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# **Participatory Research in Ecology for Agroecological Transitions: A Case Study in Viticulture**

*Baptiste Bedessem, Cyril Zappellini, Antoine Mathias, Pierre-Alain Maron, Samuel Dequiedt, Lionel Ranjard*

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## **Abstract**

Participatory ecological research in agricultural contexts is on the rise. Developing collaboration between farmers and ecology researchers is expected to both foster the acquisition of fundamental knowledge, and guide farmers towards the adoption of ecological practices through the co-construction of relevant expertise. Yet the impacts of these participatory approaches on farmers' practices are still poorly characterized. In this paper, we tackle this issue by considering as a case study a participatory research project in viticulture (EcoVitiSol®) conducted in 2022-2023 in the Côtes-de-Provence AOC vineyards (France). EcoVitiSol® (EVS) engaged winegrowers in a participatory research approach aiming to assess the relationships between agronomic practices and soil microbiological quality. Participant winegrowers entered into close collaboration with ecology researchers both to collect data, and to interpret global and individual soil health diagnoses. Following a pragmatic sociology approach, we conducted 22 semi-structured interviews with participant winegrowers in order to understand how their engagement in EVS had impacted their practices, knowledge, and professional networks. We found that the impacts of EVS on agronomic change is independent of the value of the diagnosis, and depends primarily on contextual factors: winegrowers (plan to) modify their practices after their engagement in the EVS protocol only if their current technical itinerary is not well stabilized, and if they do not face strong limiting environmental constraints. We also show that winegrowers interpret their individual EVS diagnosis on the basis of what we characterize as their formal, experiential and ethical knowledge. We furthermore suggest that, beyond the scientific results they provide, participatory research projects in ecology are valuable in that they foster peer group discussions. These results raise broader questions on the role of ecological expertise in fostering farmers' adoption of environmentally sustainable practices, by deciphering how this expertise interferes with specific agronomic situations and the different forms of knowledge held by farmers.

## **I-Introduction**

Agroecological transitions have emerged since the 1980s as a horizon of public policy action to address the environmental and economic limitations of modern agriculture as it developed after the Second World War (Compagnone et al. 2018; Loconto and Fouilleux 2019). Despite the coexistence of a diversity of models and practices, agroecology (as a set of agricultural practices) is usually opposed to conventional agriculture insofar as it pays particular attention to the maintenance of biological regulation and ecological interactions within cultivated areas (Toffolini et al. 2019). It is commonly claimed that this root principle entails a search for local solutions adapted to each ecosystem and farming context (Prost et al. 2023) – contrary to the top-down linear process where agronomists disseminate generic knowledge to farmers through technical advisors (Duru et al. 2015). This search for locally adapted solutions for agroecological transitions reinforces the role of the farmers as knowledge holders and producers (Šūmane et al. 2018; Salembier et al. 2018). Much attention and effort has therefore been devoted to the development of participatory research and innovation practices in agronomy, involving different forms of collaboration between agronomists and farmers to generate, discuss and disseminate knowledge and innovations (Pagliarino et al. 2020).

Aside from agronomy, the context of agroecological transitions has given momentum to other scientific disciplines as relevant to agricultural innovations, primarily the ecological sciences. Reducing the pressure exerted by agriculture on ecosystems requires ecological knowledge for designing and assessing agroecosystems (Berthet et al. 2019), and strengthening agricultural productivity requires the evaluation of ecosystem services on farms (Bretagnolle et al. 2018). Participatory research in ecology in agricultural contexts is therefore increasing (Ryan et al. 2018). It may involve citizens and/or professional farmers in studying pollination and pollinators (Le Féon et al. 2016), evaluating soil invertebrate biodiversity (Billaud et al. 2021), and assessing ecosystem services such as the decomposition of dung (Kaartinen et al. 2013). In addition to their value for scientific knowledge production, these approaches are often described as a potential way to improve farmers' awareness of biodiversity and environmental issues, and to foster agroecological transitions (Billaud et al. 2021). However, the possible impacts of these participatory research approaches in ecology for agroecological transitions are still poorly studied. How might collaboration between farmers and ecology researchers foster individual and collective changes in agronomic practices? What kind of farmers' participation in ecological research should be developed in order to define more sustainable production models, and to encourage farmers to adopt them? This contribution tackles these issues by considering as a case study a participatory research project in viticulture (EcoVitiSol®). EcoVitiSol® engages

winegrowers in different winegrowing areas across France in a participatory research approach aiming to assess the relationships between agronomic practices and soil microbiological quality. EcoVitiSol® (hereafter EVS) aims to build fundamental knowledge in ecology, and to initiate individual (at farm scale) and collective (at vineyard scale) changes towards more sustainable practices. This project took place in the Côtes-de-Provence AOC (protected designation of origin) winelands in south-eastern France, from November 2022 to December 2023. As a sociologist, the main author of this paper conducted a study to determine the effect on agronomic practices of (past) winegrowers' engagement in EVS. The paper is organized as follows. First, we propose a conceptual framework to analyze the impacts of collaboration between farmers and academic researchers (Section 2). We then present the EVS program in more detail (Section 3), as well as our research methods (Section 4). In Section 5 we set out our results by investigating sequentially three dimensions of EVS impacts — practice, knowledge, and professional networks —, and then deduce a global scheme of how EVS (and more generally, co-constructed ecological expertise) may influence an agroecological transition. Finally, we discuss our results, notably in light of the literature which, over the last decades, has studied the factors influencing farmers' adoption of environmentally sustainable practices (Section 6).

## 2-Conceptual framework: studying the effects of participatory research on agronomic practices

Collaboration between academic researchers and farmers to design or to assess innovative agricultural systems is obviously not new. The general notion of participatory research is commonly used today to describe a wide diversity of forms of such collaborative dynamics aimed at developing new agricultural techniques and assessing their impact on food production and the environment (Jackson-Smith and Veisi 2023)<sup>1</sup>. Despite the diversity of participatory schemes, these approaches share the common objective of building close collaboration between farmers and academic researchers in collecting and/or interpreting scientific data. For instance, in viticulture, different kinds of participatory approach have been developed to involve winegrowers in the design and/or the agronomic and ecological evaluations of innovative agricultural systems (Renaud-Gentié et al. 2023). Many of them focus on the reduction of pesticide use, as in the case of the DEPHY network in France, for instance, which engages

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<sup>1</sup> These participatory practices endorse a diversity of other labels which reflect the variety of spaces and contexts in which they take place, as well as the diversity of forms of farmers' involvement in the research and innovation processes: on-farm experimentation (Lacoste et al. 2022), living-labs (Toffolini et al. 2023), open-innovation platform (Berthet et al. 2018), citizen science (Van de Gevel et al. 2020), and co-innovation processes (Cardonna et al. 2018).

winegrowers in on-farm experimentation to demonstrate their capacity to reduce their pesticide use (Fouillet et al. 2023). Such on-farm experimental approaches are sometimes combined with co-design and/or co-evaluation workshops to encourage the implementation of new pest management strategies (Perez et al. 2023). Serious games have also been used to stimulate thinking about innovative pesticide-saving practices (Hossard et al. 2022). Another form of participatory approach is reported by Madouas et al. (2023) who document a participatory action research initiative, engaging winegrowers, NGOs, elected officials, and civil society in the design and implementation of less pesticide-intensive viticultural practices in France, Switzerland and Germany.

