present.

Compared to lowland AAVs, mountain and hilly ones are significantly penalized (−6.2k €/ha and - 3.1k €/ha).

Finally, the average agricultural value of the soil is negatively influenced by the average company size (−33.9 €/ha per hectare of average company size) and positively by the density of the population and the outsourcing of the economy. Ultimately, the value of land for exclusive agricultural use is positively linked to general factors of economic and urban development.

Table 1. The average agricultural value in Italy.

Variable	Coefficient	Standard error	b/St.Er	P[|Z|>z]
Presence of irrigation system	9.520,4	1.254,1	7,6	0,00
Irrigated area (%)	78,8	12,1	6,5	0,00
Consortium source of supply	856,8	533,0	1,6	0,11
Irrigation system: sprinkler or micro irrigation	−12,7	595,0	0,0	0,98
Presence of irrigation system arable	1.751,2	1.511,5	1,2	0,25
Presence of irrigation system orchard	8.780,3	1.542,0	5,7	0,00
Presence of irrigation system vegetable	17.217,9	1.516,8	11,4	0,00
Presence of irrigation system Centre Italy	−3.974,7	1.225,5	−3,2	0,00
Presence of irrigation system South Italy	−8.775,9	1.006,3	−8,7	0,00
Type of arable crop (vs. meadow)	16.118,6	1.080,8	14,9	0,00
Type of crop orchard (vs. meadow)	31.246,3	1.103,2	28,3	0,00
Type of vegetable garden (vs. meadows)	18.840,1	1.084,3	17,4	0,00
Valuable crops: vegetable garden and orchard (%)	124,9	12,9	9,6	0,00
Altimetric area mountain (vs. plain)	−6.187,0	1.169,2	−5,3	0,00

(*continued*)

Table 1. (*continued*)

Variable	Coefficient	Standard error	b/St.Er	P[|Z|>z]
Altitude hill area (vs. plain)	−3.150,5	796,2	−4,0	0,00
Average size of agricultural holdings (UAA ha / az.)	−33,9	16,6	−2,0	0,04
Main use of subcontractors (% of shares)	19,6	14,5	1,3	0,18
Agriculture employees (%)	0,9	0,4	2,6	0,01
Industry employees (%)	−1,0	0,4	−2,5	0,01
Service employees (%)	0,3	0,2	2,0	0,04
Common population (inhab.)	0,0	0,0	−0,5	0,60
Population density (inhab./sq. km)	1,7	0,6	3,0	0,00

R-squared = .71
Adjusted R-squared = .71
Akaike Info. Criter. = 19.5
AAV dependent variable (€/ha)
UAA: utilized agricultural area

Table 2 deepens the analysis by reporting three models developed without including the interactions between the presence of irrigation and the geographical area. The first of the models was estimated with reference to the entire national territory and the other two on the opposite realities from a climatic point of view: the northern and southern agricultural regions. In principle, these models confirm the main results obtained with the model shown in Table 1.

The presence of irrigation ensures a higher value of 9 thousand €/ha, with a slight prevalence in the southern regions (+10 thousand €/ha) compared to the northern ones (+9 thousand €/ha). The AAVs appear to be influenced, even in these models, by crop destination. In particular, arable crops, orchards and horticultural crops have a significant effect compared to the lawn in all the considered territorial realities. Taking into consideration the differences between the agricultural regions of northern and southern Italy, it is noted that:

- fruit crops induce a greater effect in the northern regions;
- the mountain location uniformly penalizes the AAVs of the peninsula;
- the hilly location penalizes the AAVs of the Southern Agricultural Regions the most;
- the availability of agricultural labor has a positive effect on AAVs, particularly in the north;
- population density positively influences AAV, especially in the North;
- the effect of the interaction with the presence of irrigation is always positive for vegetable crops while for fruit crops it is positive only in the agricultural regions of the north.

Table 2. The Average Agricultural Value by geographical areas in Italy.

