AG-WaMED | Advancing non conventional water management for innovative climate-resilient water governance in the Mediterranean Area

Integrated Watershed Management Plan (IWMP) - Val d'Orcia Living Lab

Partnership for Research and Innovation in the Mediterranean Area Programme (PRIMA)
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Disclaimer:

This IWMP has been created within AG-WaMED project ("Advancing non conventional water management for innovative climate-resilient water governance in the Mediterranean Area"). It focuses on agricultural water management in Val d'Orcia (Tuscany Region). This document shall not be equated to the official water resources management plans developed by the regional authority (Tuscany Region) and the Northern Apennines District Basin Authority. It presents a vision on water management in Val d'Orcia which has been co-constructed together with local stakeholders and gathers a set of near- and long-term measures to realize this vision. This IWMP differs from institutional plans for three main characteristics:

- It focuses on Non-Conventional Waters (NCW)[1], excluding a comprehensive analysis of surface and groundwater bodies.
- It has been developed through a close collaboration process with local public and private stakeholders
- It has a territorial focus on the five Val d'Orcia's municipalities, despite some considerations apply to the regional level.

[1]In this document conventional waters are defined as surface water bodies (rivers and lakes) and groundwater (springs, shallow and deep aquifers) and NCW are defined as a set of techniques to harvest and treat rain, runoff water, wastewater and desalinated water.

Introduction

Climate change, drought and Non-Conventional Waters

Climate changes represent one of the main global challenges to be faced, increasingly involving Italian territory (MASE, 2023). Indeed, Italy is located in the so-called "Mediterranean hotspot", a region where climate change is more intense than the global average (MedECC, 2020). Italy, already prone to several natural hazards, such as hydrogeologic disturbances, floods and droughts, is facing an increase of these risks due to rising temperatures and increased frequency of extreme climatic events (droughts, heat waves, intense rainfall etc.). Economic, social and environmental consequences of these changes are already visible and expected to intensify in the next decades (MASE, 2023).

The alterations in hydrological cycle are one of the main climate changes' impacts, with consequent increase in frequency and intensity of extreme meteorological events both with strong rainfall and droughts. Italy is currently facing a medium-high level water stress (MASE, 2023) and a further increase in temperatures and rainfall variability could exacerbate water scarcity and drought conditions with severe consequences for agriculture, energy production, freshwater provision and ecosystems wellbeing.

Thus, it is fundamental to promote a sustainable water management able to maintain a balance between water availability and human and natural water demand. Although intelligent water use and water saving are the most important actions to balance water availability and demand, it is also necessary to promote the sustainable use of NCWs. Not only could these resources complement conventional water sources during dry spells, but also they could reduce pressure on the already overexploited conventional sources (Romano and Portoghese, 2024).

However, social, economic, technical and legislative barriers exist that limit the exploitation of NCWs. For instance, the installation of water reservoirs for runoff storage can require significant infrastructure interventions and raises issues on their potential environmental impact and downstream hydraulic risk. Treated wastewater use in agriculture may be hindered by farmers' mistrust and normative barriers. More in general, these issues limit the consideration of NCWs in policies for water management and their potential contribution to water availability.

AG-WaMED's approach to promote NCWs use

The AG-WaMED project aims to promote the use of NCWs in the Mediterranean for a climate-change-resilient water governance. The research approach implemented in the four case studies (Italy, Spain, Egypt, Tunisian/Algerian Living Labs) is inspired by the Responsible Research and Innovation concept promoted by the European Union aiming to align research and innovation processes with shared social values to tackle global challenges like water management in a changing climate. Thus, transdisciplinary research is implemented integrating advanced scientific knowledge with the experience of local non-academic stakeholders such as public authorities, farmers, private enterprises and citizens.

In particular, stakeholders involvement in the four case studies is carried out through the "Responsible Research and Innovation (RRI) Roadmap©TM"methodology, consisting of eight phases reported in Figure 1.

Figure 1. The eight phases of The Responsible Research and Innovation (RRI) Roadmap©TM methodology applied in AG-WaMED project.

The Integrated Watershed Management Plan for Val d'Orcia (the Italian case study) is the result of a three-years process including participatory identification of local problems related

to NCWs, co-creation of a shared co-creation policy and co-construction of measures to implement the proposed policies.

IWMP structure

The Val d'Orcia IWMP consists of three main parts. Part I describes the case study in geographical, socio-economic terms and characterises the area's NCWs. Part II shows the main problems related to NCWs focusing on small agricultural reservoirs (SmARs). Part III shows the intervention strategy.

Part I: Description and characteristics of Val d'Orcia Living Lab

1.1 The Orcia river watershed

The Orcia Basin is located in Southern Tuscany, across Siena and Grosseto provinces (Figure 2). It covers a surface of around 748 km² and flows into the Ombrone river. Orcia provides water to Val d'Orcia, an agricultural and tourist- vocated valley of central Italy. Val d'Orcia consists of 5 municipalities and in 2022 its population amounted to 13.366 inhabitants (Censimento, 2022) (Appendix 1). The study area is characterised by a mediterranean climate. Average annual temperature is around 13.6 °C and total annual rainfall amounts to 715 mm, mainly distributed in winter and autumn, with average rainfall minima of 596 mm in Ripa d'Orcia and maxima of 854 mm in Castel del Piano (Tuscany Region Hydrological service data). Val d'Orcia is a tourism-vocated area with its landscapes classified as UNESCO World Heritage site and has also significant agricultural vocation with production of renowned wines like the Brunello di Montalcino DOCG and the Orcia DOC. According to the regional database ARTEA (2022), the 40,500 ha of cultivated surface are divided into fodder (29%), cereals (22%), other herbaceous crops (16%), vineyards (8%), pastures (7%) and olive groves (6.6%).

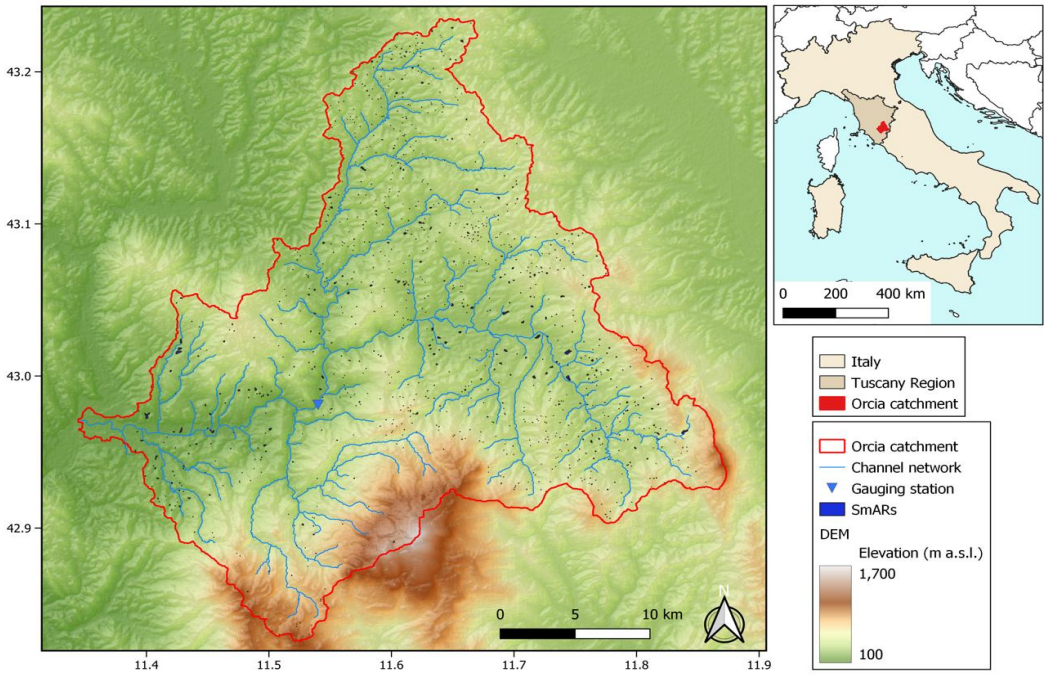

Figure 2. The Orcia basin.

