

CAN WATER STORAGE FOSTER TERRITORIAL AGROECOLOGICAL TRANSITIONS IN A WATER-STRESSED AREA?

EST-CE QUE LE STOCKAGE DE L'EAU PEUT ENCOURAGER LES TRANSITIONS AGROÉCOLOGIQUES TERRITORIALES DANS UNE ZONE SOUMISE À UN STRESS HYDRIQUE?

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ABSTRACT

The relationship between agroecological transitions and the sharing of water is central for irrigated territories, as water access is a core element of farm productivity and resilience. This makes the equitable sharing of water a major driver of both agricultural dynamics and agroecological transitions of the larger territory, especially as climate change negatively impacts water needs and access.

To address these challenges, “substitution” reservoirs are widely considered in countries like France. These highly contested forms of storage are heterogeneous in terms of size, type of water inflow, governance and intended use. They are built to procure water during high-flow periods (typically autumn and winter) either to substitute for withdrawals during low-flow periods, to provide security against potential droughts, or to increase the volume of water available for irrigated agriculture.

The objective of this paper is to understand how various storage projects affect the dynamics of agroecological transitions in irrigated agricultural territories, using the Drôme Valley (France) as case study. It is a prominent irrigated area where storage development and agroecological transition dynamics are both pronounced. Public actors and a segment of the local civil society share an ambition to create an agroecological territory, whether through local agricultural policies or watershed-scale water-management policies. We show that these infrastructures have heterogeneous impacts on agricultural dynamics. If larger storage projects tend to promote the preservation of highly capitalized and water dependent farms, small-scale reservoir have allowed to sustain agroecological transition dynamic in the regions. This study offers insights on how to create an institutional framework that enables the development of storage facilities to support the agroecological transition.

Keywords : Water storage; farm productivity; agricultural dynamics; agroecological transitions; small-scale reservoir.

RESUME

La relation entre les transitions agroécologiques et le partage de l'eau est cruciale pour les territoires irrigués, car l'accès à l'eau est un élément essentiel de la productivité et de la résistance des exploitations agricoles. Cela fait du partage équitable de l'eau une force majeure tant de la dynamique agricole que des transitions agroécologiques à l'échelle du territoire dans son ensemble, d'autant plus que le changement climatique exerce un impact négatif sur les besoins en eau et l'accès à celle-ci.

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Afin de relever ces défis, les réservoirs de «substitution» sont largement tenus en compte dans les pays comme la France. Ces formes de stockage très controversées sont hétérogènes en termes de taille, de type d'apport en eau, de gouvernance et d'utilisation prévue. Elles sont construites pour capter de l'eau pendant les périodes de débit élevé (généralement l'automne et l'hiver), soit pour compenser les prélèvements effectués pendant les périodes de faible débit, soit pour offrir une sécurité contre l'éventuelles sécheresses, soit encore pour augmenter le volume d'eau disponible pour l'agriculture irriguée.

Cet article vise à comprendre la manière dont divers projets de stockage exercent des impacts sur la dynamique des transitions agroécologiques dans les territoires agricoles irrigués, en prenant en compte l'étude de cas menée dans la vallée de Drôme (France). Il s'agit d'une zone irriguée importante où le développement des infrastructures de stockage et la dynamique de transition agroécologique sont tous deux marqués. Les acteurs publics et une partie de la société civile locale partagent l'ambition de créer un territoire agroécologique, que ce soit par le biais de politiques agricoles locales ou de politiques de gestion de l'eau à l'échelle du bassin versant.

Nous montrons que ces infrastructures exercent des impacts hétérogènes sur les dynamiques agricoles. Si les grands projets de stockage tendent à encourager la préservation d'exploitations agricoles fortement capitalisées et dépendantes de l'eau, les réservoirs à petite échelle ont permis de soutenir la dynamique de transition agroécologique dans ces régions. Cette étude fournit un aperçu sur la manière de créer un cadre institutionnel permettant le développement d'infrastructures de stockage favorisant la transition agroécologique.

Mots-clés : Stockage de l'eau; Productivité agricole; Dynamiques agricoles; Transitions agroécologiques; Réservoirs à petite échelle.

