Modernization and users participation, a key issue towards irrigation sustainability in Valdichiana, central Italy

MODERNIZATION AND USERS PARTICIPATION, A KEY ISSUE TOWARDS IRRIGATION SUSTAINABILITY IN VALDICHIANA, CENTRAL ITALY

[Graziano Ghinassi[1] and Lorella Marzilli[2]]

ABSTRACT

Water supply for irrigation purpose can be done either by individual users or through collectively managed structures that deliver water from the intake to the farm inlet. Due to a number of reasons, such as ineffective cost recovery or limited participation, worldwide experience on transformation from individual to participate irrigation is not always success stories on irrigation performance and agricultural productivity. Modernization can play a fundamental role, on condition that users are trained on infrastructure use and informed on the expected benefits. In Valdichiana, an irrigated area of inland Central Italy, after decades of uncontrolled individual water withdrawals mainly from in-farm wells, a new piped network to deliver high quality freshwater for irrigation, available under pressure at the farm hydrant, was completed. Conversion towards collective management began in 2012 under the Reclamation and Irrigation Consortium named Alto Valdarno 2. At the end of 2018, collective water management involved around 20% of the irrigable area, a rather low value despite the benefits offered such as the low or nil energy cost for lifting. However, compared to previous individual withdrawals, the average supplied volumes decrease considerably. This work aims to provide a brief overview on the evolution of irrigation during the initial 7 year collective management, focusing on the evolution of climatic conditions, cropping pattern and irrigation systems, in addition to farming constraints and users attitude, in order to collect information to assess whether participation can actually support the achievement of expected individual and collective benefits.

Keywords: Modernization, Reclamation and Irrigation Consortia, Irrigation districts, user participation.

1. INTRODUCTION

After Spain, Italy is the European Country with the largest irrigated area, mostly managed by Reclamation and Irrigation Consortia (RIC) which are public authorities operating upon associative basis. They play a fundamental role in soil protection, water regulation, delivery of irrigation water, management of collective irrigation networks, landscape and environment protection, mitigation of the effects of climate change. Conditions of Italian territory greatly benefited from the activities carried out by RICs. Over time, the role and importance of Consortia changed due to a number of reasons related to the growing water crisis. In particular, the multifunctional activity allows them to play a fundamental role in solving intersectoral competition for resource use, impact on climate due to production activities, including agricultural practices, and

[1] Department of Agricultural, Environmental, Food and Forestry Science and Technology (DAGRI) University of Florence Via San Bonaventura, 13 – 50145 Firenze graziano.ghinassi@unifi.it

[2] Consorzio 2 Alto Valdarno, via Ernesto Rossi, 2 – 52100 Arezzo lorella.marzilli@cbaltovaldarno.it

implementation of European directives on the accounting of resource use (e.g., water for irrigation).

Tuscany is among Italian regions that organized late with RICs, and since 2012 six Consortia manage about 11,000 Km^2 of territory, corresponding to 47% of the total area of the Region. Land morphology, climate and cultural traditions are the basis of different agricultural production contexts within the Region. Valdichiana is an irrigated fertile reclaimed plain, located in the eastern part of Tuscany, inland central Italy, with a strategic role in the regional water balance. Despite traditionally water is not a limiting production factor in Valdichiana, critical situations, such as limitations of water withdrawals, can occurr in dry and hot years, as it was in 2003. This work aims to provide a quick view on irrigation in this area during the initial 7 year of collective management, focusing on the activities of the Reclamation and Irrigation Consortium Alto Valdarno 2 (CAV2), actual performance under collective management and possible limitations or slowdowns to achieve expected results (e.g., % of the irrigable area).

2. METHODS

2.1 Case study: Valdichiana

Valdichiana is a plain located in the provinces of Arezzo and Siena, central Italy, where agriculture is the main production activity. On annual basis, the climate is classified as sub-humid, with average precipitation of about 800 mm. Since the beginning of the 90's, rainfall and temperature during spring-summer months changed in such a way that climate classification of that period switched from dry into semi-arid sub-humid (Lamma, 2012a). A recent study on the effects of climate change on different species of vegetation (Ghinassi et al., 2014), carried out in a close and climatically similar area, confirms for future decades the evolution envisaged (figure 1).

