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Towards pesticide free agriculture in the Pilat Rhodanien, France

A socio-technical systems analysis into barriers and opportunities on a territorial scale

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Master of Science in Agroecology

Dedicated to Catherine Reinaud (1941-2022)
Luminous, loving source of inspiration

Gratitude and acknowledgements

Abstract

List of abbreviations

AOC: Protected Designation of Origin (*Appellation d'origine contrôlée*)
ARDAB: Organic Producers Association for Rhône and Loire (*Association Rhône-Loire pour le Développement de l'Agriculture Biologique*)
ATCR: Technical Association of Côtes du Rhône Septentrionales (*Association technique des Côtes du Rhône Septentrionales*)
AURA: Region *Auvergne-Rhône-Alpes*
Be Creative: Built pEstiCide-free agRoecosystEms At TerrItory leVEl
CUMA: Cooperative for the use of agricultural equipment (*Coopérative d'utilisation de matériel agricole*)
DDT: Departmental Directorate of Territories (*Direction départementale des territoires*)
DRAAF: Regional Chamber of Agriculture (*Direction régionale de l'Alimentation, l'Agriculture et la Forêt*)
EU: European Union
FAO: Food and Agricultural Organization of the United Nations
HLPE: High Level Panel of Experts on Food Security and Nutrition
HVE: High Environmental Value (*Haute Valeur Environnementale*)
IGP: Protected Geographical Indication (*Indication Géographique Protégée*)
IIA: Interest/Impact Analysis
INAO: National Institute for Origin and Quality (*Institut national de l'origine et de la qualité*)
INSEE: National Institute of Statistics and Economic Studies (*Institut national de la statistique et des études économiques*)
INRAE: French National Institute for Research in Agriculture, Food and the Environment (*l'Institut national de recherche pour l'agriculture, l'alimentation et l'environnement*)
IPES-Food: International Panel of Experts on Sustainable Food Systems
IPM: Integrated Pest Management
ISARA: Higher Institute of Agriculture and Agribusiness Rhône-Alpes (*Institut Supérieur d'Agriculture et d'Agroalimentaire Rhône-Alpes*)
KET: Key Existing Technologies (*Technologies révélatrices*)
MLP: Multi-level perspective (MLP) theory on socio-technical transitions
PAC: Common Agricultural Policy (*Politique agricole commune*)
PDI: Parallel design interventions (*Innovations couplées*)
PNR: Natural Regional Park (*Parc naturel régional*)
SAFER: Land development and rural settlement company (*Sociétés d'aménagement foncier et d'établissement rural*)
SMAGGA: Union for the enhancement, protection and management of the Garon watershed (*Syndicat de Mise en Valeur, d'Aménagement et de gestion du bassin versant du Garon*)
STSA: Socio-technical systems analysis (*Diagnostique socio-technique*)
STS: Socio-technical system
STT: Socio-technical transition
TFI: Treatment frequency indicator (*Indicateur de Fréquence de Traitements phytosanitaires*)
WP1/2: Work package 1/2

Figures

Tables

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Abstract

This research was conducted as part of the first phase of a 6-year long project run by INRAE called “Be Creative” (2021-2026). The project’s ambition is to study specific agricultural territories in France in view of designing initiatives with local inhabitants, farmers and other territorial actors for the realization of zero-pesticide agricultural systems. Our territory of study was the Pilat Rhodanien, a geographical zone along the west side of the Rhône river valley, south of Lyon. We investigated viticulture, a prominent and historic production on the plateaus and steep hillsides of this peri-urban landscape. Our goal was to understand the influences on chemical input use in these vineyards through qualitative ethnographic research. This was followed by multi-scalar, thematic analyses using the multi-level perspective on socio-technical transitions, actor network mapping and stakeholder management strategy, which we enriched using a political ecology lens. Our findings center on barriers and opportunities to reduce the use of chemical inputs, notably herbicides and fungicides. The socio-technical lock-ins that we found to be maintaining the use of chemical inputs were multifaceted. We highlight the role of social networks, norms, values, knowledge systems and practices held by the historic, familial and deeply-embedded productions characterized by prestigious geographical indications. We identified actors in these social networks who play diverse roles in the territory related to chemical input use and reduction, their participation and activities being key aspects of agroecological transition processes in the territory. We forecast the next phase of the Be Creative research project, by proposing potential innovations that may further help reduce and/or eliminate pesticide use in the vineyards of the Pilat Rhodanien, many of which rest on multi-actor collaborations.