1.2 Conventional waters in Val d'Orcia

Status of surface water bodies

The valley is crossed by the Orcia river and its tributaries Formone, Ente and Asso. It is included in the Ombrone river watershed, which covers a 3494 km² area. In the Orcia watershed, protected natural areas represent important sites for ecosystem protection and management. Three protected areas of the Natura2000 network are fully included in the basin while the other four are only partially included (Appendix 2). Tuscany Region located a further area of regional interest and another exists of provincial interest. The total surface of protected areas amounts to 28.385 ha.

Despite the intention of protecting water resources and ecosystems, the environmental flow - a requirement set by the EU Water Framework Directive - has not been defined for the Orcia river. The relevant authorities are working on this issue. The ecological status of Orcia river in its downstream section is considered "sufficient", while its chemical status, once considered "scarce" due to the presence of cadmium and its components, is now considered "good" (Autorità di bacino distrettuale dell'Appennino settentrionale, 2025).

Quality and status of groundwater

The majority of Val d'Orcia area does not host aquifers considered as "significant groundwater bodies". Beyond domestic, geothermal and industrial uses, in case of lack of resources, groundwater is occasionally used for irrigation. It appears that several users have installed undeclared wells (Interviews, Deliverable 4.1 - AG-WaMED project, 2023). According to the Regional Environmental Agency ARPAT (2022), groundwater is generally in good status with few local exceptions in Tuscany Region. However, groundwater use is not a long-term sustainable and reliable solution for irrigation in Val d'Orcia as it is prone to pollution and saline water intrusion from the sea.

1.3 Non-conventional waters in Val d'Orcia

Presence of Non-Conventional Waters

The main NCW sources used in Val d'Orcia are rainfall and runoff water harvesting. These are stored in SmARs. Analyses carried out during the AG-WaMED project based on the reservoir cadastre (Consorzio LaMMA, 2018) showed that 1097 SmARs exist in the basin. These occupy a total surface of 155.3 ha (Figure 3) and an estimated volume of 5.3 millions cubic meters (Mm³, Figure 4). The average SmARs' surface is 0.14 ha and 58% of them is smaller than 500 m². The largest reservoir has 4.54 ha area and only 29 reservoirs are wider than 1 ha.

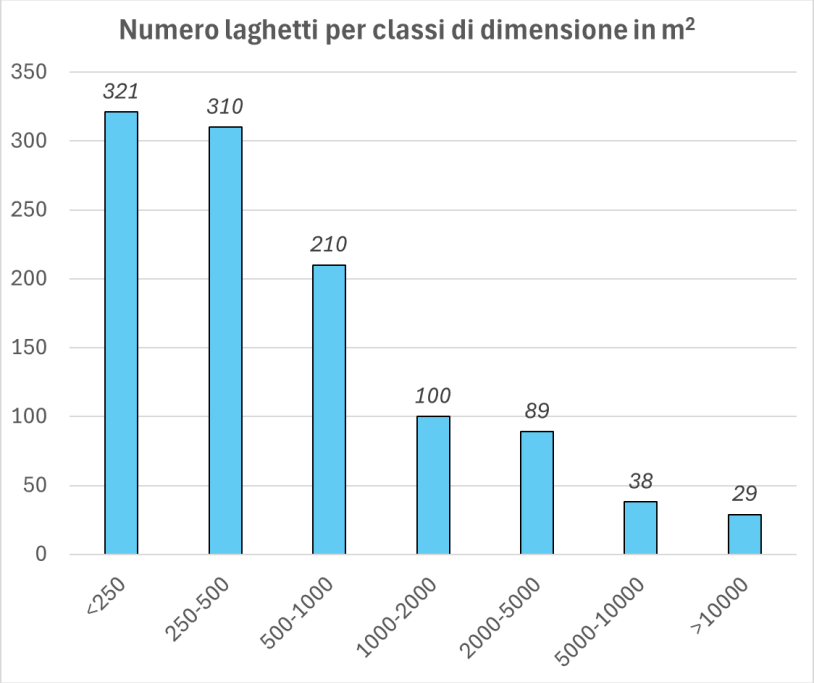

Figure 3. Number of SmARs by surface class.

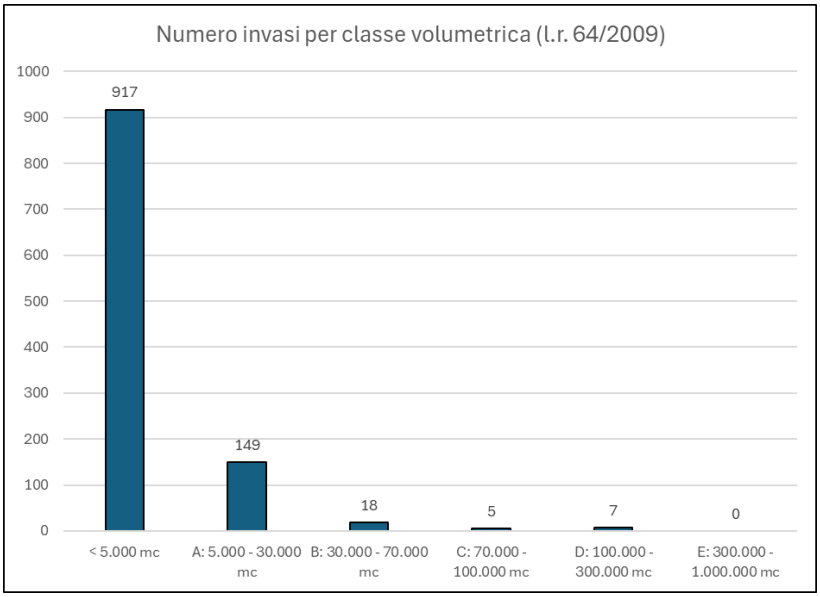

Figure 4. Number of SmARs by volume class, as defined per regional law L.R. 64/2009.

The production and utilization potential for other NCWs from technological solutions (e.g. treated wastewater and desalinated water) is low. Small-scale treated wastewater use for agricultural purposes is not economically and technically feasible also due to the low amount of water which can be reclaimed. Indeed, there are few urban centers with wastewater treatment plants. Nevertheless, wastewater for wineries are locally treated and utilized to irrigate the wineries' gardens or discharged into the Orcia river.

1.4 Synthesis of anthropic impact and pressure

Main water usages per sector

Val d'Orcia's population density is relatively low. Considering the 17 municipalities at least partially included in the Orcia watershed (Appendix 1), mean annual domestic water consumption between 2012 and 2021 was 5,19 Mm³ (elaborations based on Tuscany Water Authority and Regional Hydrological Service). Domestic water comes from springs or wells, more rarely from surface water bodies.
Although in the past vineyards and olive groves in Val d'Orcia were mainly rainfed, now irrigation is common in summer as droughts are increasingly frequent due to climate change (Bartolini et al., 2022). Most recent available data show an increase in irrigated surface from about 2302 ha (ISTAT, 2010) to 2711 ha (ISTAT, 2020) over a total of 40,500 ha of cropped surface (ARTEA, 2022), with an irrigation water volume of 5.64 Mm³ (ISTAT, 2010). According to the last agricultural census (ISTAT, 2020), the majority of irrigated surface (1990 ha, 73.4% of total irrigated area) uses water withdrawn from surface bodies within the farm, thus from SmARs.
Industrial water consumption is 6.19 Mm³ (elaborations based on Tuscany Water Authority and Regional Hydrological Service). Water used in wineries is drawn from groundwater or water conveyance networks, as surface water quality is not of suitable quality for wineries operations.