INTRODUCTION

The relationship between agroecological transitions and the sharing of water resources is central in irrigated territories. Agroecology, defined as a re-organization of agricultural production systems across multiple scales, from the farm to the entire agri-food system, with the explicit goal of fostering more just and sustainable modes of production (Gliessman, 2018) is particularly played out at the territorial scale. This scale constitutes a pivotal link for establishing sustainable food systems (Caron et al., 2018) and for conserving natural resources (Wezel et al., 2016). Its importance is even greater in irrigated agricultural regions, where water access is a core element of farm productivity and resilience (Hossard et al., 2021), making the equitable distribution of water a major driver of both agricultural dynamics and the agroecological transition of the territory.

The issue of water sharing is becoming all the more pressing as climate change exerts a “scissors” effect on irrigated territories. On the one hand, water availability is declining especially during low-flow periods as stream discharges fall and aquifer recharge capacity diminishes. On the other hand, plant evapotranspiration is intensifying, leading to increasing irrigation water requirements for irrigated crops and new water needs for crops that have historically been rain-fed (Calvin et al., 2023).

To address these challenges, action can be taken either on the supply side by developing hydraulic infrastructures or on the demand side. Demand-side measures may be implemented directly, through the imposition of restrictions and the regulation of water-sharing, or indirectly, by promoting the development of food supply chains with low water consumption. Historically, the former option has been pursued, leading to the massive global expansion and intensification of irrigation; and this solution continues to be considered in many territories affected by drought (Mehta et al., 2024).

Among supply side solutions, “substitution” reservoirs are widely considered. These are smaller-scale structures than conventional dams that aim to shift water temporally in order to meet demand. They store water during high-flow periods to release it during low-flow periods, thereby alleviating pressure on water resources during low water periods. Although such facilities have existed since the 1980s, their deployment has accelerated in recent years in response to water-resource depletion and

climate-change impacts (Schmitt et al., 2022). These new storage forms are highly heterogeneous in terms of size (from a few hundred cubic meters to several million), the type of water inflow (run-off capture, groundwater or river pumping, etc.), governance (individual or collective), and intended use (Payen et al., 2019). They are built to procure water during high-flow periods (typically autumn and winter) either to substitute for withdrawals during low-flow periods, to provide security against potential droughts, or to increase the volume of water available for irrigated agriculture.

There is a public debate on the substitution reservoirs in countries like France, alerting to the double risk of infrastructure benefiting only “a particular agricultural system or sector, water users, etc.” to the detriment of other users, and of negative hydrological impacts due to a lack of monitoring to verify that the foreseen hydrological conditions are met (Aubertin et al., 2023). These authors, all members of the Agricultural Academy of France, plead to condition the authorization of such reservoirs to a comprehensive monitoring of water resources, to agroecological transitions and to more inclusive governance mechanisms. Despite the highly polarized nature of the public debate with prominent social movements, the literature on the consequences on agricultural and agroecological transition dynamics associated with water storage is scarce. One strand of research emphasizes the potential of such infrastructure for expanding irrigated areas, thus increasing yield and resilience to drought (Khasanov et al., 2025; Smith & Edwards, 2021) and climate change (Heinzel et al., 2022). On the contrary other research shows how water storage promotes a shift towards productivist agriculture rooted in conventional practices (Billaud & Temple-Boyer, 2010), thereby increasing the vulnerability of agricultural territories to prolonged drought periods. Finally, other studies show that small-scale storage techniques have historically been widely used as sources of livelihood and diversification (Spielman et al., 2021), enabling a diversified local production and sustaining small farms. From the perspective of water access - an essential issue for agroecological transitions in irrigated territories (see Leauthaud and Leenhardt, 2025) - the effects of these storages can also be highly variable, depending on the governance regime. Implementation rules can, in fact, generate inequalities among farmers and among different irrigators (Aubertin et al., 2023), yet few comprehensive studies have examined this topic. Indeed, the great diversity of storage facilities makes it difficult to identify their effects. For example, from a hydrological perspective, it has been shown that each storage unit can produce differentiated impacts depending on its mode and timing of water intake (low-flow or high-flow periods) (Habets et al., 2018). Likewise, the cumulative effect of the various storages at the watershed scale is hard to quantify (Carluier et al., 2016).