While the diversity of these collaborative processes engaging academic researchers and farmers is quite well described in the literature (e.g Frank et al. 2022), their effects on farmers' practices are still poorly known. The few available data focus on cases of participatory research involving agronomists (e.g. Hellin et al. 2008; Thompson et al. 2019). In order to study the effects of participatory research in ecology on farmers' practices (in our case, on winegrowers' practice), we propose a conceptual framework bringing together the notion of *conception*, a typology of the forms of knowledge held by farmers, and the pragmatic notion of *épreuve* (test). Following Compagnone et al. (2013) who study farmers' conception of their soils, we first consider that farmers hold certain conceptions both of their environment and of their practice. The notion of conception used here is anchored in cognitive sociology (Kaidesoja et al. 2022), which argues that these conceptions depend on individuals' experiences with the natural environment (e.g. through their agronomic practice), on cultural context (e.g. the valorization of ecologically intensive agriculture), and on social interactions (e.g. with agronomic advisors, peers etc.). These conceptions, in turn, give meaning to farmers' practices, guide the identification of potential problems to solve, and may define future trajectories. Second, we consider that these conceptions are at least partly grounded on (and justified by) the different forms of knowledge held by farmers (Ingram 2014). To describe them, we draw on Gorman (2002)'s taxonomy of knowledge which distinguishes between four types: information (*knowing what*, i.e. knowledge of the facts), skills (*knowing how* to do things), judgement (*knowing when* it is relevant to apply an already know solution) and wisdom (*knowing why* we do what we do, i.e. the values or moral principles guiding our action). As Loconto (2023) has shown, this framework is well suited to describing the different cognitive resources mobilized by farmers to foster agrifood system transitions. Even if they are held by individuals, these forms of knowledge are also social, in the sense that they may circulate within the

sociotechnical networks in which they are embedded (Thiollet-Scholtus et al., 2020; Bre and Hickey, 2018; Richardson et al. 2022). These networks (populated by peers, public or private advisors, sales engineers, etc.) then participate in the social construction and the stabilization or destabilization of farmers' conceptions and agronomic practices (Compagnone, 2019). In French viticulture, in particular, where 95% of production is controlled by protected designation of origin (e.g. AOC, Ruggieri 2024), collective strategies and associated knowledge networks play an important role in regulating agronomic changes.

We then propose to consider engagement in participatory research as a trial or test of farmers' conceptions and underlying knowledge, in the pragmatic sense of *épreuve* (Thévenot 2006). This *épreuve* may lead to the reinforcement, dismissal, or discussion of farmers' conceptions and the knowledge partly underpinning them. The aim of our work is then to decipher, in the case of the EVS participatory research program, the different determinants that may explain the way winegrowers react (by adapting their practice) to the *mise à l'épreuve* (testing) of their conceptions and underlying knowledge. Following this pragmatic tradition, and its cross-fertilization with science and technology studies, we argue that the effects of participation are far from unequivocal (Lemieux 2007; Martucelli 2015): first, ecological knowledge is often subjected to a variety of interpretations when applied to agronomic practices (Berthet et al. 2019); second, co-constructed ecological knowledge coexists with other forms of knowledge; third, material conditions (environmental constraints, agronomic situations, socio-economic conditions) may play a role in guiding winegrowers' action. We also derive from this notion of *épreuve*—as situated at the crossroads of pragmatic sociology and science studies—an emphasis on disputing processes, which we analyze through their political, cognitive, and socio-technical effects (Lemieux 2007). In our case, engagement in EVS is then conceptualized as a moment of intra- and inter-individual (controversial) dialogues, where actors collectively redefine both their relationships and the social and material worlds.

Our inquiry will therefore focus on three aspects: (i) the effects of EVS on agronomic practices, as reported by winegrowers; (ii) the way winegrowers integrate co-constructed ecological knowledge within the other forms of knowledge they hold, notably regarding soil; and (iii) winegrowers' involvement in sociotechnical networks, and the way they interfere or may interfere with the EVS project.

### 3-Context of the study

## a-Ecovitisol: design and objectives

With 20% of all pesticides used on 3% of the agricultural surface area of France, along with extensive mechanization, viticulture is widely criticized for its impacts on air, water, and soil pollution (Karimi et al. 2020). Transition towards more sustainable models is therefore both a challenge and a necessity for this sector, since current practices strongly affect its environmental and economic viability (Costantini et al. 2018). In relation to this issue of pesticide use, soil management is a central element of winegrowers' agronomic strategies (Renaud-Genié et al. 2023). It is also a key lever for agroecological transitions, since reduction of herbicides may entail an increase of soil tillage to control weeds (Fried et al. 2019). Yet soil management practices have strong impacts on soil ecological quality (Christel et al. 2021). In particular, the microbiological state of the soil (the abundance and diversity of the microbial communities) depends on the modalities of tillage, fertilization, crop protection and crop rotation (Lemanceau et al. 2015). At a more global scale, understanding the impacts of the different farming systems as a whole (e.g. conventional, organic, biodynamic farming) on soil ecological quality is then crucial for agroecological transition in viticulture. This implies taking into account the diversity of technical itineraries (or pathways of technical operations, Sebillote 1974) characterizing the different systems of production. Winegrowers' involvement in this research process may therefore be useful, to identify relevant variables impacting soil ecological quality, and to interpret the quantified diagnoses.

In this context, EcoVitiSol® is the first large (national)-scale study to evaluate the physical, chemical and microbiological quality of vineyard soils, for three different farming systems (conventional, organic, biodynamic). This five-year program, led by INRAE researchers from the UMR Agroecologie lab in Dijon (Burgundy), is co-funded by INRAE and the professional organizations (e.g. syndicate) representing winegrowers from the vinegrowing region under study. The program was originally designed by ecology researchers, with two complementary objectives: first, to assess whether conventional, organic and biodynamic farming make a difference to soil quality; and second, engaging winegrowers from these three types of farming was seen as a way to access a diversity of agronomic practices and to test their impact on soil microbiological quality.

As described below, conventional, organic and biodynamic winegrowers are directly involved during the different steps of the process, from data collection to results analysis during co-interpretation workshops. After a previous campaign in the Burgundy and Alsace vineyards

(2019-2020), the EcoVitiSol® method was applied in 2022-2023 to the Côtes-de-Provence (hereafter CDP) AOC vineyards in south-eastern France, in collaboration with the local winegrowers' professional organization (*syndicat des vins de Côtes-de-Provence*). It is worth noting here that social scientists were not involved at the beginning of the EVS project as regards Côtes-de-Provence; the program was designed and conducted exclusively by the ecology researchers. The sociological research was conducted after the end of the CDP project, both to pursue disciplinary objectives (see Section 2 for details), and to help the EVS consortium assess the impacts of the project. From the point of view of ecology researchers, the advantages of bringing sociology on board was then to find possible ways to improve the general organization of the program in the future.

#### *b- EcoVitiSol® in Côtes-de-Provence*

The Côtes-de-Provence AOC vineyard is France's leading rosé wine-producing region, with a total surface area of 20,332 hectares (ha) or 2,033,200 ares, a production of 978,000 hL/year, 3,500 producers, 372 private cellars, and 38 wine cooperatives. This large geographical area includes a diversity of soils, with a dominance of sandyloam and sandy clay textures. It is characterized by a Mediterranean climate, with relatively low rainfall, which makes water management an important issue for this vinegrowing region. The AOC is managed by a professional union (*syndicat des vins de Côtes-de-Provence*, hereafter *syndicat*) which has a management board composed of some winegrowers from the AOC and a team of 14 employees (agronomists, lawyer, administrative staff). The *syndicat* fulfils classical roles of defending the AOC and controlling winegrowers' compliance with AOC specifications. These specifications mainly target geographical areas, wine-making practices, grape varieties and maximum yields. There is no rule regarding soil management. The only constraint regarding pesticide use concerns the limitation of chemical weeding, which cannot be applied on the totality of a given wine estate, nor in the headlands (*tournières*). However, in 2022, the *syndicat* created a sustainable development service and hired an agronomist to initiate reflection on agronomic change and thus to support a new dynamic structured around research, innovation or development projects, such as EVS. Through this service, the *syndicat* was then directly involved in the different stages of the EVS approach, together with the EVS consortium. This consortium was composed of: four researchers from INRAE (UMR Agroécologie, Dijon); two researchers from the ENS Paris (Laboratoire de géologie); the association *Soin de la Terre*

which advises winegrowers about biodynamic farming; and one company providing digital tools for geographic data management (Agaric-IG).