Flooding risk
Floodings are not a major risk in the Orcia watershed. The basin's flooding risk has been classified in three zones associated with three risk levels (P1, P2 e P3) (Piano di gestione del rischio di inondazione). In the Orcia watershed, 53 SmaRs are located in zone P1 (low flooding risk), 111 in zone P2 (intermediate flooding risk) and 52 in zone P3 (high flooding risk). Intense rainfall events are expected to increase (MASE, 2023) and this could affect the future flooding risk.

Pollution sources
Observed pollution comes from agricultural and urban activities. The main polluting pressure comes from agricultural diffuse pollution and nutrient load. To a lesser extent, there is pollution pressure from urban and industrial contaminants discharge. These pressures, either observer or potential, are due to nutrient, organic and chemical pollution (Tuscany Region). Many measures are being implemented to improve water quality.

Drought risk
Non-irrigated crops in Val d'Orcia are prone to drought and supplementary irrigation is considered a solution to this problem. According to the National Plan for Climate Change Adaptation, a slight increase in drought frequency is expected in many Italian areas, including central-southern Tuscany (MASE, 2023). Data from the Drought Observatory of the National Research Center - Bioeconomy Institute for the period 1982 - 2022, show for Val d'Orcia an increasing frequency of drought events since 2002 (Figure 5).

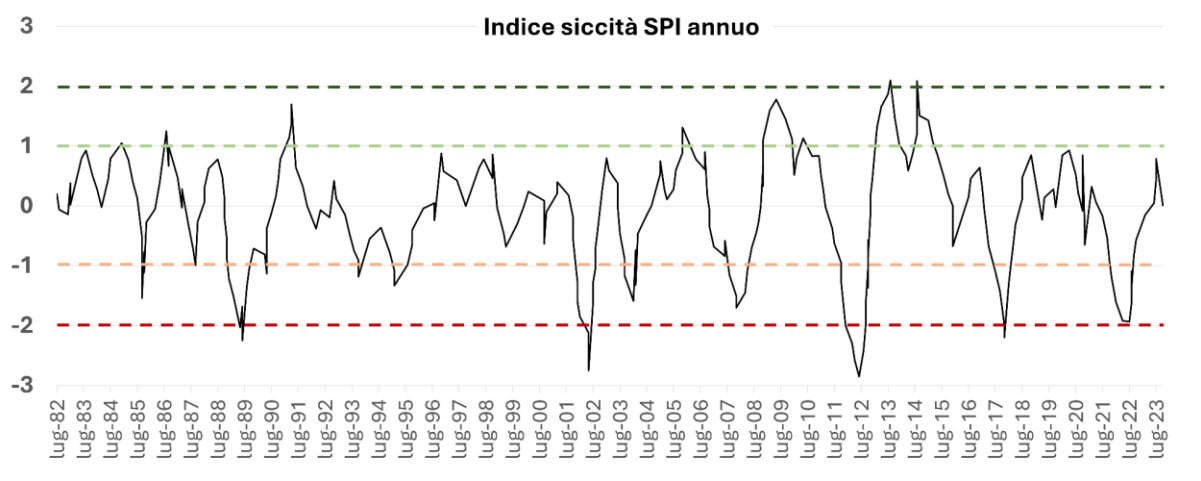

Figure 5. Drought index "Standardized Precipitation Index (SPI) - annual" in Val d'Orcia (https://droughtcentral.it/en/)

On the 13th of July 2016 the Water Utilization Observatory of the Watershed District Authority of Northern Apennine was established. It is the operational structure supporting the management of water resources and real-time monitoring of water availability and use.

With the Law 68 del 13/06/2023, the Observatory became an effective organ of the Watershed Authority in charge of evaluating the present water scarcity severity level (regular situation, low, medium and high severity) and its possible evolution through the elaboration of forecast scenarios and to formulate proposals to address it also including temporary limitations of water withdrawals. In case of high severity the prolonged drought conditions can be declared (Water Framework Directive 2000/60/CE) as well as the status of National Emergency (L. 225/1992).

1.5 Future water availability and needs perspectives

Water availability perspectives

The analysis reported in the recent National Plan for Climate Change Adaptation (MASE, 2023) shows that future precipitation in central Italy is highly uncertain due to differences in climate models outputs and possible different projected trajectories of greenhouse gases. However, temperature increases are clear (Piano di Gestione delle Acque, 2021). An increase of extreme precipitation events is also expected, together with a slight increment in drought frequency (MASE, 2023). A synthesis of different scenarios presented in the Watershed District Authority of Northern Appennine's Water management Plan reports a reduction in projected future precipitation (Piano di Gestione delle Acque, 2021).

More locally, Table 1 shows the results of climate and hydrologic simulations created within AG-WaMED project referring to the annual average discharge of Ombrone river from which data for Orcia watershed area can be retrieved.

Both hydrological models (H08 and CWatM) in different scenarios (SSP126, SSP370 and SSP585) project a reduction in average annual flow of Ombrone watershed over time. The mean annual flow, estimated at 0.92 km³/year from 1980 to 2019, is expected to range from 0.87 to 0.96 km³/year for 2020-2059 and between 0.68 and 0.94 km³/year for the 2060-2099

period. This represents a reduction up to 6% for the period 2020-2059 and up to 27% for the 2060-2099 period.

Regarding the low-emission scenario (SSP126), model outputs' average shows that water availability will increase; while in the other scenarios (SSP370 e SSP585), it will reduce especially for the period 2060-2099.

For Val d'Orcia, mean annual discharge contribution shows a ~ 31% reduction in SSP585 long-term (2080-2100) scenario, compared to historical measurements. In current conditions, if maintained, Val d'Orcia is and will remain severely exposed to these flux variations. Indeed, irrigation water comes almost exclusively from rainwater stored in reservoirs.

Table 1. Future scenarios for Ombrone watershed (units km³/year).

Scenario	obsclim 80-19	historical 75-14	ssp126 20-59	ssp370 20-59	ssp585 20-59	ssp126 60-99	ssp370 60-99	ssp585 60-99
gswp3	0.92							
gfdl		0.97	1.18	0.93	1.04	0.87	0.83	0.73
mri		0.96	0.94	0.90	0.98	1.01	0.88	0.74
ipsl		0.98	0.89	0.79	0.76	0.91	0.62	0.55
mpi		0.96	0.79	0.71	0.82	0.90	0.67	0.73
ukesm1		1.01	1.00	1.01	0.83	1.01	0.91	0.66
mean	**0.92**	**0.98**	**0.96**	**0.87**	**0.89**	**0.94**	**0.78**	**0.68**

Source: AG-WaMED, 2024.

A following, more detailed study carried out within AG-WaMED project considering only the Orcia watershed and the worst emissions scenario confirms the general trends of temperature increase and rainfall reduction both regarding annual and only summer periods (Figure 6). The climate models ensemble using SSP585 scenario forecasts for the end of this century a ~20% precipitation reduction and an almost 5°C increase in annual temperatures.