The objective of this research is to understand how various storage projects affect the agroecological transition dynamics in irrigated agricultural territories. The Drôme Valley (France) was selected as a case study. It is a predominantly irrigated area where storage development and agroecological transitions are both pronounced. Public actors and a segment of the local civil society share an ambition to create an agroecological territory, whether through local agricultural policies or watershed-scale water-management policies. After presenting the case study and methodology, the results will be detailed and discussed.

CASE STUDY

The Drôme Valley is a southeastern French territory at the edge of the Mediterranean arc, strongly marked by the expansion of irrigation (Figure 1). Although productivist modernisation of agriculture in the valley began in the post-war period, it was the expansion of irrigation that profoundly transformed farming in the area (Bouihed, 2021). A collective irrigation network was constructed in the valley starting in 1979, followed by the deployment of individual and collective direct river pumping and, from the early 1990s, supplementary groundwater abstraction. In the lower valley, farms that secured water access were able to shift toward orchard cultivation and, above all, to large-scale specialized crops: initially maize, then seed production, and, over the past fifteen years, garlic. This shift occurred at the expense of livestock production, which progressively retreated to non-irrigable zones. Up-river, irrigation was less extensive, yet it still enabled the introduction of specialized crops on some farms and the establishment of diversified farms that operate short-circuit vegetable production units and adopt practices close to agroecology.

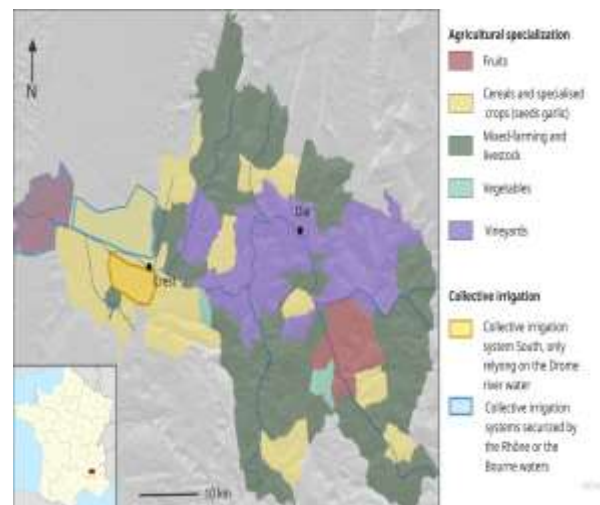


Figure 1. Map of the Drôme Valley agricultural specialization and main collective irrigation infrastructures

From the 1990s onward, the Drôme Valley became, through multiple initiatives of several municipalities and an agricultural settlement movement, a pioneer region for agroecological transitions (Bui, 2015), achieving one of the highest organic-farm shares in France (30 % of the agricultural surface area) (French Agricultural Census, 2020)

However, the surface and groundwater resources of the Drôme Valley, on which the expansion of irrigation has depended, experience important low flow periods. This has created recurrent water-scarcity situations. This does not only affect intensive and conventional farming systems, but also agroecological farms. Withdrawal restrictions were implemented for eight out of ten years since 2014 (Vigi'EAU, 2025). Two types of solutions have been deployed to avoid the recurrence of the effects of such crises. First, hydraulic infrastructures have been built to maintain and increase water supply by importing water from other basins. Since 2006, water from the Bourne canal and, since 2022, from the Rhône River have been conveyed into the valley, together supplying more than half of the volumes used by the collective irrigation network.

Second, institutions and rules for collective water governance have been established (Girard, 2012). The Water Development and Management Scheme (Schéma d'Aménagement et Gestion de l'Eau or SAGE) was adopted in 1992 and renewed in 2012 and 2025, setting a withdrawal ceiling of 4.9 million m³ during low-flow periods for agricultural use. It represents a 16% reduction compared with historic withdrawals. In addition, since 2012, the regional Chamber of Agriculture has operated a Unique Collective Management Organism (Organisme Unique de Gestion Collective or OUGC) that allocates each year the authorized withdrawal volumes to the various agricultural actors.