From April to June 2022, participant winegrowers were recruited by the *syndicat* through information meetings and personal contacts. Depending on the structure and size of the wine estate they were from, these participants might be the head of the farm, the crop manager, or in some rare cases, the head of the R&D service. This mode of recruitment enabled us to identify a first sample of wine estates: 63 plots belonging to 52 wine estates were selected, all belonging to the AOC. The main selection criteria at this stage was the constitution of three well-balanced groups: 23 plots in conventional farming, 22 in organic farming (that is, with the French AB label), 18 in biodynamic farming (that is, with at least one of the existing certifications for biodynamic farming, for instance Demeter). As shown in Figure 1, the engaged wine estates cover the whole area of the AOC. Section 5 provides a more precise sociological and agronomic description of the wine estates corresponding to the sample of interviewees in this study. Generally speaking, the recruitment process might have over-selected winegrowers who were well inserted in local professional networks (administrators from the *syndicat*, heads of cooperatives, members of winegrowers associations), and/or who were particularly engaged in furthering the agroecological transition, and/or who were used to working in collaboration with external experts (e.g. by dedicating plots for tests or experiments by scientific or farming institutes). We do not have quantitative data to support this point, but it was reported by the two members of the *syndicat* we interviewed. We will not enter here into more details about the description of EVS participants, since our focus is more on the sub-samples of winegrowers we interviewed (Section 5).

In November 2022, soils were sampled by members of the EVS consortium who spent a week visiting the wineries. The winegrowers selected the sampled plots on the basis of a set of general criteria defined by the researchers (mainly, the age of the vines and the duration of the mode of production). The sampling zones were then defined with the winegrowers during the field campaign, with considerations of homogeneity and representativeness of the plots. During the sampling processes, a 20- to 30-minute discussion was conducted by the ecology researchers piloting the EVS project with every winegrower, based on a predefined interview grid<sup>2</sup>. It allowed the researchers to co-construct a fine description of the winegrowers' technical

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<sup>2</sup> This grid was predefined but evolving: during the different EVS field campaigns, it was modified on the basis of the discussions with participant winegrowers in order to best reflect the diversity of their practices.

itineraries: tillage practices, type of cover crops, use of vine protection products (pesticides and copper), type of mineral and/or organic fertilization, managements of vine shoots, and use of irrigation. During this discussion, the ecology researchers also explained the objectives and the protocol of the study, and offered some insights about soil microbiology. They also discussed with the winegrowers the possible effects of their practices on soil ecological quality.

After this field campaign, soil samples were sent to the different research laboratories from the EVS consortium and analyzed in three respects. First, classical physico-chemical variables were characterized (pH, texture, organic carbon, nitrogen, copper). Second, a part of the samples was analyzed through thermal analysis (Rock-Eval® method) in order to quantify the stable and active forms of soil carbon (Kanari et al. 2022). Finally, the soil's DNA was extracted from a third part of the samples for microbiological analysis (see Christel et al. 2023 for a detailed description of the protocol). The DNA was quantified to measure molecular microbial biomass, then purified, and taxonomic microbial genes were quantified through qPCR in order to estimate the fungi/bacteria ratio. A part of this DNA was finally sequenced to evaluate bacterial and fungal biodiversity. All these indicators were compared to the RMQS national referential for soil microbiological quality (Dequiedt et al. 2020). The RMQS provides theoretical values for microbiological indicators, based on soil parameters and geographical positions. These theoretical values were compared to measured ones, after which soil indicators were converted into distinct diagnoses of soil state: organic carbon, fungi/bacteria ratio, fungal and bacterial biodiversity, and an aggregated indicator of soil quality, calculated as the arithmetic sum of the other four indicators. This last indicator provides winegrowers with a global evaluation of whether agronomic practices improved or affected the soils' microbiological quality.

The third step of the EVS protocol consisted of two co-interpretation workshops on December 5th and 6th, 2023 in two different places of the Côtes-de-Provence AOC. Each workshop was attended by members of the EVS consortium, representatives of the *syndicat*, and half of the winegrowers. Note here that more than 90% of the winegrowers attended these workshops, which is a good indication of their interest in the EVS approach. The workshops, which lasted for about three hours, were organized in two phases. First, members of the EVS consortium presented a general review of agriculture and soil microbiological quality. They then presented the results obtained in vineyards sampled in 2019 (Bourgogne and Alsace), and the aggregate results obtained in Côtes-de-Provence, according to the production mode (conventional, organic and biodynamic) and agronomic practices (mainly tillage and cover crop management).

These results proved to be roughly consistent between the three regions, showing a positive impact of cover crops on biomass and biodiversity, and a negative impact of tillage. Regarding modes of production, plots that were cultivated with organic and biodynamic farming methods yielded, in average, better aggregated indicators of microbiological quality than conventionally farmed ones<sup>3</sup>. However, it is important to note an important disparity between plots, even when they follow similar modes of production. As explained below, first, practices and local conditions (e.g types of soil and climate) may be highly variable, and second, the aggregated indicator is a sum of variables (e.g biomass and biodiversity) which may react differently to a same agronomic practice.

After a session of general discussions, individual results were distributed to the winegrowers in the form of four-page diagnosis files presenting indicators for carbon, microbial (bacteria and fungi) biomass, bacterial and fungi biodiversity, microbial equilibrium (the ratio of bacteria and fungi biomass), and lastly the global, aggregated indicator of soil quality (the arithmetic sum of the other four indicators). In the diagnosis file, these indicators were placed on a scale from red to green: red (resp. green) indicated that the sample was under (resp. over) the reference level. Hence, a 'red' aggregated diagnosis meant that the corresponding soil was in a 'bad global microbiological state' ; an 'orange' diagnosis means that the soil was in a 'non-critical global microbiological state, but to be monitored'; and a 'green' one meant that the soil was in 'a good global microbiological state'. An open discussion session then allowed the scientists and winegrowers to freely interact in small groups in order to co-interpret individual results in light of plots' characteristics and technical itineraries. These co-interpretation workshops were necessary for participants (winegrowers as well as scientists) to give global agronomic meaning, for each plot and for the whole region, to the different indicators measured. Indeed, as there is theoretically no reason for biomass and biodiversity, or for microbial diversity, to react in the same way to a given agronomic practice, the link between soil quality and agronomic practices cannot be assessed with one simple variable. Even for plots cultivated with similar modes of production, there is a wide diversity of soil management practices (kinds and duration of the cover crop, tillage techniques, etc.) as well as environmental conditions. It is therefore necessary to explain every diagnosis with a close look at local, past and present agronomic practices. The whole process ~~can be considered without ambiguity as a form of~~

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<sup>3</sup> The global results over the three studied regions (Alsace, Bourgogne and Côtes-de-Provence) indicate that respectively 49% and 42% of plots cultivated with biodynamic and organic farming methods had a 'green' aggregated diagnosis, vs. 29% for conventionally farmed plots.

participatory research, since it thus involves close collaboration between researchers and winegrowers, both in data collection and in results interpretation. Regarding its aims and organization, this process is fundamentally different from ecological expertise delivered, directly or indirectly, by academic research or private analytical laboratories. We therefore argue that EVS is correctly described as a *participatory research* project, given the diversity of meanings commonly attributed to this concept (see Section 2).