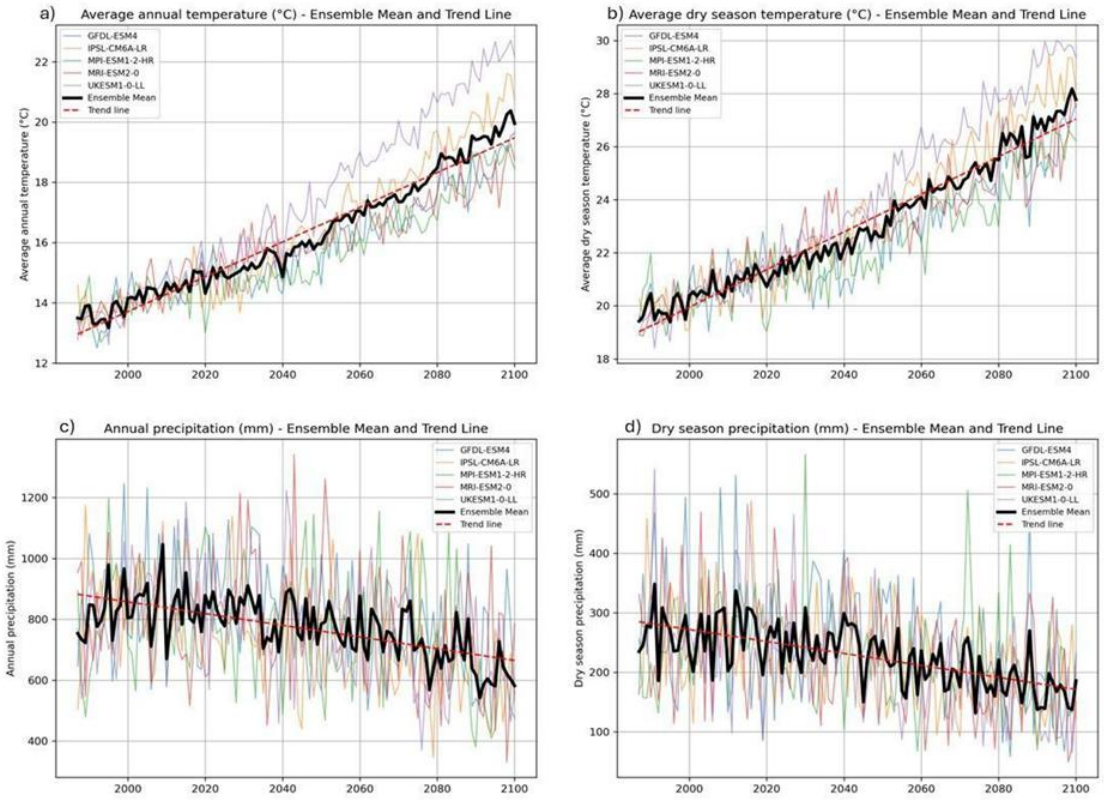

Figure 6. Future temperature and precipitation scenarios in Val d'Orcia. Only the more "pessimistic" greenhouse emissions scenario (RSP 8.5) has been considered.

Water needs perspectives

Domestic water demand

The current Val d'Orcia's population density is relatively low. It is one of the lowest among those of Northern Apennine district's basins, ranging between 20 and 70 inhabitants/km² (Piano di gestione delle acque, 2021). This decreasing trend could intensify due to Italian rural areas' depopulation and population aging. Thus, an increase in future domestic water demand is not expected.

Agricultural water needs

To estimate agricultural water demand WATNEEDS model outputs have been used, specifically applying the model to the four AG-WaMED's Living Labs. The model effectively represents the main water balance's processes at field scale and utilises as inputs regional, national and european scale data. However, not all the physiological processes relative to each crop are considered, and input data may not always be updated to the last years. Consequently, model's specific outputs are prone to noticeable uncertainties even though they are extremely useful to describe the current situation and especially future irrigation water needs to optimize agricultural production. Figure 7 reports the rainfed and irrigated surfaces by main crop types in Val d'Orcia, while Figure 8 shows the blue water consumption and irrigation water requirements. Olive groves, which traditionally are not irrigated, have irrigation requirements of 4.96 Mm^3. The irrigation requirements of vineyards are currently only satisfied to an estimated 13%, leaving an irrigation unmet demand of approximately 7.3 Mm^3. Finally,

over 70% of irrigation requirements of other tree crops (e.g. fruit trees) are already currently satisfied. Total irrigation water requirements for Val d'Orcia estimated by WATNEEDS are 22.13 Mm^3 per year, showing that an increase in irrigated surface (mostly with the use of NCWs) could lead to significant increases of agricultural production in Val d'Orcia.

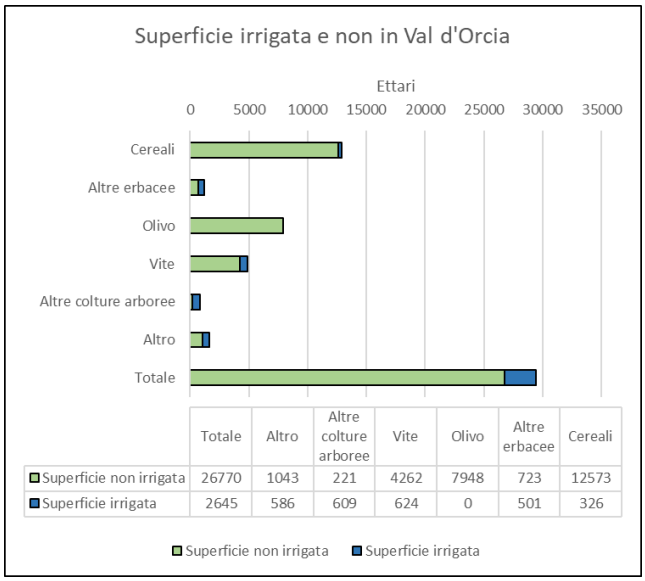

Figure 7: Irrigated and rainfed surfaces in Val d'Orcia from WATNEEDS model simulations carried out within AG-WaMED project.

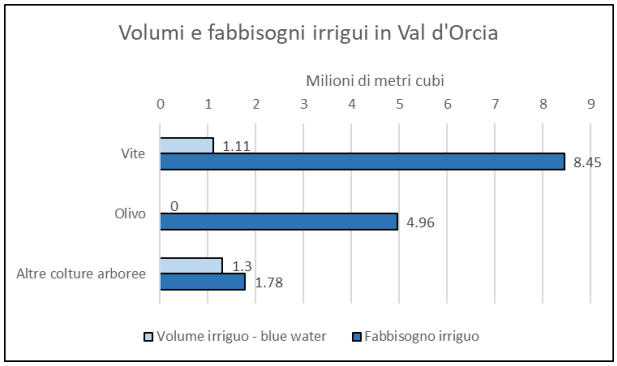

Figure 8: Available water volumes and irrigation needs in Val d'Orcia from WATNEEDS model simulations carried out within AG-WaMED project.

Balancing water availability and demand

In a climate change scenario, we expect an increase in irrigation water requirements both due to rising temperatures and to increased frequency and intensity of drought events. Effectively exploiting SmARs rainwater storage capacity represents a possible solution for climate change adaptation in Val d'Orcia.

At the same time, the installation of larger reservoirs could be another adaptation solution. In Val d'Orcia, in 2024 the prosecution of the works to build the San Piero in Campo dam (located close to Radicofani) was approved to increase water availability in the area. The project had been suspended in the '80 due to environmental issues while now it has been reconsidered due to prolonged droughts. A 1-million euros funding has been allocated for the feasibility

evaluation of the dam. This latter would have a potential capacity of 17 Mm^3 water and will be able to support a new irrigation district and favour groundwater recharge.