Although the SAGE defines several pillars such as “sobriety,” “resilience,” and a “fair sharing of the resource” (SAGE, 2025), the use of storage is regarded as unavoidable for adapting to climate change. At least a dozen individual storage reservoirs have already been constructed, and three collective-storage projects, including one of one million m³, have been identified. Individual storages are initiated by the farmers themselves, sometimes with technical assistance from the Chamber of Agriculture and regional subsidies. Collective-storage projects are promoted by the irrigation association (Syndicat d'irrigation) and by local authorities.

MATERIAL AND METHODS

To assess the effects of these storages on agroecological transitions, interviews were carried out with 36 farmers and with 7 public actors involved in water-resource management. The farmers were selected to represent the diversity of farms and farming systems in the valley. In order to gain a deeper understanding of the storage-construction phenomenon, farmers who already had implemented storage

projects were deliberately included in the sample. They were questioned about the structure of their farm, the types of practices they employ, their water-access conditions, and their future strategies, with particular focus on agroecological approaches and water-access strategies. Farmers who were engaged in a storage project were asked additional, project-specific questions (motivation, cost, desired volume, intended use, etc.).

Institutional actors interviewed who play a key role in storage projects (project sponsorship, funding, and regulation) were interviewed: inter-municipalities (2), collective and individual irrigation associations (2), the Chamber of Agriculture (1), the OUGC (1), the mixed basin-scale committee (1), and the administrative Region funding program (1). They were interviewed through semi-structured interviews in which the following topics were explored: their institution's strategy regarding water-access, agroecological transition, and any potential sponsorship of storage projects. This survey was complemented by an analysis of grey literature on local water management, funding sources, and the regulatory framework governing the construction of storage facilities.

RESULTS

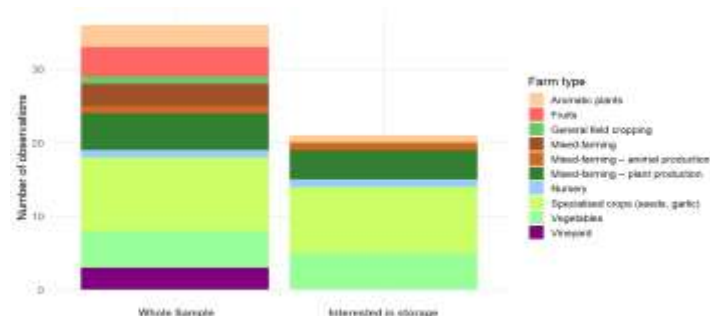
This section presents the results, beginning with a review of the determinants of interest in storage, then outlining the diversity of storage projects and their associated uses, and finally describing the effects of storage deployment on the agroecological transition

Production type and water access: key determinants of interest in storage

Water scarcity during the summer period is one of the main concerns of interviewed farmers (33 out of 36 farmers). More than half of them (20) view storage as a feasible solution for their situation, whether the facility is already built (9) or still at the project stage (11). This differentiated interest can be explained by both the type of production and the type of water-access, two factors that are themselves closely related.

However, storing water is not part of the management strategy of the majority of dry-land farms. Apart from farm creations, only two respondents (out of 8) mentioned storage as a possible strategy, one of them already having a built facility. This limited interest reflects the fact that these farms are predominantly specialized in livestock production or vineyards, where water access is not a priority. Livestock-dominated farms generally do not grow high-value vegetable crops such as garlic or seed, so investing in storage infrastructure does not make sense. Likewise, wine growers do not consider irrigating vineyards because irrigation offers only limited mitigation against the multiple stressors that affect vineyards, notably hail, summer heatwaves and a lack of market outlets.