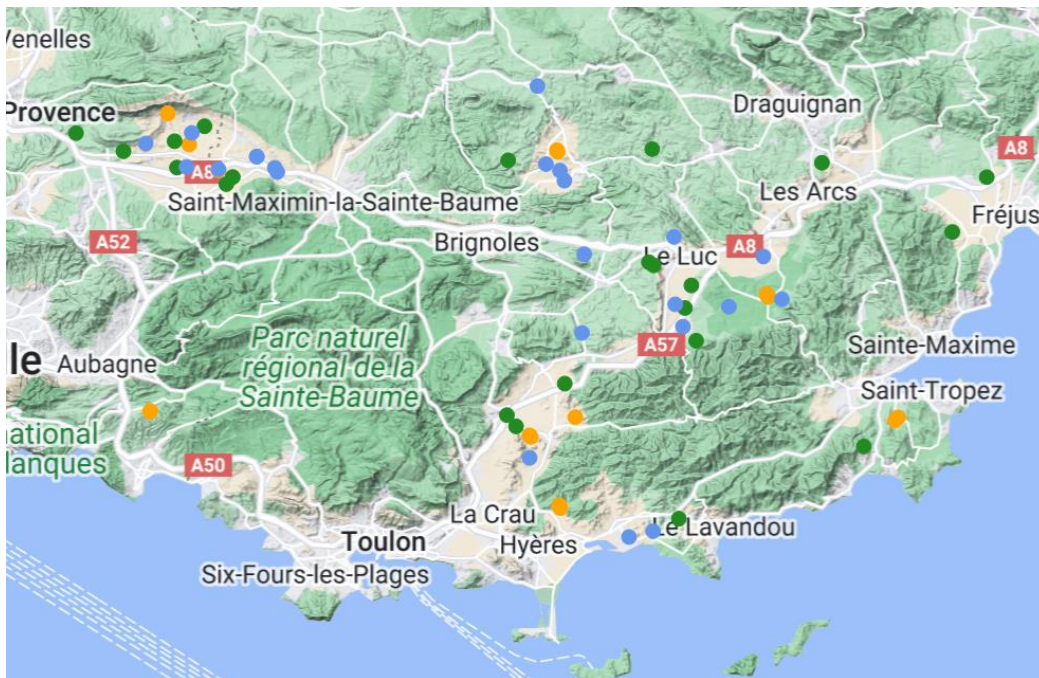


Figure 1-Spatial distribution of the sampled plots. The colors of the spots indicates the mode of production: green=organic (22 samples), blue=conventional (23 samples), orange=biodynamic (18 samples).

#### 4-Methods

This study explores the ways in which participatory research and related co-produced expertise may impact winegrowers' agronomic practices. As described and justified in Section 3, our research focuses on three interrelated dimensions: (i) the modifications of agronomic practices; (ii) the integration of EVS diagnoses within the set knowledge held by winegrowers, notably regarding soils; and (iii) winegrowers' sociotechnical networks and the way they interfere or may interfere with the EVS project. Regarding the latter point, it is worth noting here that given the timelapse of our study, the circulation of EVS results among professional networks could not be fully assessed, and our conclusions will therefore necessarily be incomplete.

The data used in this analysis are mainly from interviews with winegrowers. Following the two workshops<sup>4</sup> (December 5th and 6th), an email was sent to participants to set up semi-structured interviews. Importantly, we did not focus on modes of production to recruit interviewees. Two weeks after this first email, we sent a reminder email to the participants who had a ‘red’ aggregated diagnosis and who had not yet responded. The objective was to gather a maximum of interviews with winegrowers who had a ‘bad’ diagnosis, in order to test whether they were more inclined to initiate agronomic changes. Based on the answers obtained, we were able to conduct 22 semi-structured interviews (30 minutes to 1 hour) from March to May 2024. This tight schedule was constrained by the limited availability of winegrowers after the winter period. Interviews were held following the sociological techniques of biographic analysis, in order to access both individual trajectories and the meanings actors give to them, from a comprehensive perspective. Thus, we relied on what winegrowers said about their practices, rather than on the observation of the practices themselves. In a pragmatic perspective, we were mainly interested in the way farmers *justified* their interpretation of co-constructed ecological knowledge, and their (non)-use within their agronomic practice. More precisely, the interview grid focused on six points:

- General characteristics of the wine estate and interviewee’s professional trajectory
- Agronomic trajectory of the wine estate: evolution of the technical itinerary, potential agronomic problems or environmental constraints faced by the winegrower
- Professional socialization of the interviewee: participation in professional organizations, number and types of technical advisors, interactions with other winegrowers
- Internal R&D agenda: physical, chemical and biological analysis, on-field experiments, work led in collaboration with public researchers in agronomy or ecology, and with private companies
- Opinion on EVS: perception and evaluation of the program in general, and winegrowers’ interpretation of their individual diagnosis
- Modifications of practices following EVS, as they were actually implemented or envisioned.

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<sup>4</sup> Note here that we carried out non-participant observation during these workshops, but we have not used the data collected in that context for the present paper.

The interviews were transcribed and qualitatively assessed by classifying relevant information for each of the 22 cases, following distinct dimensions (physical and economic characteristics of the wine estates, frequency of soil quantitative analysis, types of knowledge expressed by winegrowers, environmental constraints or agronomical problems, discussions during the EVS workshops, etc.). This first analysis of collected data allowed us to reconstruct, for each case, a description of the winegrowers' and wine estates' characteristics and agronomic trajectories, as well as EVS integration with winegrowers' practices, knowledge, and professional networks. Boxes 1 to 3 provide some examples of these detailed descriptions obtained from interview analysis. These individual results were then compared and discussed in order to elucidate general pathways of impacts for EVS. It is worth noting that this phase of interpretation was conducted in close collaboration with all members of the EVS consortium, including members of the *syndicat*. The main author of this article also conducted two interviews with the director of the *syndicat* and with the head of the sustainable development service. The aim was to gain more understanding on the current issues faced by the Côtes-de-Provence vineyards, as well as the objectives and expectations of this professional organization when engaging in EVS.

Two further comments are warranted at this stage. First, the data we mobilize in this study was collected immediately after the end of the project (January-May 2024, see next section). Our research was then designed to capture mainly short-term impacts. This schedule (with the interviews done right after the end of the project) was also chosen in order to access more accurate and detailed feedback on the EVS methodology from the participants. Second, as the EVS was implemented in 2018-2019 in two other regions (Burgundy and Alsace), it would have been possible to conduct a similar study in those vineyards to get a more exhaustive and long-term view of the project's impact. However, as noted above, we assumed that this impact strongly depended on territorial and individual situations, and therefore chose to focus on one specific EVS campaign in order to avoid bias or complexity due to the diversity of local contexts.

## **5-Results**

Among the 22 interviewees (5 women and 17 men), 10 winegrowers practice conventional farming, 8 organic farming, and 4 biodynamic farming; 3 of them belong to wine cooperatives, and 19 have private cellars. The legal forms and economic structures of the corresponding wine estates are widely diverse, from small family-owned estates to large properties belonging to corporate groups. Their size is also variable: 3 between 7ha (700 ares) and 20ha (2,000 ares),

16 estates between 20ha (2,000 ares) and 50ha (5,000 ares), and 3 between 50ha (5,000 ares) and 300ha (30,000 ares). The number of permanent workers ranges from 1 to 30, with 10 wine estates employing fewer than 5 people, and 3 employing 10 or more. Depending on the structure and size of the wine estate, the interviewees (which were in most cases the individuals directly engaged in the EVS program) might be the head (owner or manager) of the farm, the crop manager, or (rarely) the head of the R&D division. In terms of education or academic training, all interviewees had a post-graduate degree from a university or technical college. In our sample, there is no significant correlation between the color of the diagnoses, the modes of production, and the size of the wine estate. Global EVS results are distributed as follows: 5 plots have a ‘red’ aggregated diagnosis regarding soil microbiological quality, 12 have a ‘green’ one, and 5 an ‘orange’ one<sup>5</sup>. As indicated in Section 5.d, interviewed winegrowers belonged to diverse professional networks, involving public or private advisors, scientists, or peer groups.

#### *a-Typology of agronomic situations*

The qualitative analysis of the interviews reveals three groups of winegrowers, characterized by specific agronomic situations. In Section 3-b we show that these agronomic situations are good predictors of the impacts of EVS on agronomic practices. This three-dimensional typology is based on two variables: (i) the stability of the technical itinerary (Is the winegrower in a phase of wanting to modify its agronomic practices?); and (ii) the presence of strong environmental constraints. As explained below, we consider as environmental constraints certain physical, biological or climatic conditions that concretely and effectively (that is, in a way that is precisely described by the winegrowers) challenge the winegrowers in their search for a satisfactory technical itinerary. We did not find any correlation between this typology, wine estate characteristics (mode of production, size of the farm), and socio-demographic factors such as age, gender, or crop manager’s qualifications. Table 1 gives a synthetic description of these groups in terms of agronomic characteristic, modes of production, and EVS global diagnosis.