1.6 Economic considerations

Cereal crops (especially wheat), vineyards and olive groves have always characterised Val d'Orcia's landscapes and been central in its economy. In particular, wine production is an ancient tradition still ongoing and leading the touristic and economic development of Val d'Orcia. Landscapes are another important tourist attraction which have been classified as UNESCO World Heritage sites.

If water is a key element for economic development of the valley, its supply and usage costs definition is very challenging. It first depends on the quantity and type of water sources, and then on tariff changes. In particular, it is difficult for farmers using wells or private SmARs to determine the water price as it is not explicitly computed. This lack of information makes the evaluation of financial impact and profitability of NCWs for agriculture very difficult.

Regarding NCWs, although very local examples of cost analyses, these are valid only for the specific cases and cannot be generalized. As a general consideration, the NCWs-related costs are one of the major barriers hindering their utilization.

Part II Analysis of priority problems

1. Existing SmARs show severe issues related to their maintenance, especially due to sedimentation and their high restoration costs

Sediments' presence reduces available water storage volume and sediment disposal is really expensive for farmers. This is mainly due to the law "Regolamento recante la disciplina semplificata della gestione delle terre e rocce da scavo" (DPR 120/17) e DL 152/2006. According to this regulation, sediments are classified as waste, often making their disposal very expensive and challenging. Moreover, the law requires that a preventive evaluation of sediments' chemical quality must be carried out before reutilizing the sediments. However, it is unclear which characteristics determine if the sediments can be reutilized (i.e. can be spread on cropped fields to improve their agronomic qualities) and which ones have to be disposed as pollutants. Furthermore, even if sediments were reusable, farmers would need suitable fields (non-sloped terrains and not subject to landslides) to spread them. If these conditions do not apply, a possible solution would be allowing farms to stipulate agreements to spread suitable quality sediments in neighbouring farms' terrains with adequate characteristics. However, nowadays sediment transfer is not allowed by the law and their spreading is allowed only within the farm that "produces" the sediments.

2. Lack of physical room or suitable sites to realize new reservoirs

The main difficulties hindering new reservoirs' realization are the very high costs and the lack of suitable space. Realization criteria include the filling capability, terrain's slope, location and cost (if it is necessary to expropriate/buy it). In addition, the feasibility project has to undergo an environmental impact evaluation. Given these challenges, often farmers opt for alternatives such as the realization of wells. Furthermore, complying with the LR 64/2009 law where it applies requires the help of professionals who often are not familiar with this regulation and also due to this ask for significant fees (ANBI, 2022).

3. Numerous administrative obstacles hinder the realization and restoration of reservoirs

Farmers and other local and regional stakeholders have urged the Ministry to facilitate the creation of new reservoirs. Despite the promulgation of the so-called Drought Decrees (DL 39/2023) and decrees on flooding (DL 100/2023), which should improve the procedures to create hydraulic infrastructures, administrative difficulties persist due to the high number of authorizations required by many institutions at different level. These processes can require up to two years.

4. Absence of a collective regulation among farmers to share SmARs water which hinders the common utilization of this resource, preventing an optimized use and a reduction of operational costs

In Val d'Orcia, collective regulations for water sharing do not exist at any level. This lack of communication between users hinders an optimized management of water. Groundwater utilization is based on individual withdrawals without collective access regulation. Generally, all wells and SmARs are built for individual use. This prevents conflicts between owners/users of the same water source especially in water-scarce periods. Users are only required to

declare their annual consumption to the relevant authority. Occasionally, agreements between farms to share water can be reached.

5. Conflicts between cultural landscapes conservation and new reservoirs realization in downhill areas

Difficulties in new reservoir implementation are also due to deep tensions between a part of the local population worried for the future of agriculture and another focused on environment and cultural landscapes protection of Val d'Orcia. The national government allocated funds for new reservoirs but sometimes regional and local environmental departments block the implementation procedures. These associations claim that new reservoirs would significantly alter the landscape and/or cause environmental damage.

6. Water scarcity represents a significant challenge for rural development and farms' sustenance

Given this situation, many farms are looking for alternative income sources such as agrotourism. However, increased tourism means increased pressure on available water.

7. Unequal access to water stored in reservoirs and to water withdrawal authorizations exacerbate disparities between users

Obtaining new water withdrawal authorizations and difficult access to water infrastructure can cause inequalities. New authorizations are often denied while existing ones are renewed every 5 years (more frequently than in the past), causing uncertainties among farmers. At the same time, the majority of large farms ensured their own access to water through reservoirs building or obtaining authorizations to withdraw water directly from rivers, streams or other close surface water bodies. However, some farmers do not have the possibility to obtain these rights or to realize/restore reservoirs. The only remaining solution is to withdraw underground water, even if the Region is trying to limit this. The Tuscany Region recently promoted funding for reservoirs' realization and farmers can access it through a dedicated call. Moreover, a preliminary feasibility project for the public large San Piero in Campo dam has been approved. Nevertheless, these fundings are economically sustainable only for farms with high-quality high-added-value productions able to cover investment costs, which remain partially covered by farmers. Consequently, this kind of support tends to favour enterprises and farms with higher financial availability.

Part III Mid and long-term strategy

The strategy for a sustainable management of NCWs in Val d'Orcia has been co-created with local stakeholders and consists of a vision, four objectives and several implementation measures (Figure 10).

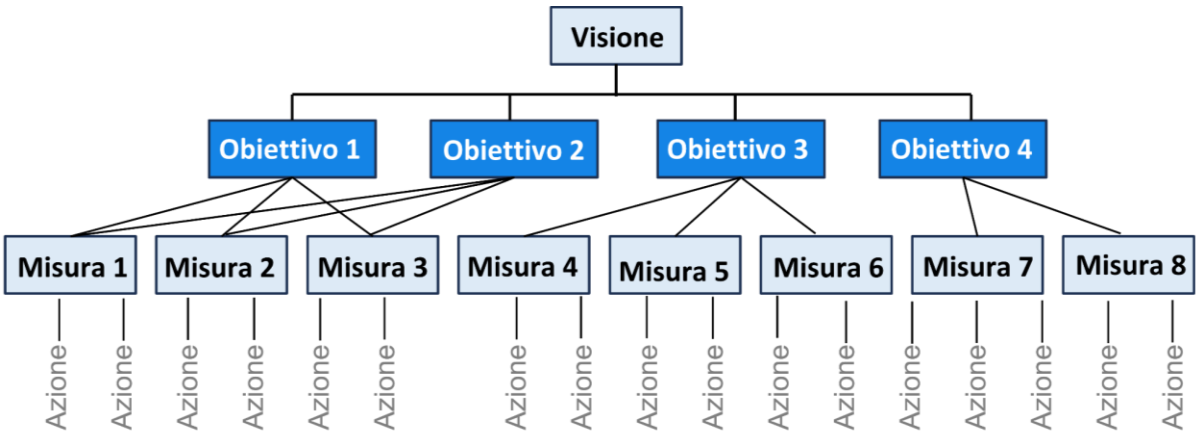

Figure 10. The vision, objectives and measures of the proposed strategy for NCW use promotion in Val d'Orcia

3.1 The plan's vision

The iterative definition of a shared vision with local Living Lab's stakeholders led to the common statement below:

"By 2040, all Val d'Orcia's farms will have the means to contrast water scarcity through the integrated territory and landscape management, access to a reliable water source, and agronomic innovation ensuring a sustainable and high-quality agricultural production."

3.2 The plan's objectives

Four strategic objectives are derived from the vision, focused on sustainable water management practices. The objectives aim to tackle the primary problems presented in Part II, particularly focusing on SmARs.