Variable	Italy		North		South	
	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Presence of irrigation system	8,965.58	7.13	9,127.33	5.58	10,179.10	4.59
Type of arable crop (vs. meadow)	17,652.40	16.50	15,122.10	9.95	13,009.80	7.92
Type of crop orchard (vs. meadow)	32,669.60	29.86	38,504.70	24.61	23,481.10	14.23
Type of vegetable garden (vs. meadows)	20,388.00	18.98	17,675.20	11.62	15,891.40	9.68
Average size of agricultural holdings (UAA ha/az.)	−33.94	−2.03	−4.37	−0.18	−9.30	−0.52
UAA valuable crops (%)	124.87	9.59	183.45	7.84	10.58	1.20
Prevailing use of the CT (%) of the shares)	19.55	1.34	35.62	1.31	−44.17	−4.70
UAA Irrigated (%)	78.78	6.46	69.56	3.65	17.79	1.91
Irrigation system: sprinkler or micro-irrigation	−12.70	−0.02	601.97	0.56	−334.10	−0.88
Supply source: aqueduct, consortium or other entity with delivery in turn or on demand	856.81	1.60	2,130.99	2.47	−766.00	−1.98
Altimetric area mountain (vs. plain)	−6,187.02	−5.26	−11,407.80	−3.59	−10,083.60	−14.27
Altitude hill area (vs. plain)	−3,150.49	−3.94	−1,905.62	−1.49	−6,108.98	−10.94
Agricultural labor (number of people)	0.92	2.59	2.36	2.65	0.45	2.24
Industry employees (number of people)	−0.98	−2.45	−1.55	−2.25	1.11	1.92
Service employees (number of people)	0.33	2.03	0.56	2.08	−0.30	−1.52
Municipalities population	−0.02	−0.52	−0.09	−1.07	0.00	0.15
Density (inhab./sq. km)	1.67	2.97	6.31	2.42	1.08	4.58
Presence of irrigation system_arable	−1,316.48	−0.89	−1,452.48	−0.68	−2,928.39	−1.29

(*continued*)

Table 2. (*continued*)

Variable	Italy		North		South	
	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Presence of irrigation system_orchard	5,933.61	3.94	10,641.70	4.87	−2,298.82	−1.01
Presence of irrigation system_vegetable garden	14,122.10	9.55	20,206.20	9.49	3,918.53	1.73
R-squared	0.71		0.71		0.83	
Adjusted R-squared	0.71		0.71		0.83	
Akaike Info. Criter	19.59		19.58		17.56	

Table 3 shows the results obtained by taking into account, at national level, the effect of irrigation on the AAV of the main crops. In addition, in this case, the fixed effects models confirm, on average, the results of the analysis illustrated above. The effect of irrigation on the value of the soils is positive for all crops examined. The increase in value is particularly evident in orchard soils (+€ 15.4 thousand) and more contained in vegetable gardens (+€ 9.6 thousand), lawn (+€ 9 thousand) and arable land (+7, € 6 thousand). Another significant element is that the AAV is always penalized by mountainous and hilly locations, except for fruit crops.

Table 3. The Average Agricultural Value by crop in Italy.

Variable	Crop							
	Arable		Orchard		Vegetable		Garden	
	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Presence of irrigation system	7,612.49	33.17	15,394.00	8.26	9.59	32.72	8,965.58	21.90
Average size of agricultural holdings (UAA ha/az.)	7.17	0.77	−66.50	−0.35	18.23	1.33	32.62	2.31
UAA valuable crops (%)	46.33	6.49	338.90	7.01	8.34	0.96	18.29	1.37
Prevailing use of the CT (%) of the shares)	14.55	1.86	71.90	1.14	0.24	0.02	−12.83	−0.81
UAA Irrigated (%)	14.80	2.17	305.40	6.01	−7.71	−0.75	30.48	2.59

(*continued*)

Table 3. (*continued*)