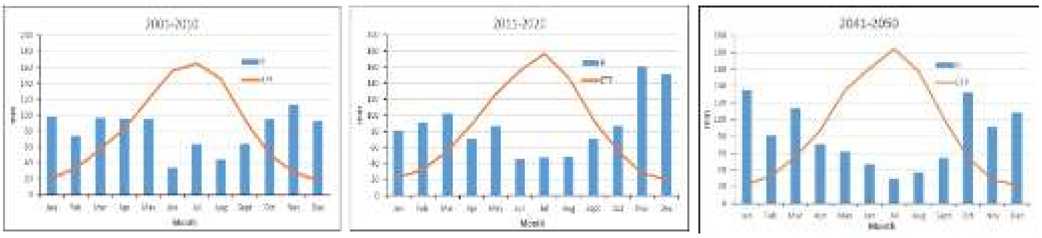

Figure 1. Effect of climate change on rainfall (R) and reference evapotranspiration (ETP) pattern for three decades of the first half of XXIst Century in inland central Italy.

According to scenarios, evapotranspiration demand increases a little during July and August, while rainfall distribution pattern is quite modified in spite of total annual precipitation depth does not change significantly. For agricultural purposes, there is evidence of increased water deficit during the traditional irrigation season (i.e., from May to August) mainly due to reduced precipitation, with expected increase in demand of irrigation water. Data recorded by the meteorological station of Cesa, located in the central part of Valdichiana, have been processed to calculate the evapotranspiration demand and the water deficit in July-August, the period with the peak water demand, from 2012 to 2018 that is the initial activity period of CAV2 (figure 2). Deficit is given here as the rough difference between reference evapotranspiration and total rainfall.

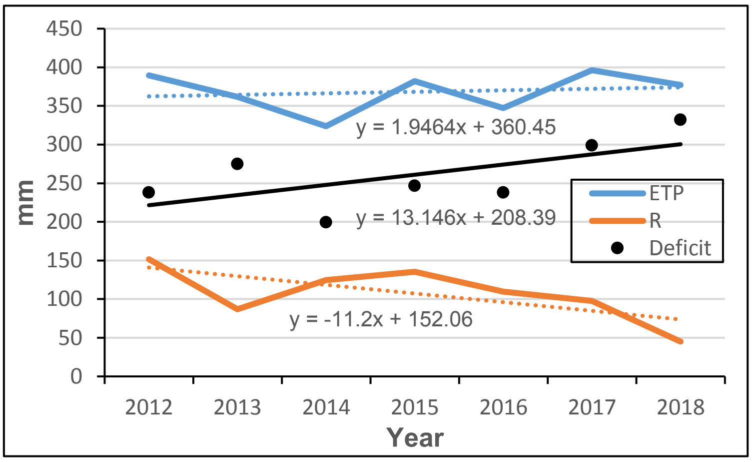

Figure 2. Increase of water deficit in July-August from 2012 to 2018.

According to results, the main reason of water deficit in the period is the reduction of precipitation more than the increase of evapotranspiration demand, in agreement with the 2011-2020 scenario given in figure 1, and with data recorded from 1991 to 2008, which testify the reduction of about 20% of summer precipitation on the Regional territory (Lamma, 2012b). Moreover, according to the Environmental Sensitive Area Index (ESAI) Valdichiana is subjected to desertification (UNCCD definition) because of water imbalance due to climate change and anthropic pressure caused by agricultural activities (Lamma, 2012a).

2.2 Individual withdrawal of irrigation water

Until 2011, control on water withdrawals for irrigation consisted in concessions released by local administration for the drawing from both surface water bodies and groundwater, without control on actual use. Basic information on agricultural water use were supplied by the General Census on Agriculture, carried out every ten years on average. According to the 6th Census (ISTAT, 2012), the average supply per ha was about 3,100 m^3 on regional basis. This value accounts for specific applications that dramatically change among the irrigated areas within Tuscany. According to estimates yielded by the Regional Agency for Agricultural and Forestry Development and based upon the 6th Census, highest specific water supply (about 6,000 m^3/ha and more) occurs in areas where nursery and floriculture are widespread. Where industrial crops prevail, average applied water is about 3,100 m^3/ha. In Valdichiana, where both annual (e.g., industrial and forage) and perennial (e.g., fruit orchards) irrigated crops are cultivated, about 2,700 m^3/ha are supplied on average.

According to data collected during the SEAgriT research project, coordinated by the University of Florence from 2005 to 2007, withdrawal of irrigation water in Valdichiana was made by farmers mainly from in farm wells, in independent way and without concession at that time. Other outputs showed that water use was affected by crop type, irrigation system and specific agronomical practices. Compared to forage crops, water applied to fruit orchards and industrial crops was found to be 1.8 and 1.7 times, respectively, on average. Compared to sprinkler irrigation (e.g., center pivot, hose reel, and solid set), water supplied by micro irrigation systems (e.g., drip, micro sprinkler) was about 1.6 times. In Valdichiana many orchards are equipped with two irrigation types (i.e., drip and overhead sprinkler), in order to cope with excess heat during summer. Compared to sprinkler application, water supplied by drip systems on annual crops was about 1.5 times (Ghinassi and Cecchi, 2012).