#### ***Group A (10 winegrowers).***

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<sup>5</sup> Among the total of 63 plots from the EVS participants, 31 were diagnosed as ‘green’, 25 as ‘orange’, and 7 as ‘red’. The fact that we interviewed most of the winegrowers with a ‘red’ diagnosis is due to our sampling strategy; see Section 4.

Group A includes winegrowers who are satisfied with their technical itinerary, which is well stabilized. In this group, 6 winegrowers have a ‘green’ global diagnosis, 3 of them an ‘orange’ one, and 1 winegrower a ‘red’ one.

***Group B (8 winegrowers).***

Winegrowers from this group are unsatisfied with their current technical itinerary (which is not stabilized), since they have identified an agronomic problem they would like to solve. The identified problems or issues are diverse: lack of organic matter (2 winegrowers); lack of vigor for some vines (1); bad structure of the soil (3); or too intensive tillage (2). Contrary to Group C, this search is not challenged by strong environmental constraints. In this group, 6 winegrowers have a ‘green’ global diagnosis, 1 has an ‘orange’ one, and 1 has a ‘red’ one.

***Group C (4 winegrowers).***

Group C is characterized by the presence of strong environmental constraints that challenge winegrowers in their search for a satisfying technical itinerary (which is not stabilized). For 3 winegrowers, the constraints are linked to the physical characteristics of their sandy soils, which make the sowing of cover crops difficult. Another winegrower reports a strong limitation in the development of cover crops due to water stress. A last one describes the difficulties he faces to adapt cover crops to his clay soils (which is hydromorphic in winter and presents desiccation cracks in summer). Winegrowers from this group have all been engaged for many years in an intensive search for solutions to adapt their technical itinerary to the environmental constraints they face (e.g by searching for an equilibrium between the development of cover crops and water stress). In this group, 2 winegrowers have an ‘orange’ global diagnosis, and 2 have a ‘red’ one.

Type	Group A	Group B	Group C
<b>Short description</b>	Technical itinerary is stabilized	Technical itinerary is not stabilized	Technical itinerary is not stabilized and the winegrower faces strong environmental constraints
<b>EVS diagnoses (number of winegrowers)</b>			
<i>Green</i>	6	6	0
<i>Orange</i>	3	1	2

<i>Red</i>	1	1	2
<b>Modes of production (number of winegrowers)</b>			
<i>Conventional</i>	4	4	2
<i>Organic</i>	4	3	1
<i>Biodynamic</i>	2	1	1

*Table 1-Composition of the three groups of winegrowers in terms of modes of production and EVS diagnosis*

*b-Impacts of EVS on agronomic practices*

Our analysis indicates that EVS may have clear short-term effects (and possibly long-term effects) on agronomic practices, and that these effects depend primarily on the winegrowers' agronomic situation. Interestingly, in our sample the diagnosis itself is not a determinant of EVS impacts. More precisely:

-In **Group A**, EVS does not have any impact on agronomic practices, whether real or envisioned, even when the diagnosis is 'orange' or 'red'. For winegrowers with a 'green' diagnosis, EVS is perceived as a confirmation of the technical itinerary and/or the long-term agronomic trajectories. For instance, one of them stated that the EVS program reinforced his long-term plan to extend sowing in the headlands.

-In **Group B**, EVS has a clear short-term impact on agronomic practices. Six winegrowers of the 8 we classified in Group B had immediately implemented new practices right after the EVS sampling and/or workshops, or had clearly planned to do so the next fall/winter season. These changes were implemented explicitly to solve the agronomic problems already identified by the winegrowers. One could assume that (at least in some cases) EVS has accelerated or triggered changes that were already planned. Table 1 presents the changes that were implemented by these 6 winegrowers. Interestingly, this impact of EVS on technical itineraries seems to be independent of the diagnosis itself, as changes were implemented in cases of 'red' as well as 'green' diagnoses. It is worth noting that the changes reported by the interviewees were implemented at different moments, depending on the case: after the EVS sampling period (November 2022); between the workshops (December 2023) and the interview (March-May 2024); or for some of them, they were planned for fall 2024. Table 2 indicates whether the changes were concretely implemented (and when) or planned for the following months.

-In **Group C**, EVS does not have any impact on agronomic practices. Winegrowers from this group all have ‘red’ or ‘orange’ diagnoses. They have all been engaged for many years in (unfruitful) tests and experiments to adapt their technical itinerary to strong environmental

<i>Winegrower</i>	<i>EVS global diagnosis</i>	<i>Agronomic issue already identified</i>	<i>EVS-induced changes</i>
1	Orange	Lack of organic matter	Increase of organic amendment (W)
2	Green	Lack of vigor of some vines	Systematization of horse manure amendment and extension of the cover crop period (W)
3	Green	Soil compaction	Limitation of the use of tractors by stopping tillage under the vines (P)
4	Green	Lack of organic matter	Sowing in all inter-rows (on some test plots) (S)
5	Green	Attempts to reduce tillage	No-tillage on 2 test plots (W)
6	Red	Attempts to reduce tillage	No-tillage during winter (W)

constraints. EVS results are therefore not surprising to them, but the program does not offer them the concrete solutions they are looking for.

*Table 2-Changes implemented by winegrowers from Group B after participation in EVS sampling and workshops. In the next column, S=changes implemented after the EVS sampling period (November 2022) and before the workshops (December 2023); W=changes implemented right after the workshops; P=changes planned for the next (2024) fall or winter season.*

### *c-Impacts on winegrowers' knowledge about soil*

On the basis of the interviews we conducted, we first propose to slightly modify Gorman's (2002) analytical frame (presented in Section 2) to describe winegrowers' knowledge about soil. We propose a three-dimensional typology, which distinguishes:

-*Formal* knowledge, such as quantified data produced by robust physical or chemical soil analysis, or general knowledge about soils or plants. This knowledge is characterized by its genericity, in the sense that it comes from widely used analytical techniques, or well-established scientific knowledge. Formal knowledge is clearly part of Gorman's *knowing what*.

-*Experiential* knowledge, from winemakers' observations of their own soils and ecosystems. This knowledge may derive from tests or experiments, or direct observations. It is mainly local; for instance, it deals with the types of plants specifically adapted to local environmental conditions, or with the way in which local soils react to mechanization. This experiential knowledge is also part of Gorman's *knowing what*. These first two categories are then a refinement of Gorman's *knowing what* class.

-*Ethical* knowledge, which guides action without necessarily being justified by well-identified empirical data. This corresponds exactly to Gorman's *knowing why* (also qualified as *wisdom*). This form of knowledge is mobilized to produce *value* judgements; contrary to expert judgements, it is not necessarily based on factual knowledge. As highlighted by Loconto (2023), this category then reflects explicit or implicit ethical reasons justifying a specific action. For instance, one winegrower may value 'plant diversity', or no-tillage practices in order to let 'soil life flourish'. Following Gorman's perspective, this form of judgement is grounded on a specific form of value-laden, non-factual knowledge, that we qualify (following Gorman (2002)'s and Loconto (2023)'s analysis) as ethical knowledge. Note here that winemakers also expressed elements corresponding to Gorman's '*knowing when*' and '*knowing how*', for instance, when describing in detail their technical itineraries and their evolution. However, in our cases, the latter two forms of knowledge were always justified by (or grounded on) formal, experiential or ethical knowledge.

Our data first show that these three forms of knowledge continuously interact to build winegrowers' conceptions of their practices in local agronomic situations. For instance, for one winegrower from Group C, the willingness to implement cover crops (partly supported by *ethical* knowledge) clashes with *formal* knowledge about water drainage in sandy soils, which is itself confirmed by *experiential* knowledge acquired from previous efforts at developing cover crops. These conceptions are then verbalized, during interviews, in the form of *justifications* of the individual's practices or actions. This general observation is similar to Compagnone et al. (2013)'s findings in their study of farmers' conceptions of soil for conservation agriculture, organic agriculture, or conventional agriculture. Without specifically using Gorman (2002)'s

analytical frame, the authors show how, in the three groups, farmers justify their tillage practices by referring to factual<sup>6</sup>, experiential<sup>7</sup> or ethical knowledge<sup>8</sup>.