1. Introduction: Research context, the Be Creative project

The present study was conducted as part of the first phase of a research project called Be Creative (Built pEstiCide-free agRoecosystEms At TerrItory leVEl)**,** coordinated by the French National Institute for Research in Agriculture, Food and the Environment (INRAE). It takes part in a national research agenda called "Cultivating and Protecting Alternatively" (*Cultiver Protéger Autrement)*, which groups programs that work, by their own design, to tackle the issues with pesticide use in France. The goal of our project was to identify the barriers and opportunities that exist across the food value chain for designing zero-pesticide farming systems in a specific territory. Our territory of study was the Pilat Rhodanien, a geographical zone south of Lyon. We partnered with the Pilat Natural Regional Park (PNR), a government agency working to protect biodiversity, preserve natural and cultural heritage, and contribute to rural sustainable development. Our research was meant to produce action oriented results which lay the groundwork for designing and implementing innovations in distinct socio-technical contexts, and to catalyze coordinated efforts on the territorial scale to reduce, or eliminate, the use of chemical inputs.

1.A. Chemical input use in modernized agriculture

Over the course of the twentieth century, pesticides gradually became the main crop "protection" strategy on European farms. Chemical inputs[1] are used to prevent, destroy or control various pests: fungi, insects, weeds, or other harmful organisms (FAO, 2002). They are meant to help farmers "secure" their harvest and cut down production costs above a certain scale. Known as green revolution technologies, chemical input use was encouraged from the 1960s onwards by agricultural modernization and development policies (Brunier, 2015), which went hand in hand with the rise of pesticide industries whose lobbies continue to play a role in the economy and organization of rural worlds (Aulagnier and Goulet, 2017; Clapp, 2003).

It is difficult to generalize the impacts of pesticides on biodiversity and ecosystems functions and services. Available knowledge on the subject is fragmented and heterogenous, in part due to the fact that it covers a wide range of entities (chemicals, active substances, products; species, habitats), which act differently according to the environmental conditions (hydrologic, soil characteristics) and practices (agriculture, forestry, resource management; Leenhardt et al., 2022). Nonetheless, numerous studies since the late twentieth century have condemned chemical inputs for their role in harmful environmental pollution, biodiversity loss, and negative health consequences (Nicolhopoulou-Stamati et al., 2016; Wilson and Tisdell, 2001). Societal awareness of the harmful effects of pesticides on the environment has been around since Carson's foundational work, *Silent Spring* (1962), which emerged at the same time as the first scientific considerations to use biological control in addition to, or instead of, chemical control (Deguine et al., 2021; Van Den Bosch and Stern, 1962). Following these developments, and since the early 1980s, organic agriculture has undergone enormous growth, first in the Global North and then elsewhere around the globe (Youngberg and DeMuth, 2013). When we use the term "organic" in the present research, we

[1] We use the terms 'chemical inputs' and 'pesticides' interchangeably, to refer to products that are commercialized as, including but not limited to, herbicides, fungicides, insecticides or fertilizers, made from synthetic or natural molecules of active substances. This includes some products used in organic production, or for biological control. Some specific examples are glyphosate-based herbicides, the fungicide *Vivando*, or the insecticide *Success.*

imply an agriculture that follows French requirements as indicated in the organic certification, *Agriculture Biologique*. This should not be taken to mean an agriculture of zero pesticides. The certification restricts the use of plant protection products to those of "natural" origin, which is complicated to define.

In France, the development of specialized, "professionalized" farms and territories has been favored over mixed crop-livestock farming systems and diversified landscapes (Meynard et al., 2018; Schott et al., 2010). This has been accompanied by dependance on synthetic chemical inputs, which help ensure a large output of 'inexpensive' food products for supermarkets and customers. These systems are costly, however, in terms of negative externalities, be it water, ground and air pollution; destruction of natural habitats; toxic fabrication processes; impacts on human health; or labor exploitation (Buttel, 2003; Neumeister, 2022; Wilson and Tisdell, 2001).