2.3 Establishment of Reclamation and Irrigation Consortium

With the establishment of CAV2, the management of water coming from a dam built on Tiber river, which flows in a nearby valley, finally started. Difference in elevation of about 100 m between the intake of delivery network and Valdichiana irrigated plain allows water to flow by gravity through large diameter pipes and compensation tanks. Total irrigable area is planned to be about 45,500 ha, divided into Districts equipped with pipelines and automated tele-controlled hydrants, where irrigation water is available with a static head from 2.5 to 9.0 bar, depending on the position. Each hydrant is equipped with a water meter, remotely controlled via General Packet Radio Service (GPRS) communication technology.

From the ecological side, available pressure by gravity is an excellent opportunity to reduce the impact of irrigation on climate (Belaud et al., 2019). CAV2 is managing an area of 4,025.72 km^2, over half of which (i.e., 2,300 km^2) falls in Valdichiana. Currently, four irrigation Districts (i.e., D1, D7, D21, D42-43) are operating (figure 3).

Figure 3. Feeding dam (red circle) and Valdichiana with the four Districts active in 2018 (blue oval).

3. RESULTS AND DISCUSSION

3.1 Development of irrigated land

The activity of Consortium as supplier of irrigation water started in 2012 with Districts D1 and D21, followed by D7 in 2015 and D42-43 in 2016. Districts are equipped with devices to control and record the water delivered to farmers, so the irrigable area of each District is planned and known in advance. On the other hand, irrigated area increases during time because farmers start to use the water provided by the Consortium. Evolution of irrigated vs irrigable area within each District is given in figure 4.

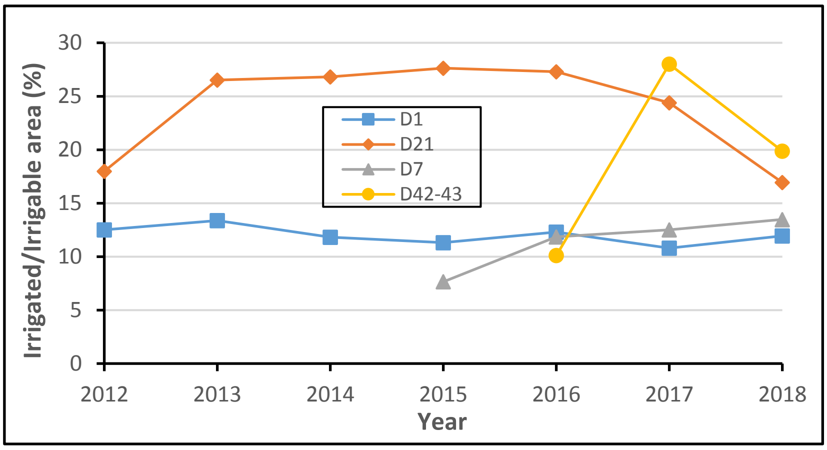

Figure 4. Evolution of irrigated vs irrigable areas in the Districts.

The trend of D21 decreases sharply in 2018 because of the increase of the irrigable area from 1,000 to 1,600 ha. However, variation of the ratios seems quite irregular during time. From 2012 to 2018, both irrigable and irrigated areas increases in absolute terms, as illustrated in figure 5.

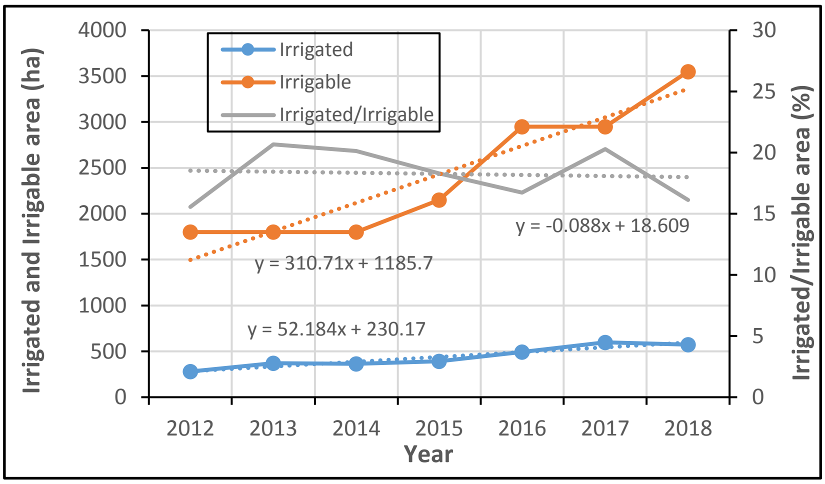

Figure 5. Evolution of total irrigated and irrigable area from 2012 to 2018.