That said, what does our empirical data tell us about the way EVS-related expertise (individual diagnosis as well as general information on microbiology and soils) is integrated within this set of knowledge and related conceptions about soil? Our main result here is that participants mobilize their factual, experiential and ethical knowledge to produce an *interpretation* of global and individual EVS diagnoses. These interpretations then depend on winegrowers' conceptions of their current agronomic situation and planned trajectory (since these conceptions depend on winegrowers' formal, experiential and ethical knowledge). For instance, a winegrower from Group A (see Box 1) who had observed the positive effects (on vine productivity and vigor) of massive organic waste inputs (*experiential* knowledge) interprets his 'green' diagnosis as the result of this practice. In Group C, EVS results are generally seen as confirmations of winegrowers' agronomic difficulties: globally, winegrowers from this group are not surprised by their ('orange' or 'red') individual diagnoses, which are interpreted through the lens of their experiential knowledge (e.g difficulties to develop cover crops in sandy soils, or under hydric stress conditions). Interestingly, in some cases EVS results clash with other sources of formal knowledge; for instance, a winegrower from Group A found his individual EVS diagnosis contradictory to other microbiological analyses he had previously performed on other plots on his wine estate. In this case, interpretation focused on comparing measurement methods in terms of sampling and analytical strategy.

Reciprocally, EVS results may enrich or justify winegrowers' experiential or ethical knowledge. For instance, one winegrower from Group A who valued plant diversity interpreted the global and his individual ('green') EVS diagnosis as an empirical justification of his *ethical* knowledge. By doing so, he also established a link between plant diversity and microbiological diversity. More globally, we found in various cases that EVS results enriched winegrowers' representation of biodiversity, which has previously often been limited to macrofauna and flora.

Importantly, it is through this interpretation activity that EVS may have concrete effects on agronomic practices of winegrowers from Group B. For instance, winegrower n°1 from Group

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<sup>6</sup> E.g. by referring to analytical methods used to characterize soil physicochemistry (p. 92)

<sup>7</sup> E.g. some farmers give arguments dealing with an observed drying-out of their soils due to cover crops (Compagnone et al. 2013, p. 90)

<sup>8</sup> Compagnone et al. (2013) note for instance that farmers practicing conservation agriculture justify their choice by valuing the 'abstract notion' of 'living soil' (p. 92)

B (see Table 1) interpreted his individual results, as well as global EVS scientific inputs, through the lens of his own agronomic preoccupations (the low level of organic matter in his soils). He then insisted, during the interview, on the importance of organic matter to foster the soil's microbiological life, and decided (after his participation in EVS) to increase organic amendments. Similarly, winegrower n°3 (see Table 1) interpreted global EVS results from the perspective of his soil compaction problem, by concluding that soil compaction is detrimental to microbiological life. Finally, our data suggest that co-produced ecological knowledge does not modify winegrowers' conceptions of their practice. On the contrary, EVS diagnoses are interpreted in a way that serves to justify, enrich or support individuals' formal, experiential and ethical knowledge.

#### *d-Influence on winemakers' professional networks*

Farmers are generally engaged in complex networks of professional interactions with heterogeneous sets of actors (Klerks and Proctor, 2013; Cerf et al. 2017): not only agronomists and advisors, representatives of farmer organizations, machinery manufacturers, and seed suppliers, but also their peers (that is, other winegrowers, gathered in formal or informal collectives, Slimi et al. 2021). These networks, as supporting interactive learning and knowledge exchanges, strongly influence (positively or negatively) the development and diffusion of agronomic innovations (Skaalsveen et al. 2020; Thiollet-Scholtus et al. 2020). In the specific case of viticulture, Compagnone (2014, 2019) has studied how the structure of these professional social networks, and the positions individuals occupy in them, determine their adoption of new agronomic practices. Among other results, he shows that when these networks have a 'core-periphery' structure, winegrowers situated in the core of the network exert a strong (positive or negative) influence on collective changes. At a larger scale (that of an AOC), Ruggieri et al. (2023) have shown how the governance structure of winegrowers' professional organizations (such as the *syndicat* in our study) may influence the efficiency collective action.

Even if these considerations might be relevant to discuss our results, we do not aim to contribute directly to the literature on social networks and collective changes. First, our focus is on an isolated collective project involving specific actors: ecology researchers. Our aim is to investigate how this specific collaboration may influence individuals. Second, the timelapse of our inquiry does not allow us to draw conclusions about medium- and long-term circulation of co-constructed ecological knowledge within territorial professional networks. However, even though we did not conduct an exhaustive study on winegrowers' social relationships, our results

first suggest that winegrowers generally discussed EVS results within their professional network. Data from interviews allow us to sketch an overview of these professional networks. First, we classically found different kinds of individual or collective actors populating individuals' networks:

- Territorial professional organizations (fostering peer-to-peer relationships): the *syndicat*; a local association of winegrowers from the Sainte-Victoire Mountain area; a GIEE (*Groupement d'intérêt économique et environnemental*) focusing on soil management in this Sainte-Victoire area; and cooperatives;

- Private laboratories performing physicochemical soil analysis;

- Experimental networks animated by regional or national agricultural organizations, such as the DEPHY network; and collective or bilateral experimentations led by technical institutes (notably the *Centre du Rosé*);

- Private consultants: some of whom work for equipment, seed or chemical product sellers, and others who are specialized in vine cultivation (this is notably the case for biodynamic winegrowers);

- Other winegrowers from neighboring estates.

Winegrowers vary widely regarding the number of types of actor in their professional network. However, we found no obvious links between the density or structure of an individual's professional networks and the reception of EVS. We will therefore not go further into the analysis of winegrowers' social network profiles.

Another result of our study is that EVS workshops led to the constitution or reactivation of peer-to-peer professional links. First, workshops were indeed perceived as an opportunity to interact with other winegrowers. Some of these interactions may already have been part of winegrowers' existing social networks, but interviews indicate that in many cases these peer-to-peer interactions were new. In particular, various winegrowers indicated that their participation led them, during the workshops, to create or reactivate links with neighbouring estates. Most of the winegrowers expressed their regret that these dynamics were not maintained after the official end of the EVS project for the territory. Second, this value of discussions among peers was emphasized by winegrowers working in areas with strong environmental

particularities. This is the case of the southern zone of the Côtés-de-Provence vineyards, close to the sea, between Hyères and Saint-Tropez (see Figure 1), which is characterized by sandy soils and a relatively high number of ‘orange’ and ‘red’ diagnoses. As one of the winegrowers explained: “we have issues which are specific to our area, and talking to people working in the same area is interesting”. It is worth noting that three of the five winegrowers in this area explicitly reported their feeling of being geographically (and then socially) isolated from the *syndicat*. Our hypothesis is then that participation in EVS reinforced their sense of belonging to an area with environmental and physical particularities. Furthermore, during the interviews, the recognition of these local specificities led them to insist on the value of peer group discussions at this scale to find solutions to their agronomic problems (see Box 3 for an example). These different elements (the constitution or reactivation of peer-to-peer professional links; the winegrowers’ wish to maintain these peer-to-peer discussions facilitated by the *syndicat*; the necessity to adapt these discussions to local particularities) point towards reflexion about the *syndicat*’s roles, governance and modes of action. We propose some developments on this question in the discussion section.

#### **Box 1**

##### *Winegrower from Group A-Conventional farming- ‘Green’ aggregated EVS diagnosis*

The interviewee (a man) is the head of a 36-ha (3,600-ares) wine estate. He is a member of an association of winegrowers from the area he lives in (*association des vigneronns de la Sainte-Victoire*). With 16 other winegrowers from this association, he is engaged in a GIEE (a professional organization aiming to promote collective discussions and innovative practices) which develops the use of organic waste to fertilize soils. This GIEE also monitors soils through physical and chemical analysis. His technical itinerary is now well stabilized, after ten years of tests. He sows cover crops (clover) in every fourth inter-row. Even though he is interested in EVS global insights, he does not plan to extend cover crops (he has concerns about water stress, even if he has never directly faced such a problem). The interviewee spreads massive quantities of organic waste on 12ha (1,200 ares) of his wine estate (250t per ha). He is very satisfied with the results: his soils retain water better during dry periods, and he has observed an increase of the number of earthworms. He interprets his (‘green’) EVS diagnosis as a consequence of this use of organic waste: “I was quite good, the diagnoses were green. But as I said during the meeting, on these plots we put green

manure and vegetal organic waste. Those cultural techniques lead to that; it's not representative of all the area"<sup>9</sup>. After the workshops, he discussed with the head of the GIEE his idea of engaging in the future in the pooling and cross-checking of the different available information (that is, the results from EVS in the area and the soil analysis performed by the GIEE).