Except for vineyards and livestock, most surveyed farms have a substantial share of their production and revenue that depends on irrigation: on average they estimate that 68.5 % of their output is irrigation-dependent. Nevertheless, not all of them mention storage as a strategy. The four downstream fruits producers interviewed have individual groundwater-pumping access to the aquifer of the Drôme; they consider their water access to be secure and sufficient. The same holds for the three farmers who



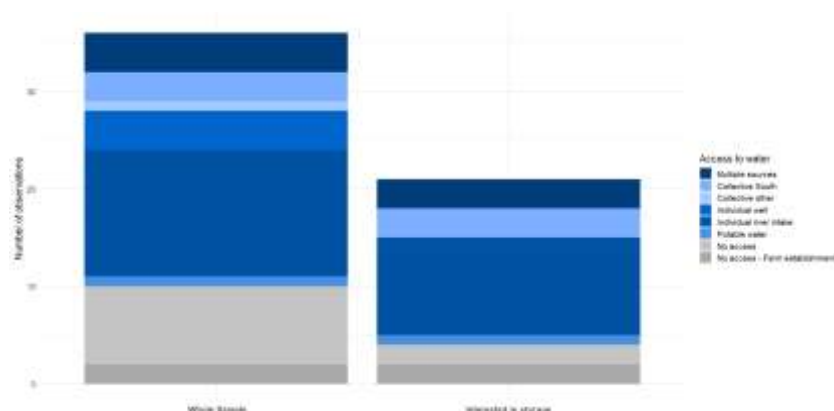


Figure 2. Repartition of surveyed farms in terms of water access and farm specialization for the whole sample and those interested in storage

belong to the collective irrigation networks supplied either by Rhône or Bourne waters: both sources are considered reliable. Thus, it is mainly the farmers of irrigated farms whose water access is threatened that show an interest in storage. These farms are either directly connected to the Drôme River or its tributaries (12) or linked to an insecure segment of the irrigation network (6). Viewed from the perspective of production, three categories of farms interested in storage can be distinguished. First, storage is mentioned by high-value-added-crop farms that operate on long supply chains and generate substantial revenue (6). They predominantly rely on the collective irrigation network. Second, medium-size mixed farms that run several production units (animals and/or crops) also show an interest in storage. Usually one or more of their production units are irrigated, such as walnut orchards, field crops or vegetables production (6). Finally, diversified market-garden farms also make use of storage (4). For the two latter categories, the majority are organic and have adopted agroecological practices such as intermediate cover crops and reduced or no tillage.

Diversified storage solutions adapted to farmers' needs and constraints

The choice of water inflows is constrained by the regulatory framework set by the SAGE: storages must be supplied either by runoff or by river pumping outside low-flow periods. Which option is selected depends on the geographic situation of farms and the reservoirs; farms with favorable topography opt for runoff, whereas others rely on the diversion of a watercourse. The decision between individual and collective storage is primarily driven by the type of project leader: collective-storage projects are promoted either by inter-municipalities or by the collective irrigation association.

The size of the storage varies widely, ranging from roughly 50 m³ to more than one million m³ for the collective-storage project. The choice of storage capacity is determined by several key criteria, the foremost being regulatory requirements. Reservoirs whose dam height is below 10 m are subject only to a declaration, whereas those that exceed this threshold require a formal authorization that is conditional upon the completion of administrative and public-consultation investigations. This substantial additional administrative burden discourages farmers who are planning individual storages from building dams taller than 10 m. In addition to the regulatory framework, the size of a storage facility is determined by three criteria: the water-demand identified by the farmer, the farmer's financial capacity, and technical constraints (size of the reservoir on the ground, availability of land, and compatibility with wetland preservation).

Even though subsidies can cover up to 70% of the investment cost, financial capacity remains a major limiting factor for the smallest farms, whereas it is less of an issue for medium and large-scale farms. The latter are more capitalized, possess greater investment capacity, and can often re-allocate funds that would otherwise be spent on agricultural equipment toward storage infrastructure.

The various storage facilities can be grouped into subcategories (Figure 3). Among collective reservoirs, the large-scale reservoir project in the valley can be distinguished from other collective projects led by inter-municipalities, which are primarily intended to support the establishment of new farms or to sustain small-scale irrigators. Individual storage facilities, meanwhile, can be categorized as either buffer tanks used solely to bridge summer shortages (insufficient flow or dried-up watercourses), small individual storage facilities (generally the main water source for small farms often specializing in market gardening), and larger reservoirs of over 20,000 m³, operated by larger agricultural operations, often with specialized crop production.