According to the figure, decrease of irrigated vs irrigable ratio is affected by the change of D21 in 2018. Nevertheless, the extent of the ratio depends on the different growth rates of irrigated land within individual Districts.

3.2 Changes in cultivated crops and type of irrigation over time

In addition to the water supplied by CAV2, farmers can also withdraw water independently from both surface and deep water bodies through concessions issued by the Regional Administration upon payment of a fee. Since the use of water meters is non mandatory, the volume withdrawn is not measured and the fee is set by a combination of fixed and variable quota. Total amount of each concession is calculated upon the irrigated area, the number of withdrawal points and the derivable flow rate, regardless of actual withdrawal. Therefore, on farm irrigation water can be taken from both autonomous and collective source in many cases.

This possibility proves useful, mainly for orchards in periods of very high water demand, especially during heat waves, when water is supplied both to compensate for evapotranspiration and lower the plant temperature. This is generally done by combining micro and overhead sprinkler irrigation, with large water applications as the unavoidable consequence. Another benefit of individual water withdrawal is related to the size of the fields and to farm fragmentation, as well as to psychological aspects supported by the idea of operational autonomy.

The increase in irrigated area within each District has also led to changes in cropping pattern and cultivated crops, namely forage (Fo), industrial (In) and orchard (Or), as reported in table 1.

Table 1. Percentage of crop types in each District from 2012 to 2018.

YEAR	2012			2013			2014			2015			2016			2017			2018		
CROP	Fo	In	Or	Fo	In	Or	Fo	In	Or	Fo	In	Or	Fo	In	Or	Fo	In	Or	Fo	In	Or
D1	100	-	-	100	-	-	100	-	-	51	18	15	56	16	13	50	14	19	46	15	13
D21	-	-	100	-	-	100	-	-	100	7	5	88	3	6	89	6	4	95	3	2	95
D7	-	-	-	-	-	-	-	-	-	15	3	82	8	1	88	33	40	22	13	55	14
D42-43	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-	85	5	9	79	3	11

According to the table, there is evidence of the agronomic suitability of individual District towards specific crop categories. For example, orchards are traditionally cultivated in D21, while forage crops prevail in D42-43 and D1. In D7, most of cultivated crops fall into industrial and orchard category, while forage cultivation is limited. Cropping organization addresses the choice of agronomic practices the farmers believe as the most suitable. Selection of irrigation system and management of irrigation practice are basically related to crop type, as well as annual water application depends on the climate (e.g., evapotranspiration and rainfall) along the season. In both cases, user's skill plays the most important role towards the ultimate efficient and effective use of irrigation water.

Basic information on irrigation at the District level are given in table 2, where S and M stand for Sprinkler and Micro irrigation, respectively, and the irrigation depth is the average on annual basis, regardless of the irrigation type. Values are derived by the total volume taken from hydrants and by the total area farmers declare to irrigate in the incoming season.

Table 2. Irrigation types (%) and annual average irrigation depth, in mm, in each District from 2012 to 2018.

Year	2012			2013			2014			2015			2016			2017			2018		
Item	S	M	mm	S	M	mm	S	M	mm	S	M	mm	S	M	mm	S	M	mm	S	M	mm
D1	100	-	100	100	-	134	100	-	125	-	-	169	51	49	110	66	34	231	66	30	181
D21	-	100	392	-	100	187	-	100	246	-	-	366	50	50	274	90	10	569	60	40	328
D7	-	-	-	-	-	-	-	-	-	-	-	303	24	76	209	42	58	200	45	28	165
D42-43	-	-	-	-	-	-	-	-	-	-	-	-	100	-	66	76	24	162	11	89	155

Data of table 2 confirm the output of the 2005-2007 research project. Generally speaking, irrigation of forage crops is carried out by sprinkler systems, while perennials are micro irrigated. Industrial crops are less dependent by specific irrigation techniques, so both micro and sprinkler are used to the scope. In the absence of constraints, such as available pressure and discharge, decision is often based on personal beliefs on what the most suitable irrigation system is, and specific strategies developed over time. The impressive value of water applied on orchards (D21) in 2017 was originated by the very hot and dry climate which hit central Italy in that year. Traditional drip irrigation was supplemented by overhead sprinkler applications during July and August, the most critical period for irrigation. Average values of water delivered by CAV2 to the different Districts from 2012 to 2018 are given in figure 6.