## Box 2

### *Winegrower from Group B-Biodynamic farming- 'Orange' EVS diagnosis*

The interview was conducted with the two crop managers (women) of a 30-ha (3,000-ares) wine estate where biodynamic farming methods had been used since 2018. They maintain self-growing cover crops in winter and spring, before destroying them. They want to delay cover crop destruction (later in spring), but, like many winegrowers in the area, they have concerns about water stress (while recognizing that “there are no scientific results behind these concerns, only fears and habits that are hard to change”). Because of the sandy-clay texture of their soils, they face soil compaction issues when using tractors. They interpret the ‘orange’ EVS global diagnosis as the result of an excess of tractor use in 2022 for antifungal treatments (due to heavy rainfalls): “Ecovitisol has shown...we already know that...we have soil with a strong tendency to slacking and we used the tractor a lot. What has emerged from Ecovitisol is that we have compact soil, with little microbial activity”<sup>10</sup>. They had therefore decided to stop tillage under the vines as of the fall 2024, to limit tractor use. During workshops, they were keen to discuss this with a neighbour who maintain permanent cover crops. They want to follow up these peer group discussions in the future.

## Box 3

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<sup>9</sup>« C’était pas trop mal, j’étais pas mal dans le vert. Après, c’est ce qu’on avait dit dans la réunion, c’est des parcelles où il y a eu de l’engrais vert et de la MVA [matière végétale affinée]. C’est des techniques culturales qui poussent vers ça, et ça représente pas tout le secteur »

<sup>10</sup>« L’étude ÉcoVitiSol, qui avait mis en avant que... on le sait... on a des sols qui sont à tendance de battance et on a pas mal multiplié les passages. Ce qui est ressorti d’ÉcoVitiSol c’est qu’on avait des sols qui étaient tassés, avec peu d’activité microbienne »

*Winegrower from Group C-Organic farming- 'Orange' EVS diagnosis*

The interviewee (a man) is the technical manager (crop and wine production) of a 15-ha (1,500 ares) wine estate where organic farming methods have been used since 2015. Before then, soils were intensively tilled. For the past four years, he has tried to develop cover crops in order to improve soil structure (he has soil leach and collapse issues). He faces a lot of difficulty in finding a technical itinerary adapted to his sandy soil, a central issue being water stress and soil organic matter: “we have sandy soil here, it’s very hard to stock organic matter. We can do whatever we want, it will be very complicated to reach good levels”<sup>11</sup>. He tested various solutions: sowing cereal crops, or a mix of cereals and legumes (fava beans to “store water during summer”) on all inter-rows or every second inter-row. He also tested different methods of cover crop management (tillage or mulching). He describes a form of contradiction between the need to preserve water resources, and the attempt at developing cover crops; and EVS results do not offer him concrete solutions to overcome his difficulties. However, he was very interested in talking to winegrowers from the same area (Gulf of Saint-Tropez, southern zone of the Côtes-de-Provence vineyards) during the EVS workshop; these peer group discussions seem to have reinforced his awareness of the particularities of this area: “Soils are heterogenous, we saw that during the meeting... We really have specific problems in our area, and discussing this with people working in the same area, it’s interesting. To go to the syndicat, from here, it is 90-minute drive”<sup>12</sup>. He was also surprised by aggregated EVS results which showed that a technical itinerary (in particular, tillage practices) is more determinant than modes of production themselves (conventional, organic, or biodynamic farming) for the soil’s microbiological quality: “the conclusion is that someone in conventional farming can have a soil’s microbiological life as rich as someone in biodynamic or organic farming, because of less tillage; on the contrary, someone in organic or biodynamic

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<sup>11</sup>« Mais on a des sols plutôt sableux ici, la matière organique c'est très compliqué de la stocker. C'est pour ça qu'on aura beau faire ce que l'on veut, je pense que c'est très compliqué d'arriver à des taux satisfaisants »

<sup>12</sup>« Parce que les sols sont assez hétérogènes, on l'a vu notamment au compte rendu de novembre... On a vraiment des problématiques propres à notre secteur et c'est vrai qu'échanger avec des gens qui travaillent dans le même secteur géographique, c'est intéressant. Au syndicat, ici, ça nous fait 1 h 30 de route à chaque fois »

farming, who always goes in the vineyard and compacts the soil, there's almost no life anymore"<sup>13</sup>.

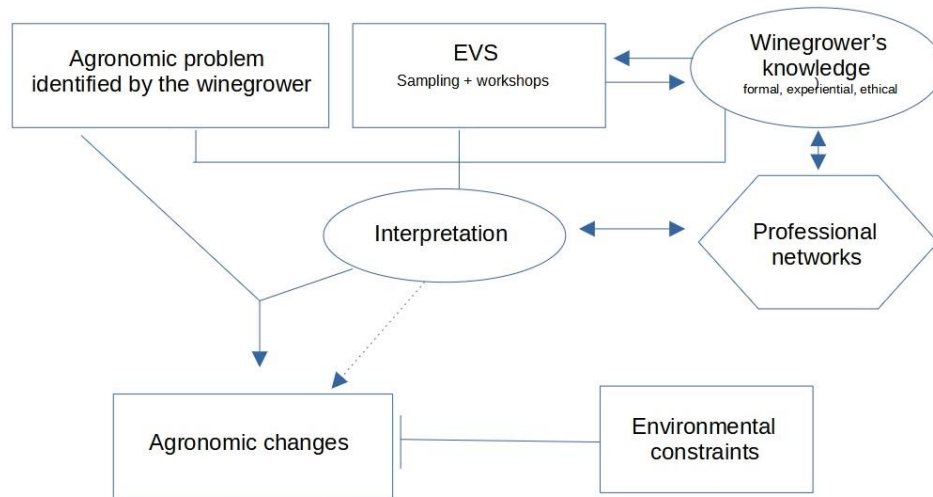


Figure 2-General model of EVS impact on practices, knowledge and professional networks. Full lines stand for short-term effects which are clearly established from our empirical data. Dotted lines stand for hypothetical, long-term effects.

#### 4-Discussion

To what extent can co-produced ecological expertise foster agroecological transitions? We examine this issue by taking as a case study a participatory research project dealing with soil ecological quality in viticulture (EcoVitiSol, EVS). In order to assess the effects of winegrowers' engagement in EVS in their agronomic practices, we propose to conceptualize this collaborative approach as an *épreuve* in the pragmatic sense, that is, a moment of testing of farmers' conceptions and justifications of their agronomic practices (Boltanski, 2009). This test is constituted by a series of ecological diagnoses and their co-produced interpretations: the

<sup>13</sup>« Ce qu'il en ressort c'est que d'un côté, quelqu'un qui fait du conventionnel peut avoir une vie microbiologique dans son sol tout aussi intéressante que quelqu'un en biodynamie ou en bio, parce que moins travailler les sols, avoir moins tendance à cultiver son sol, et au contraire quelqu'un qui est en bio ou en biodynamie, qui passe tout le temps dans sa vigne à tasser les sols, les décompacter, les retasser, etc., il y a une vie presque absente »