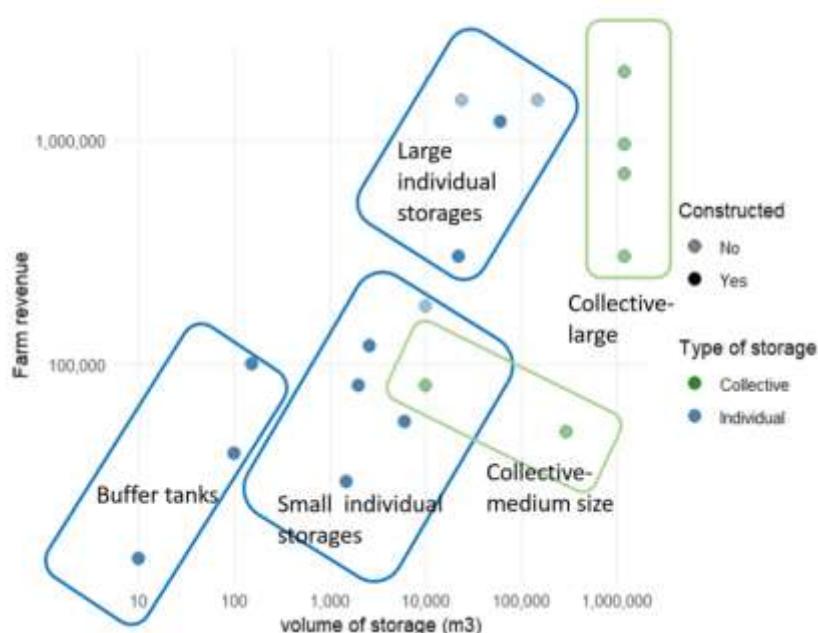


Figure 3. Storage-project size as a function of farm revenue. Each point represents a single farm. The cluster of points in the upper-right corner corresponds to the main collective-storage project; it appears four times because it was cited by four different farmers.

Multiple objectives: from securing water access to increasing resource availability

The various storage projects pursue different objectives with respect to water resources. The primary objective, shared by 17 of the 21 project sponsors, is to secure water supply, especially during low-flow periods, because the river or source has dried up in recent years; is expected to dry up in the near future; or because a substantial long-term reduction in authorized withdrawals along the Drôme is anticipated. The level of security varies greatly depending on the project, ranging from modest (i.e., enough water for at most one or two weeks) to very high, potentially eliminating the need for any river abstraction. As reservoir size increases, projects also incorporate a “buffer margin”: a modest additional capacity that helps anticipate future needs and justifies the investment.

In 10 of the 17 projects mentioned above, farmers mentioned a second objective: to increase the volume of available water. This supplemental volume of water serves different purposes to sustain crops whose water requirements are expected to rise with climate change, whether they are traditionally rain-fed or already irrigated, to initiate new crops or a new irrigated production unit, and, for four respondents, to enable the adoption of certain agroecological practices that entail higher irrigation needs. Farmers generally invoke several of these reasons simultaneously, underscoring that, in the medium to long-run; abundant water access allows to expand the range of cultivated species and to safeguard the viability

of the farm. Consequently, water access - even when not linked to a specific use - is perceived as a strategic investment that plays a central role in farm succession.

Finally, the creation of new storage facilities also allows the settlement of irrigated farmers, predominantly market-gardeners, in areas where they previously lacked either physical access to water or authorized withdrawal volumes associated with their land. In addition to two individual projects, the two inter-municipalities are developing collective-storage projects whose explicit aim is to facilitate the establishment of new farms.

Ambivalent impact on agroecological transitions

The impact of storage on agricultural dynamics is ambivalent because it is employed by a highly diversified set of farms. Small-scale storage reservoirs are typically used by short-supply chains, that is, organic farms that implement agroecological practices. In contrast, the largest projects (capacity > 20 000 m³), especially the collective one, are aimed at specialized farms cultivating high-value-added irrigated crops for long supply chains. Among these larger farms, most practice intensive conventional agriculture (4), while two allocate a portion of their production to organic agriculture and two are entirely organic.