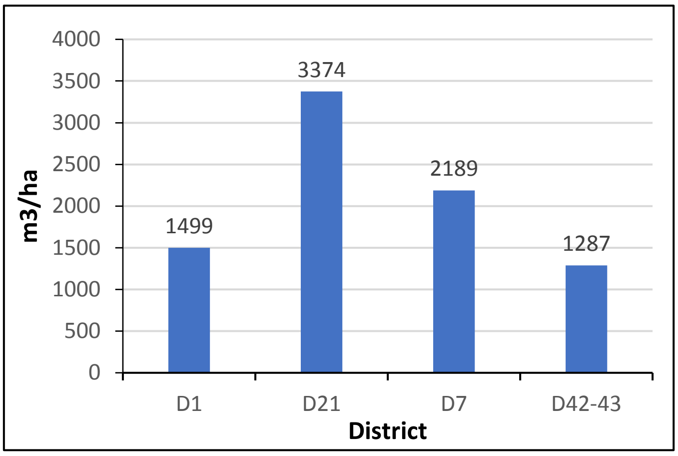

Figure 6. Average values of Consortium water applied in each District during 2012-2018 period.

During 2012-2018 period, the average amount of water delivered by the Consortium in Valdichiana is 2,536 m^3/ha, that is about 10% less than the Census estimate. It is important to notice that the value is based upon measured withdrawals and that a few is known about the uses of water taken under concession. There is no reason to believe that poor use of that water is made, since expenses for lifting are in charge of the farmer.

4. CONCLUSIONS

From 2012 to date, annual increase of the area irrigated under the control of the Consortium is low, and the area actually irrigated is just a small fraction of the total irrigable. This may seem incomprehensible to outside observer, because the water supplied by the Consortium is of excellent quality and is already under pressure.
This situation is due to different reasons. Some are practical, such as the farm size (e.g., small or fragmented) and the cultivation of rainfed crops (e.g., Wheat and Sunflower), others reflect typical attitudes of traditional farmers, such as the hesitation to experience innovation and the personal belief of water autonomy.

At present, some areas benefit from the external water supply in terms of increased groundwater level, as well as production improvements due to the high quality of irrigation water. To be complete, analysis on modernization should include also the positive effects on climate, due to the dramatically reduced use of energy for water lifting.

In spite of the evidence of individual and common benefit given by the collective management of water, some work still has to be done, both at the operational level in the form of boosting the irrigable area, and at the farmer role in terms of formation and information.

The sponsorship of decision support tools based on the control of the production system can help overcome some limitations, and represent a significant improvement for the next future. On the other hand, the lack of a steady and comprehensive development could prevent the full and effective implementation of innovations, which in turn could not display their own potential.

REFERENCES

Belaud, G., Mateos, L., Aliod, R., Buisson, M.-C., Faci, E., Gendre, S., Ghinassi, G., Gonzales Perea, R., Lejars, C., Maruejols, F., Zapata, N. 2019 Irrigation and energy: issues and challenges, Irrigation and Drainage, https://doi.org/10.1002/ird.2343

Ghinassi, G., Cecchi, S. 2012 Rapid assessment of seasonal in-field water management on micro irrigated annual and perennial crops in Central Italy, proceedings of the 7th Asian Regional Conference, 63rd IEC of the ICID, Adelaide

Ghinassi, G., Matteini, T., Ferrise, R., Grossoni, P. 2014 The Role of Water and Climate Change in the Conservation of Historic Gardens of Central Italy, in: Historic Gardens and Climate Change. Recommendations for Preservation, ISBN 978-3-361-00701-7, pp. 102-108, Edition Leipzig

ISTAT 2012 http://censimentoagricoltura.istat.it/fileadmin/template/main/res/Risultati_definitivi_-_6__censimento_Generale_Agricoltura_-_CS_breve.pdf

Lamma (LaMMA Consortium - Environmental Modelling and Monitoring Laboratory for Sustainable Development) 2012a http://www.lamma.rete.toscana.it/sites/all/files/doc/energia/2_Territorio.pdf

Lamma (LaMMA Consortium - Environmental Modelling and Monitoring Laboratory for Sustainable Development) 2012b http://www.lamma.rete.toscana.it/sites/all/files/doc/energia/1_Clima.pdf