The four objectives are:

1. Promote the restoration and use of existing small private reservoirs that are currently underutilized.
2. Promote the creation of new private and public reservoirs in the most suitable areas, also taking into account the types of crops currently requiring irrigation.
3. Promote a culture of integrated water resource management through information and awareness-raising initiatives.
4. Valorize the multifunctionality (flood regulation, fire prevention, groundwater recharge, biodiversity) and shared use of small reservoirs.

The construction of a large reservoir in San Piero in Campo has been repeatedly mentioned by local stakeholders as a priority measure to improve the climate resilience of agriculture in Val d'Orcia. However, considering this plan's focus on non-conventional water sources, no specific objective regarding this reservoir has been included. These objectives and strategy are in line with the Water Framework Directive and the Floods Decree, as they do not conflict with the definition of rivers' ecological flow. While SmARs are unlikely to have a significant impact on flow regulation, the construction of the San Piero in Campo reservoir could have a positive effect on mitigating flood events in the Orcia river. Nevertheless, the impact on river flow of a large-scale structure like San Piero in Campo should be carefully assessed before its realization.

3.3 The Plan's measures

Figure 11 shows the medium- and long-term measures to be implemented in order to achieve the strategy's objectives. These measures were developed based on activities carried out within the Living Lab and were discussed during the final participatory workshop to assess their relevance.

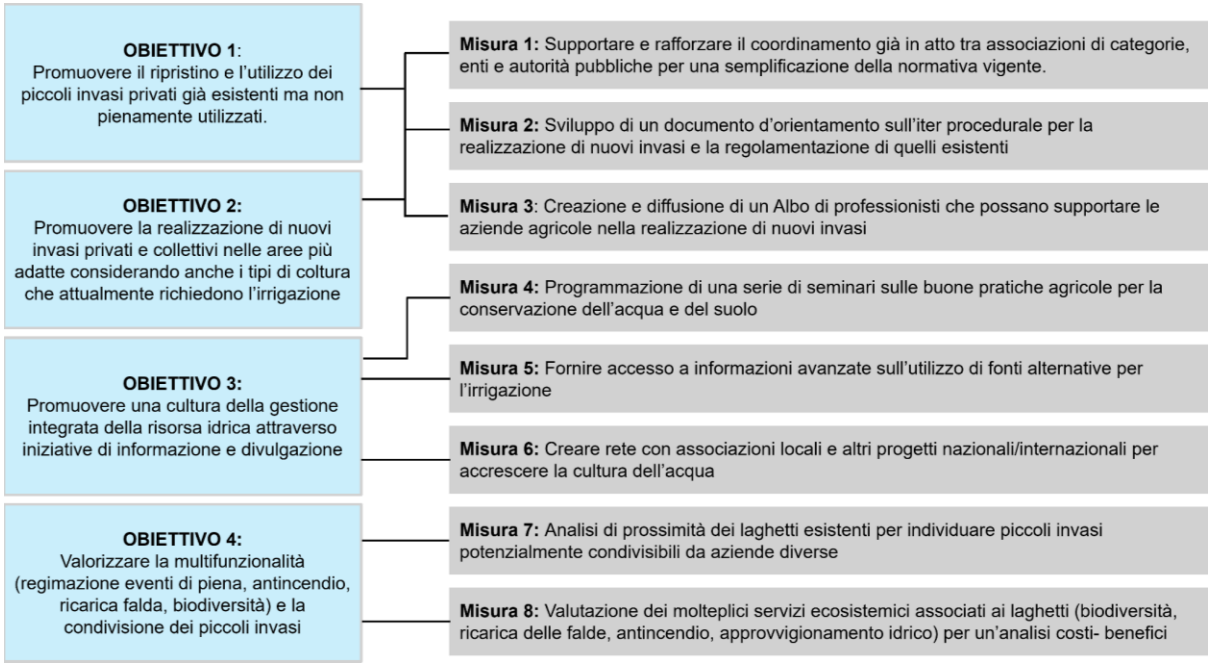

Figure 11. The strategy's 8 objectives and measures.

In the following tables, a brief description is provided for each measure, including the actions already undertaken and those required in the future for its implementation, as well as the time frame, the main issue it aims to address, and the stakeholders involved.

Measure 1	**Support and strengthen the coordination already in place among farmers associations, public bodies, and authorities to simplify existing regulations.**
Temporal frame	Medium-long term
Tackled problem	3. Numerous administrative obstacles prevent the implementation and restoration of reservoirs.
Description and possible future actions	This measure aims to support and continue the consultation and coordination activities already ongoing among the various stakeholders involved in the management and construction of SmARs. In particular, in 2022, discussions were held between the Tuscany Region, ANBI, and farmers associations (CIA, Coldiretti) concerning regulations related to the construction, maintenance, and compliance of existing reservoirs. Below are reported some suggestions for revising current regulations related to the construction of new reservoirs, as outlined in a document prepared by ANBI: 1. "Review the regulations for project approval and authorization for construction, simplifying the procedures for granting water withdrawal concessions for the rational use of public water. Administrative simplification could be achieved through better coordination among the bodies responsible for providing approvals, reduced interpretation of sector regulations by individual offices, and fewer requests for additional documentation on non-essential aspects, where necessary, further analysis could be postponed to later monitoring phases." (ANBI, 2022) 2. "To encourage the creation of SmARs in the stream network, reconsider the cases of exemption from liability to the Evaluation of Environmental Impact." (ANBI, 2022) 3. "Establish a regional steering committee/regional crisis unit/evaluation task force on reservoirs to assess the urgency and necessity of constructing such infrastructure. This would facilitate project preparation by starting from the beginning discussions with the proposing entity and defining a faster authorization process. For all authorizations, concessions, approvals, and permits, the 90/100-day decisional Services Conference should be chosen; or in case of Evaluation of Environmental Impact procedures under regional jurisdiction, to reduce the 305-day timeline required for the issuance of the PAUR - Provvedimento autorizzatorio unico di VIA " (ANBI, 2022) Additionally, regarding existing reservoirs' restoration, it is proposed that legislation on sediment removal should be designed and implemented to reduce reservoir maintenance costs and promote the reuse of nutrient-rich sediments in agricultural fields. This would also help lower production costs and minimize environmental impact. Finally, improved communication is encouraged among the various institutions and administrations involved in approving new reservoir construction and assigning water concessions, in order to facilitate the development of new irrigation water storage infrastructure.
Interested stakeholders	ANBI, CB6, farmers associations, agriculture entrepreneurs

Limitations	During the LL activities a discussion with the Regional Government highlighted that regional law cannot be revised as it dependent on national laws protecting public safety.

Measure 2	**Development of a guidelines document on the procedural steps for the construction of new reservoirs and the regulation of existing ones**
Temporal frame	Near term
Tackled problem	3. Numerous administrative obstacles prevent the implementation and restoration of reservoirs.
Description and possible future actions	This measure aims to create synergies between an initiative promoted by the Tuscany Region and the needs identified in the Val d'Orcia Living Lab. The Tuscany Region has prepared guidelines on current regulations to help farmers navigate the procedural steps required to regularize existing reservoirs. These guidelines will be published and promoted by the Region, alongside training courses for technical professionals. At the same time, members of the Living Lab - including some experts and farmers - have begun mapping the various checks involved in the procedural process (e.g., hydraulic risk, landscape protection obligations) and identifying the main difficulties encountered in building new reservoirs. Potential synergies between the two initiatives could include: ● Once the guidelines are published by the Tuscany Region, the Living Lab could promote their dissemination among local technicians and farmers. ● Given that the regional guidelines focus on the regularization of existing reservoirs, the guidance document produced by the Living Lab could instead focus on the procedural steps for the construction of new reservoirs, although the checks involved are very similar.
Interested stakeholders	Tuscany Region, ANBI, CB6, farmers associations, agriculture entrepreneurs, professionals
Limitations	The potential guideline document developed by the Living Lab would necessarily be general and would not take into account the specific circumstances of individual farms. It is therefore not intended to replace the expert advice of a professional consultant.