Shifting dynamics on a macro-level, such as available crop varieties, scientific knowledge, and social awareness and norms around sustainable agriculture, have been highlighted as windows of opportunity for change in agricultural and food systems (Vanloqueren and Baret, 2008). Still, studies on state-led pesticide reduction efforts in France have shown how difficult it is for farmers to adopt practices that depart from a reliance on chemical inputs (Bjørnåvold et al., 2022; Lamine, 2011). The usefulness of herbicides for the maintenance of vineyards on steep hillsides, for example, has led to a pesticide 'lock-in' within these modernized, monoculture systems.

1.B. "Pesticide lock-ins" and research on zero-pesticide agriculture in France

The concept of socio-technical lock-in corresponds to self-reinforcing processes that lead to a dominant technology excluding competing technologies that have similar functions, even if those may perform better in the long-run (Liebowitz and Margolis, 1995). While lock-ins were first explored in case studies on energy and transport, researchers have adopted the concept to untangle "wicked problems" in contemporary food and agriculture systems, and to reveal barriers towards the development of more agroecological systems (Duru et al., 2015; Lamine, 2011; Magrini et al., 2019; Meynard et al., 2018). Research in France has shown that the existence of lock-ins around pesticide use discourages actors from developing alternative production systems, and preventive, holistic methods for crop health such as Integrated Pest Management (IPM), and other prophylactic measures that together limit pest populations and diseases (Meynard et al., 2018).

"Favoring prophylactic measures", "developing agroecology" and "mobilizing diverse and plentiful actors within and across agricultural sectors" are the three major actions proposed by INRAE in their state of the art, zero-pesticide approach to redesigning agricultural systems (Jacquet et al. 2022a, 2022b). The use of "prophylaxis" covers all the means other than chemical pesticides used to prevent the appearance or development of pests. "Developing agroecology" in this context means increasing the complexity and diversity within farming systems in ways that improve sustainable production and systemic pest control while also accounting for the impacts on farmers and their livelihoods. Research has shown that escaping pesticide lock-in requires coordination external to the production system, sometimes involving the entire agri-food value chain (Belmin, 2016; Vanloqueren and Baret, 2008; Vanloqueren and Baret, 2004; Jacquet

et al. 2022a). This is much easier said than done, given the difficulty in catalyzing multi-sector initiatives and aligning agendas. In France, there has been dissonance between scientific discourse in favor of complex and long-term transitions, and the tendency of governmental research aimed at results that may be effective only in the short term (Aulagnier and Goulet, 2017).

The International Panel of Experts on sustainable food systems (IPES-Food) defined eight key lock-ins to industrial agriculture, which revolve around the concentration of power in agri-food systems (2016): concentration of power; export orientation; expectation of cheap food; path dependency; measures of success; short-term thinking; compartmentalized thinking; and feed the world narratives. Some of these lock-ins relate to political and governance structures; some concern the way markets are organized; and others represent psychological barriers and mindsets which frame the potential for change. These all take part in complex, vicious cycles that need to be broken in order to achieve transitions towards diversified, agroecological systems (IPES-Food, 2016).

1.C. Theoretical framework: multi-level perspective on socio-technical systems and political ecology

The multi-level perspective (MLP) on socio-technical transitions (STT) is a theoretical framework that was developed as a means to describe socio-technical systems and pathways in transition processes (Geels, 2004). It is characterized by three levels of heuristic, analytical concepts: the socio-technical landscape, socio-technical regime, and niche-innovations (Geels, 2020, 2002; Geels and Schot, 2007; Rip and Kemp, 1998). The strength of the concept of socio-technical regime is that it captures the broad community of social groups and their alignment of activities which stabilize mainstream practices (Geels and Schot, 2007; Nelson and Winter, 2004). The socio-technical landscape represents factors which have an external influence on actors' capacity to act and/or modify their practices, such as macro-economics, macro-political developments, and deep cultural patterns. Technological niches are characterized as spaces of 'incubation' where radical innovations may emerge, protected from mainstream market pressures, and developed by relatively small networks of dedicated actors who are potentially external to- or on the fringe of the socio-technical regime. In this context, transitions are defined as changes from one socio-technical regime to another, by way of both landscape pressures and niche innovations that integrate and transform the regime (Geels and Schot, 2007). The development and diffusion of a niche, however, is not an easy, linear process. It is rather complex and messy, subject to niche and regime contingencies (Elzen et al., 2012).