*épreuve* then refers both to the expertise in itself (that is, the colors of the diagnoses) and to the discussion processes (with researchers and among peers). Our main result is that these *épreuves* do not significantly modify farmers' conceptions of their practices; they confirm and enrich winegrowers' knowledges which justify these conceptions and current practices. However, they may trigger changes that were already envisioned, or at least which are not in contradiction with winegrowers' conceptions. More concretely, participant winegrowers interpret EVS results through the filter of their perceived agronomic problem and the knowledge they hold. In cases where they are currently unsatisfied with their technical itinerary, participation in EVS may accelerate or trigger the implementation of solutions to their agronomic problems — in cases where they do not face limiting environmental constraints. Interestingly, this short-term impact is independent from the individual EVS diagnosis. In cases where the technical itinerary was stabilized, none of the interviewees reported any short-term planned agronomic changes — even when their individual EVS diagnosis indicated a low microbiological quality. In other words, elements of scientific expertise alone are not likely to trigger agronomic changes; they interfere with agronomic configurations (namely, the stability of the technical itinerary) and with winegrowers' formal, experiential and ethical knowledge. Conversely, experiential and ethical knowledges are enriched by EVS expertise; the projects offers some concepts (such as microbial biodiversity) and causal relations (between this diversity and soil management practices) which are mobilized by winegrowers to describe and give meaning to their judgements (ethical knowledge) and observations (experiential knowledge). These results allow us to discuss the widespread idea that engaging farmers in the production of ecological knowledge might foster transitions towards more sustainable systems (e.g Berthet et al. 2018; Billaud et al. 2021). Without contradicting this affirmation, we bring some nuances by showing that farmers' knowledge about their agronomic practices and environmental situations leads them to interpret and discuss ecological data in a sense that may reinforce their conceptions. This result is far from being surprising. Pragmatic sociology as well as the *science studies* have highlighted for a long time that the results of an *épreuve* are not unequivocal (Martucelli 2015). First, scientific data may be subjected to diverse interpretations, above all when describing real-world systems; second, existing social and knowledge networks influence the reception (and practical uses) of raw scientific results.

These results may also be replaced in the abundant literature which, over the last decades, has studied the factors influencing farmers' adoption of environmentally sustainable innovations (see review by Rizzo et al. 2024) or ecological practices (see review by Thompson et al. 2024).

They suggest that the literature on the factors influencing farmers' adoption of ecological practices primarily focuses on those factors that are *inherent to individuals* (attitudes, beliefs, social networks) or *to the farm* (type, size, income). In the the specific case of viticulture, Zacchman et al. (2023) explore for instance the effects of providing personalized or general information about environmentally toxic fungicides to 436 grapevine growers in Switzerland. They find no effect of information on winegrowers' intentions to plant fungus-resistant varieties, and show that this result reflects the role of environmental 'noncompliant' perceptions as an obstacle to change. Similarly, Chen et al. (2022) suggest that winegrowers' general attitudes and beliefs towards viticultural practices are the main drivers of decision-making regarding pesticide use and inter-row management (including type of vegetation, duration of vegetation cover, and soil tillage). Studying winegrowers' decision-making process regarding adaptation to climatic change in the Loire Vally, Thiollet et al. (2020) demonstrate the role of winegrowers' socio-cultural profiles (including their social network) as determining levers and obstacles to changing viticultural practices. By conducting 16 interviews with winegrowers from the Napa Valley in California, USA, Gonzalez-Maldonado et al. (2024) established a link between winegrowers' perceptions and attitudes about soil health and soil management practices. By contrast with this literature, our research considers the way winegrowers perceive their whole agronomic and environmental situation, and particularly their knowledge of the specific agronomic problems they face. This allows us to assess more finely how farmers may receive, interpret and use (co-constructed) ecological information.

Out of these individuals' appropriation of EVS, our data finally gives some clue to discuss the role of professional organizations such as the *syndicat* in fostering collective changes — even if this study does not focus primarily on this question. Consistently with existing literature on farmers' social relationships (e.g. Compagone, 2014; 2019), we have shown that EVS participants are integrated in professional networks of greater or lesser density, populated by a variety of public or private actors. In this respect, the *syndicat*, as a professional organization first dedicated to the protection and control of the AOC label, originally played a regulatory role. Recently, it has also endorsed a mission of impulsion and facilitation of collective action towards agroecology, through the development of research and development projects. We have suggested that this kind of collective project is of interest as a way to foster peer group discussions. Out of the co-construction and diffusion of concrete agronomic or ecological results, it might then be relevant to capitalize on these research and development projects to drive a dynamic of professional interaction. Furthermore, the existence of areas with strong

local particularities, presenting their own agronomic challenges, points to the importance of taking into consideration local demands and needs when designing and/or facilitating the *syndicat*'s projects, including in the long-term. These two points may be discussed from the perspective of Ruggieri et al. (2023)'s study of a protected designation of origin (PDO) area within the Loire Valley. By analyzing the interactions between the different actors constituting the PDO wine system in the Anjou-Saumur area, they contrast top-down and bottom-up regulatory approaches. The former are mobilized by actors who relay national orientations or rules (e.g. national scientific institutes, chambers of agriculture), while the latter correspond notably to the activity of local professional organizations supporting geographical indication (such as the Côtes-de-Provence AOC). These ones focus more on producers' needs, local issues, and motivations for change. The authors suggest that the construction and dissemination of agroecological solutions need a combination of these two types of governance. As in Ruggieri et al. (2023)'s case study, the professional organization in charge of the Côtes-de-Provence AOC (the *syndicat*) may efficiently meet this need for bottom-up approaches. To perform this role, it would be useful if the *syndicat*'s activities, structured around research and development projects (such as EVS), came with the long-term maintenance of arenas for peer-to-peer dialogue (which was not the case with the EVS project). On this condition, the *syndicat*'s projects may fruitfully complement interactions and activities that every winegrower performs within their own professional network. This role of the *syndicat* in fostering peer-to-peer dialogue may be all the more important for those winegrowers who are relatively distant from initiatives such as EVS. As suggested when setting out our method, participants in EVS are certainly not representative (in terms of interests for ecological research and/or for innovation in soil management practices) of all winegrowers of the Côtes-de-Provence AOC. This hypothesis is consistent with Hunt et al. (2025)'s conclusions about on-farm research with farmers. Farmers participating in such programs have specific characteristics regarding their perceptions of innovative practices, social networks, and farm management. A challenge, for the *syndicat*, is then to initiate a dynamic of change among those winegrowers who are not spontaneously interested in developing a better knowledge of their soil. Among other works on the role of farmers' collectives (see Slimi et al. 2021 for a review), Rust et al. (2022) analyze the role of expertise (compared to peer groups) in adopting soil management innovations by two groups of farmers in the UK and Hungary. They show that farmers tend to trust other farmers more than agricultural researchers from academic and government institutions, partly because farmers believe that researchers would not be empathetic towards their problems and needs. These results, coupled to our own conclusions, may indicate that the constitution of such

peer groups could be a major output of participatory research approaches when supported by professional organizations, including for those winegrowers who are *a priori* less interested in (or trustful of) ecological sciences. These participatory approaches could indeed serve as a starting point to structure winegrowers' collectives. For instance, workshops such as those organized by EVS could be used to identify groups of winegrowers facing similar agronomic problems, or willing to test new practices. The peer groups could then be maintained over time, and involve other (initially non-participant) farmers in order to collectively find innovative solutions to common issues, or implement new more sustainable practices.

Beyond the formulation of these (limited) recommendations, we hope our contribution also enriches the common understanding of the role of social sciences when tasked with evaluating the impacts of a specific project and providing informed advice to improve these impacts. By uncovering some of the determinants behind farmers' appropriation of co-constructed expertise, our study highlights how the inherent complexity of social dynamics challenges the somewhat utilitarian expectations sometimes placed on social scientists—namely, to provide clear-cut solutions to wicked problems. Reciprocally, our study offers a critical perspective on a common hypothesis—whether implicit or explicit—that underpins the proliferation of participatory research approaches in agriculture: the assumption that farmers' engagement in the co-construction of knowledge is a reliable way to ensure their appropriation of scientific expertise and, consequently, behavioral change. By contrast, our work suggests that the transformative effects of participatory research are far from direct or linear. Since these collaborations with researchers are embedded in complex networks of actors, data, and representations, co-constructed knowledge hardly assumes the pivotal or decisive character that is sometimes expected of it.

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