Measure 3	**Creation and diffusion of a professionals' list (Albo di professionisti) who could support farms during the reservoir realization process.**
Temporal frame	Medium-long term

Tackled problem	1. Existing SmARs face serious maintenance issues, primarily due to sediment accumulation, and their restoration requires prohibitive costs. 3. Numerous administrative obstacles prevent the implementation and restoration of reservoirs
Description and possible future actions	This measure aims to create a list of professionals with experience in assisting farms throughout the procedural steps for the construction, maintenance, and compliance of existing reservoirs. The list would serve as a reference point for farmers participating in the Living Lab. The need to support farms in navigating the complexity of current regulations has already been highlighted by ANBI, as illustrated in this 2022 excerpt: ● "Create dedicated teams of professionals with the support of Reclamation Consortia, farmers' associations, professional orders, and trained technical experts, capable of assisting reservoir owners in being excluded from regulatory frameworks when their structures do not fall under the definition of existing installations, and in the preliminary phases of the approval process (such as notifications for updating the regional reservoir registry, declarations of existence, or ACI record searches), as already required by Regional Law 41/2018 for the assessment of hydraulic risk in municipal spatial and urban planning." (ANBI, 2022) It is also proposed to establish forums for meetings and discussions among farmers located in nearby areas, in order to promote cooperation and gradually shift from individual to more collective practices, including the flexible use of reservoirs. The *Reclamation Consortium 6 Toscana Sud* could act as a support institution in developing these practices.
Interested stakeholders	Professionals, agriculture entrepreneurs, CB6, ANBI
Limitations	The actual interest of farmers in consulting the registry, and the willingness of professionals to be included in it, will ultimately determine the long-term effectiveness of this tool.

Measure 4	**Organization of a series of seminars on best agricultural practices for water and soil conservation**
Temporal frame	Near term
Tackled problem	1. Existing SmARs face serious maintenance issues, primarily due to sediment accumulation, and their restoration requires prohibitive costs.
Description and possible future actions	This measure aims to provide advanced information on agricultural land management to reduce erosion and the resulting sedimentation of reservoirs. It includes online meetings, seminars, and on-site demonstrations led by expert agronomists on topics such as keyline design, on-farm water retention techniques, and soil regeneration practices.
Interested	Professionals, agriculture entrepreneurs, farmers associations.

stakeholders	
Limitations	Close collaboration with farmers associations is essential to ensure these initiatives effectively reach farmers.

Measure 5	**Provide access to advanced information on the use of alternative sources for irrigation.**
Temporal frame	Near term
Tackled problem	6. Water scarcity represents a significant challenge for rural development and the sustenance of agricultural activities.
Description and possible future actions	This measure responds to the interest expressed by Living Lab members in acquiring information on the use of other NCW sources for irrigation. Therefore, dissemination initiatives are proposed on the use of treated wastewater (from households, hospitality facilities, and winery processing), as well as on aquifer recharge, in collaboration with specialized companies and research centers active in the sector.
Interested stakeholders	Farms, agriculture entrepreneurs, research centres
Limitations	-

Measure 6	**Build networks with local associations and other national/international projects to foster a water-conscious culture.**
Temporal frame	Medium-long term
Tackled problem	6. Water scarcity represents a significant challenge for rural development and the sustenance of agricultural activities.
Description and possible future actions	This measure aims to further raise awareness among the local population on issues related to drought, water resource and land management, and sustainable agriculture. The goal is to create synergies with local organizations and associations that have long been active on these topics in Val d'Orcia, in order to organize informative events and citizen engagement initiatives.
Interested stakeholders	Universities, civil society, farmers associations, vocational schools of agriculture.
Limitations	-

Measure 7	**Identification of existing SmARs or areas suitable for the construction of new reservoirs that could potentially be shared by different farms.**

Temporal frame	Medium-long term
Tackled problem	2. There is a lack of physical space and/or suitable sites for the construction of new reservoirs. 7. Unequal access to water stored in reservoirs and to water use permits exacerbates disparities and inequalities among users.
Description and possible future actions	• Conduct a geospatial proximity analysis to identify which existing reservoirs could potentially be shared by multiple farms. Initially, the analysis will focus on wineries, assessing the proximity between existing ponds and vineyards belonging to different agricultural holdings. • Support small farms in finding solutions suited to their needs, for example by creating shared reservoirs that can be used by three or four small farms that lack the land and financial resources to build a private reservoir.
Involved stakeholders	Universities, CB6, agriculture entrepreneurs.
Limitations	Lack of regulation on water sharing that could prevent the emergence of conflicts.

Measure 8	**Assessment of the multiple ecosystem services provided by SmARs (biodiversity, aquifer recharge, fire prevention, water supply) for a cost-benefit analysis.**
Temporal frame	Medium-long term
Tackled problem	5. Tensions exist between the preservation of cultural landscapes and the construction of new reservoirs in lowland areas.
Description and possible future actions	This measure aims to promote the multifunctionality of SmARs through an assessment of the various ecosystem services they provide, highlighting their role in aquifer recharge, wildfire mitigation, and biodiversity support, in addition to their use for irrigation water supply. Also for this measure, we include an excerpt from the ANBI document: *"Promote incentive schemes and facilitations (regional funding for farms to secure their infrastructure, irrigation benefits for making reservoirs available for collective consortia use, municipal tax reductions for making reservoirs available for fire prevention purposes)"* (ANBI, 2022).
Interested stakeholders	Universities, environmental associations, civil society, agriculture entrepreneurs, farmers associations, CB6.
Limitations	Funding availability to carry out a research project on ecosystem services.

3.4 Funding strategy

This section presents the financial details and the stakeholders involved in the implementation of the action plan for the restoration and installation of small agricultural reservoirs. The implementation of this plan should follow and apply the "polluter pays" principle. In this regard, each user should pay a contribution/fee based on the amount of resources used or polluted.

To estimate funding for the plan, we refer to the strategy and financing model established in the 2021–2027 Water Management Plan for the Northern Apennines and its results. In that plan, the considered water uses (domestic, agriculture, and industry) contribute proportionally to the overall cost coverage: drinking water accounts for 72% of the total costs of the planned measures, agriculture and livestock 17%, and industry 11%. However, despite this, the plan is not fully funded as it includes measures amounting to €2,714.36 million, of which only €1,277.15 million had confirmed financial coverage at the time the plan was drafted (Water Management Plan for the Northern Apennines 2021–2027).

In the case of the management plan presented here, funding for the restoration of existing reservoirs and the installation of new ones could be partially covered by farmers, as well as by various national and European institutions.
The financing methods can be defined based on available grants and the financial capacity of the farmers.

The involvement of the following authorities would be essential:

- At the national level, the Ministry of Agriculture and regional authorities could offer subsidies and funding to improve irrigation systems.
- At the European level, funding could come from the National Rural Development Programme (PSRN), financed by the European Union and the Italian government, as this program aims to modernize irrigation systems and promote sustainability in the agricultural sector.
- Lastly, farmers could contribute individually, based on their income, or collectively through *Irrigation and Land Reclamation Consortia* (*Consorzi di Irrigazione e Bonifica*), which manage irrigation networks and collect mandatory fees to finance operations and maintenance.