Several authors using the MLP framework have successfully integrated additional scientific approaches in their analysis, a fertile approach to refine and operationalize the heuristic framework (El Bilali, 2019). We adopted and interpreted STT theory by taking a political ecology lens, which encourages the analysis of power, discourse, and actor networks (Adger et al., 2001; Anderson et al., 2019; Avelino and Wittmayer, 2016; Geels, 2014). A political ecology perspective adds an important layer, because the MLP theory alone risks overemphasizing material practices and technological artifacts, and underemphasizing the social relations in sustainability transitions (Anderson et al., 2019; Lawhon and Murphy, 2012). Attention to these

nuanced social dynamics can help highlight how partnerships form around change making, the impact of decision making processes, changes (or inertia) in governance (Benjaminsen and Svarstad, 2021) and how to redistribute power in STT (Lawhon and Murphy, 2012). This perspective allows for an analysis of actors' agency in the use and distribution of resources (Benjaminsen and Svarstad, 2021; Hassink et al., 2018).

Much of the literature using the MLP framework has focused on actualized transitions having occurred over the course of decades (Darnhofer, 2015). Studies on emergent transitions is a rather recent development (Hounkonnou et al., 2012; Sutherland et al., 2015). We contribute to this body of literature by providing an account of the dynamics present at a given moment in time, within a specific territory. We also consider the future development of regime and niche trajectories, by proposing and discussing potential innovations, relevant for our study given its use in the Be Creative research project to design actions to support future transition accompaniment.

1.D. Agroecological transition on the territorial scale

Studying sustainability transitions on the territorial scale has become of growing interest in academic literature on agroecology, especially in a European context (Bui, 2015; Lamine et al., 2019; Triboulet et al., 2019). Challenges involved in transitioning to more sustainable agriculture have often been articulated and conceptualized at a macro level (Ingram et al., 2015). The Be Creative research project was devised to take place within 10 specific territories throughout France. Territories are physical and symbolic entities across which stakeholders may engage in collective activities to construct viable pathways for agroecological transition (Anderson et al., 2019; Pelzer et al., 2020; Vandenbroucke et al., 2020; Wezel et al., 2016). Studying territories can help put into question how actors manage and use resources (Pecqueur, 1990) and address governance of the commons (Ostrom, 1990).

In the context of studying agroecology, transitions can be conceptualized as long-term, significant change processes that reconfigure the essential elements and connections within agriculture and food systems (Anderson et al., 2019; IPES-Food, 2016). Agroecology is understood here as three-fold: an interdisciplinary science, a social movement, and a set of practices based on 'agroecological principles' (HLPE, 2019; Wezel et al., 2009). In the framing and execution of our study, we drew primarily on the science and practice forms of agroecology. Increasingly agreed-upon agroecological principles include reducing or eliminating dependence on inputs, maintaining and enhancing diversity on multiple scales, connectivity, economic diversification, participation, synergy, soil and animal health, and the co-creation of knowledge, among others (HLPE, 2019). Multi-actor, EU-wide research projects are studying the way that these principles are observable in transition processes in specific territories (Grard and Miskulnig, 2021).

1.E. Research objectives and questions

This masters thesis aims to describe and analyze who and what influenced the use of chemical inputs in viticulture in the Pilat Rhodanien at the time of research. Our analysis is grounded in socio-technical systems theory. It explores food systems transition through the MLP framework, which we enrich with a political ecology lens to help better account for the role of social relations and power dynamics,, which an

MLP reading alone might lack. Our study looks at an emergent socio-technical transition happening in a specific territory, at a given point in time, and we explore its potential future development through an action-oriented analysis to help pave the way for future accompaniment. We considered the socio-technical transition through a multi-scalar analysis of parcel, farm, food value chain and territorial scale phenomena. Few papers bear an MLP analysis on the territorial scale, nor have they often addressed emergent transition processes, or future transition development.