Variable	Crop							
	Arable		Orchard		Vegetable		Garden	
	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Irrigation system: sprinkler or micro-irrigation	514.45	1.62	−2,078.90	−0.71	−363.62	−0.84	−1,555.93	−2.49
Supply source: aqueduct, consortium or other entity with delivery in turn or on demand	389.76	1.34	2,663.90	1.14	−185.01	−0.43	28.10	0.05
Altimetric area mountain (vs. plain)	−9,170.25	−14.64	8,205.10	1.43	−14,715.60	−9.09	−5,126.45	−1.58
Altitude hill area (vs. plain)	−5,594.53	−12.62	6,20580	2.11	−4,718.86	−7.47	−1,761.75	−1.94
Agricultural labor (number of people)	0.66	3.54	2.60	1.92	0.09	0.32	0.51	0.99
Industry employees (number of people)	−0.47	−2.27	−3.30	−1.85	0.20	0.39	−1.06	−1.64
Service employees (number of people)	0.10	1.17	1.00	1.76	−0.23	−0.75	0.46	1.59
Municipalities population	0.00	−0.05	−0.10	−0.52	0.04	0.82	−0.07	−0.87
Density (inhab./sq. km)	2.39	8.15	1.10	0.63	0.26	0.91	4.41	32.44
Number of observs	810.0		810.00		810.00		810.00	
R-squared	0.93		0.78		0.95		0.87	
Adjusted R-squared	0.93		0.77		0.95		0.86	
Akaike Info. Criter	7.19		20.43		16.32		17.37	

The estimates of the effect of irrigation on the AAV of the soils in relation to the crops grown, the geographical location and the structural characteristics of agriculture allow an initial estimate of the total value of irrigation at the national level. This estimate was made starting from the extent of the irrigated area, the use of the land and its main characteristics. The calculated value varies, depending on the econometric model adopted, between € 25.8 and € 28.6 billion, with an average of € 27.2 billion (the highest value was obtained by extending the estimates made at national level with the model shown in Table 2, which includes the effect of the interaction between the presence of irrigation and the geographical location of the soil. The lowest value is obtained using the estimates obtained by type of crop (Table 3).

This is a rather variable estimate but, nevertheless, useful for providing an order of magnitude of the contribution of irrigation to the value of the land and to agricultural income.

6 Conclusions

The study presented above applied the hedonic method to evaluate the effect of the availability of water for irrigation on the value of agricultural soils in Italy. The study made it possible to highlight the effect of irrigation and the other main variables that characterize the soils and the socio-economic context where they are located. The overall effect at the national level was estimated at approximately € 27.2 billion, equal to € 8,770/ha. Assuming that the total annual volume of water used for irrigation is equal to 11 billion cu. m./year, a greater value of the irrigated land is obtained equal to 2.5 €/cu. m. of usable water per year. Approximately 5 € cents/cu. m. is obtained by extending the estimates to the value of the water.

These estimates are consistent with what has been observed in the literature.

Furthermore, the results allow to highlight some important (and not always obvious) issues:

1. The values consistent with the reasonable a priori that can be formulated on the main effects of irrigation on the value and on agricultural income.
2. Irrigation contributes significantly to the agricultural value, and, therefore, to the income of all the main crops grown in Italy and at all latitudes.
3. Irrigation contributes not only to the amount of income but also to its stability over time, decreasing the economic risk at the level of the agricultural enterprise.
4. Irrigation is essential for the survival of agricultural systems based on specialized crops in all Italian areas, in the north as well as in the south.
5. The unit volumes used in agriculture (on average 3,500 cu. m./ha) are high and give a glimpse of ample room for improvement in the efficiency of water use in agriculture with the possibility of reducing the significant conflicts in place with competing uses.

However, the analysis carried out has some obvious limitations deriving from the database used (AAV) and from the fact that only some sample provinces were considered and not the entire national universe. Some limits could be easily overcome by re-estimating the effect of irrigation on a larger database and integrating the AAVs with direct observations on the real estate market.

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