3.5 Integrations in the current legislation

Modification of the DPR 120/17

To improve sediment management, it is essential to define clear reuse criteria. One recommendation is to establish clear and specific criteria to determine the characteristics of reusable sediments. Therefore, it is important to develop detailed guidelines based on standard chemical analyses to assess sediment quality. A simplification of sediment quality assessment procedures is also fundamental.

Another crucial recommendation is to expand existing regulations to allow the transfer of reusable sediments to agricultural land, even when it is not owned by the "producer" farm. This requires proposing legislative amendments and implementing mechanisms for training, awareness-raising, monitoring, and regulation of sediment transfers between companies and farmers.

Modification of the River Basin Management Plan and related measures

Measures for the restoration and creation of new reservoirs should be integrated into the River Basin Management Plan and programming measures of the Northern Apennines District Basin Authority, as well as in the definition of ecological flows.

Italy's transposition of the EU Water Framework Directive, known as Legislative Decree No. 152/2006, established specific principles and provisions for integrated water resource management in the country. It aims to protect and improve water quality, conserve aquatic ecosystems, and promote sustainable water use.

According to Legislative Decree No. 219/2007, the River Basin Authorities play a coordination role in implementing the Water Framework Directive within their respective districts. Their River Basin Management Plans and related measures should integrate specific actions to address the reduction of water availability, such as strengthening reservoir systems in critical areas like the Val d'Orcia.

Defining a proactive, long-term drought management plan

In April 2023, the Italian government approved the so-called “Drought Decree”, aimed at preventing and combating water scarcity while improving water infrastructure. In Tuscany, emergency measures are often approved to cope with droughts and floods. Instead of relying on emergency measures, the national and regional governments, ministries, and basin authorities—should implement a Drought Management Plan, to proactively manage water scarcity also in the long term, in Val d’Orcia as well.

Strengthening stakeholder participation

Stakeholder participation in the preparation of the River Basin Management Plan of the Northern Apennines District Basin Authority must be strengthened. According to the EU Water Framework Directive and its transposition into Italian law (Legislative Decree No. 152/2006), transparency and participation are key pillars of water governance.

River Basin Authorities should actively encourage participation during the preparation of Management Plans and Programmes of Measures, by carrying out participatory processes that integrate the views and needs of different users to define reconciliatory solutions.

Another possible instrument to promote participation is the **"**Contratto di Fiume" (*River Contract*), recognized under Legislative Decree No. 152/2006. This is a voluntary territorial governance tool within a river basin, offering an innovative governance approach that can help develop strategies and actions for building territorial resilience, including identifying local solutions to balance agricultural and tourism interests in the Val d'Orcia.

More flexible water concession procedures

Water concession procedures should be adapted to meet varying annual needs, while still providing clarity and security for both large and small-scale farmers. In Italy, the authority responsible for issuing water use rights is the "Servizio Idrografico e Mareografico Nazionale (SIMN)", belonging to the Ministry of Infrastructure and Transport. SIMN issues permits and concessions for water uses including public supply, agricultural irrigation, industry, and hydroelectric power generation.

These permits and concessions must define the rights, conditions, and responsibilities associated with water use, taking into account both local needs and water availability in the Val d'Orcia.

3.6 IWMP socialization

Beyond a funding strategy and integration into existing legislation, the implementation of the Integrated Water Management Plan (IWMP) for the Val d'Orcia requires a broader dissemination and consultation process aiming at building societal consensus around the identified priorities and proposed measures.

The participatory approach adopted by the AG-WaMED project in the Val d'Orcia Living Lab has already enabled an initial evaluation of the strategy (vision, objectives, and measures), ensuring its alignment with local needs. However, given the relatively small number of local stakeholders who actively contributed to the strategy's development, dissemination of the Plan will be pursued through presentations to public local and regional authorities, as well as to farmers' associations and professional orders.

In addition, the intervention priorities identified in the Plan will be submitted as contributions to the Water Protection Plan of the Tuscany Region and to the Water Management Plan (PGA) of the Northern Apennines District Basin Authority, both of which foresee a public consultation phase.

Creating synergies between this document and official planning tools would support greater recognition of the role of unconventional water resources in water management policies.

The implementation of the IWMP will take place through the execution of the measures proposed in Part III of this document. Starting from the individual measure sheets, specific activities will need to be defined, responsibilities assigned to relevant stakeholders, and potential funding sources have to be identified.
The Implementation should follow a participatory process with local actors, as outlined in steps 6, 7, and 8 of the RRI Roadmap©^{TM} methodology.

It will therefore be important to establish a continual collaboration framework with the Living Lab members that is officially recognized and provides the necessary tools and resources.

In an initial discussion with local stakeholders, several options were proposed, in order of preference: the inclusion of the Val d'Orcia Living Lab in future research projects, the participation in a memorandum of understanding and the creation of a non-profit association.

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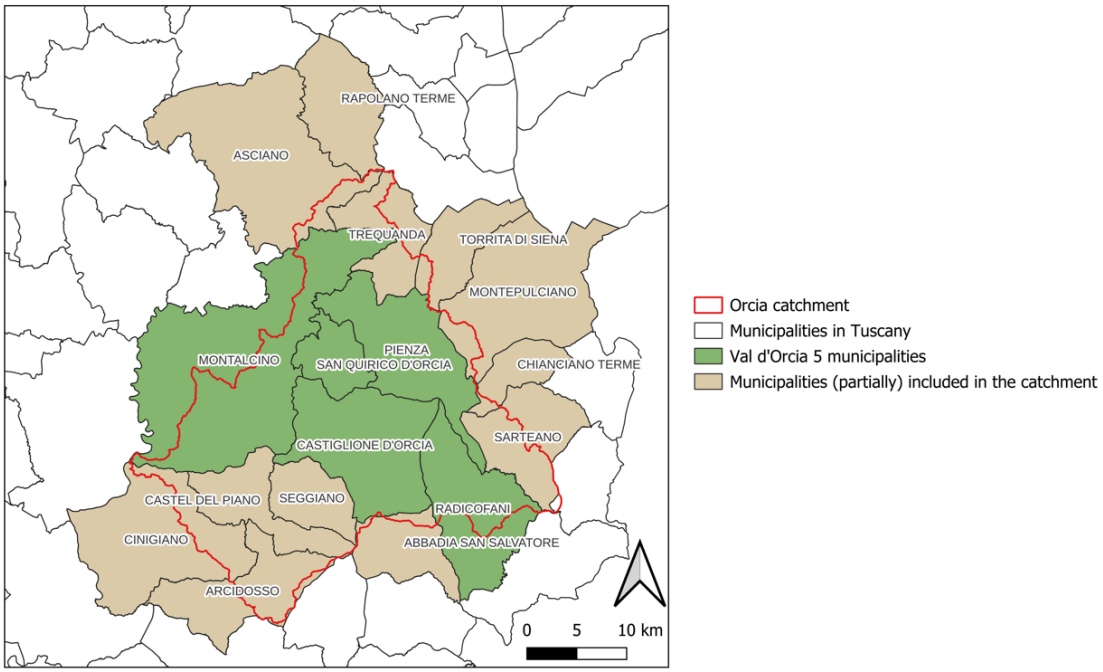
Appendix

Appendix 1. Val d'Orcia municipalities map, with the 5 municipalities consituting Val d'Orcia and the 17 municipalities at least partially included in the Orcia basin.



Appendix 2. Map of Val d'orcia's protected areas included in Natura2000 network.