We designed our study with the help of the socio-technical systems analysis methodology (Casagrande et al. 2022), and by posing the following two research questions:

1. **What are the barriers and opportunities to reduce or eliminate the use of chemical inputs in viticulture in the Pilat Rhodanien (notably, herbicides and fungicides)?**

2. **What characterizes the socio-technical systems that influence the use of chemical inputs in viticulture in the Pilat Rhodanien?**

We considered opportunities as: (i) Plant protection methods that replaced or facilitated a significant reduction of chemical input use; (ii) Factors enabling the development and/or use of these practices, including: associated know-hows, tools and infrastructures; mindsets, social norms, values, and rules; available coordination and/or supporting efforts for accessing information and knowledge, material and financial resources, selling and promotion, and networking opportunities.

By barriers, we meant : (i) Factors hindering the development and/or use of practices that replaced or facilitated a significant reduction of chemical input use. These could be economic, technical and agronomic, organizational, or personal. They included mindsets, social norms, values, and rules that were at odds with the use of alternative plant protection practices. (ii) Regime stabilization and related inertia. The co-existence of multiple barriers across different scales creates socio-technical lockins, the systemic and complex situations that can lead to dependance on chemical input use.

To forecast the second phase of the research project, and in direct continuation of the research questions, we also took interest in opportunities that do not currently exist in the territory but show promise to facilitate change in the future. We consider these as potential innovations for systemic change to address the socio-technical lock-ins around pesticide use. In agriculture, innovation can be understood as a co-evolutionary process that combines technological, social, economic, and institutional changes (Klerkx et al., 2012). It is not limited to the adoption of new technologies, but requires an alignment between the use of new techniques and new forms of organization. The innovation process is fostered by human systems that promote consistent interactions, where negotiations may occur that allow for rapid adaptation (Casagrande et al. 2022). The existence of markets is also key in transforming techniques and inventions into innovations (Schumpeter, 1939), where market and technology bring together intermediaries and generate collective activities that support co-evolutionary processes. We also propose further research needs to address remaining knowledge gaps, and to fulfill operational or experimental initiatives.

2. Methodology: An ethnographic, socio-technical systems analysis with a political ecology lens

We used a methodological guide for a "socio-technical systems analysis" (STSA) developed by INRAE agronomists (Casagrande et al., 2022, 54 pages), which is represented in Figure 1 and described in Table 1. In the guide, a socio-technical system (STS) is defined as a stable network of actors, characterized by common practices, knowledge, technologies, collective representations, norms and rules. Investigation on the use of technologies was proposed as a central strategy to highlight the different socio-technical systems of a territory, and how they may or may not allow for innovations and/or innovation processes to occur. Technologies in the STSA are defined as the combination of the (i) agricultural techniques, (ii) material artifacts, and (iii) knowledge and skills necessary to achieve a certain objective (Casagrande et al. 2022). We complemented this analytical approach with a political ecology lens. We collected data through ethnographic fieldwork, to gain an in-depth understanding of social phenomena, and to provide holistic insights into the views and actions of research participants (Suryani, 2013).