The construction of storage facilities also plays a pivotal role in farm transmission and settlement dynamics. Several small storages have removed water-access constraints along settlement pathways of new farmers (2). Other projects (6) are embedded in a transmission logic, with the dual aim of securing and expanding the water resource available to the farm. In this context, water functions as an asset as important as land in irrigated territories, reinforcing a trend toward farm enlargement.

The water volumes made available by these storages tend to reproduce pre-existing inequalities in resource access: farms that receive the largest authorised withdrawal volumes also, on average, develop the largest storage projects.

Finally, the introduction of storage heightens the territory's agricultural dependence on irrigation. Although SAGE regulations prevent an increase in withdrawals during low-flow periods, and may even reduce them, storage facilities do not only allow for substitution role but contribute to a net rise in water use across the basin. Moreover, from a cropping perspective, storage is usually associated either with the maintenance of existing crops or with diversification toward more water-intensive varieties. Indeed, farms that have installed storage for diversification consider shifting to crops such as citrus (2), seed crops (1), or potatoes (1).

DISCUSSION

First, we highlight that storage facilities tend to reinforce the historical logics of irrigation expansion. They are deployed within existing irrigation schemes, allowing the safeguarding of irrigated areas in the face of water-resource scarcity and leading to the increase of water volumes allocated to irrigation, to the detriment of environmental flows. They are also found at the margins of historical irrigation schemes, enabling new farms to gain secure access to water. These storage devices can therefore be seen as the latest incarnation of the water-supply expansion policy, adapting to the demise of the paradigm of large hydraulic infrastructures.

Our results also highlight the crucial role of the institutional framework in shaping the effects of these storage facilities. In a territory such as the Drôme Valley, with strong and dynamic collective water-management institutions, the SAGE regulation constrains the construction of such infrastructures: the prohibition of groundwater abstraction and of withdrawals during low-flow periods markedly reduces the risk of resource appropriation. Another particularity of the case study is that some agroecological farms benefit from the construction of reservoirs. This is not only due to the regulatory framework, but also to the considerable presence of agroecological farms (about 30% of the total number of farms). Consequently, by using the Drôme Valley as a case study, we are likely to over-estimate the

agroecological-transition potential associated with these storage types. contrary to the recommendations of Aubertin et al. (2023), developing storage reservoirs is rarely accompanied by explicit objectives of agroecological transitions. Future research should examine storage-deployment, and their consequences, in other regions where territorial agroecological transition dynamics are less advanced.

Beyond the SAGE framework, few constraints are imposed at the watershed level on the construction of storage facilities, whether in hydrological terms, land-use considerations, or available financing. A more robust governance regime appears necessary to harness storage construction effectively for agroecological transition. Two avenues can be adopted. First, to tie construction to specific agricultural supply chains deemed beneficial for the territory. While such a condition may look promising on paper, its practical implementation is challenging because water is not perceived by beneficiary farmers as linked to a particular crop; rather, it is regarded as an asset that enables diversification of future farm activities. Second, it is possible to impose limits on storage size. Our results indicate that, both for individual and collective schemes, larger storages are predominantly backed by highly capitalized farms that already consume substantial amounts of water. Capping storage size would therefore help curb the risk of resource capture and promote the settlement of new farms.

This finding, however, requires further investigation for collective storages: the few collective projects identified in the study area have not yet been realized, further research could investigate the extent to which collective infrastructures given their size can participate in farm enlargement and inequalities of access to water. Long-term restrictions can also be put in place, for example by limiting access to water for a specific period of time, corresponding to the payback period of the investment they have made, to ensure that these heavily subsidized infrastructures continue to serve the public interest over time (Loubier, 2024).

Finally, our research invites a deeper interrogation of the links between agro-ecology and irrigation in territories where water resources are becoming scarce. The deployment or continued use of irrigation enabled by storage can be interpreted as climate-change adaptation, because it preserves certain crops and, on the fringe, facilitates the adoption of agroecological practices. Nevertheless, it also deepens dependence on the water resource: farms that possess storage tend to shift toward higher-value, more water-intensive crops. Without a reorganization of key agricultural supply chains at the territorial scale, the rollout of storage could therefore heighten the vulnerability of the region more than it promotes an agroecological transition.

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