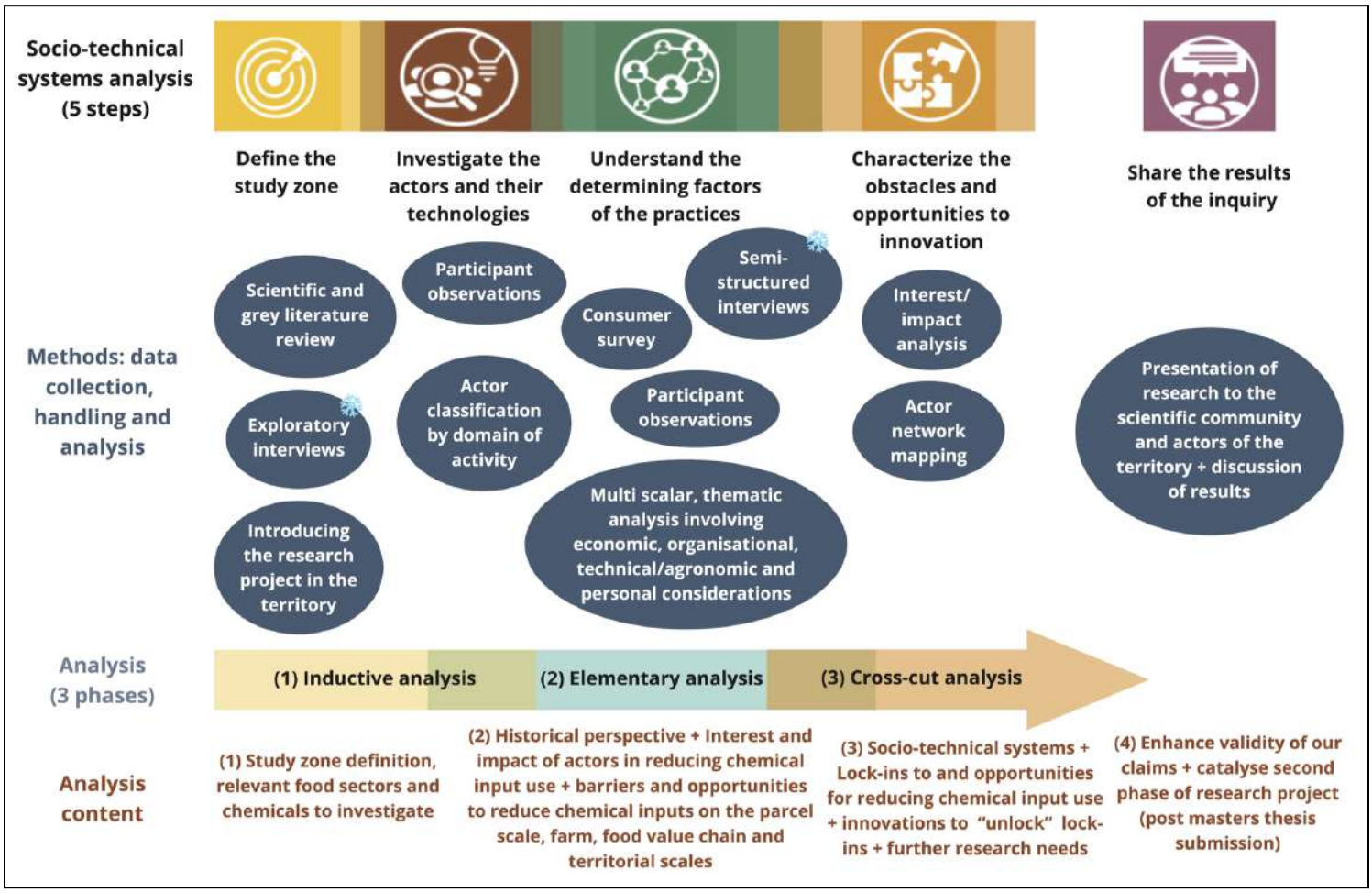

Figure 1. The five, iterative and overlapping steps of the socio-technical systems analysis, with three phases of analysis: inductive, elementary, and cross-cut. The methods of data collection and data handling that we followed (dark blue bubbles) and the results of each analysis (brown text) are indicated (Adapted from Casagrande et al. 2022).

Table 1. Description and methods associated with each of the five steps in the STSA.

Step	Description	Methods for data collection, handling and analysis
1 	***Define the study zone:*** Identifying the most appropriate food sectors and chemical inputs to research; defining the boundaries of the territory of study. Key was choosing the most urgent and appropriate topic and perimeter of study in view of future design considerations.	Gray literature review on agriculture and chemical inputs in the Pilat Rhodanien. Academic literature review on MLP, socio-technical transitions, territorial scale, pesticide use and lock-in. Exploratory interviews, notably with actors who had a global understanding of the agricultural landscape of the Pilat Rhodanien; snowball method.
2 	**a) *Investigate the actors...*** Identifying and interviewing relevant actors about their perspectives and role(s) in the use of chemical inputs in the study zone, and the evolution of the food sectors of study; crafting an interview sample to represent a diversity of perspectives on plant protection from multiple domains of activity. **b) *...and their existing technologies:*** Collecting data on common practices used to protect crops in the chosen sectors; identifying key existing technologies (in the guide, called 'revelatory technologies') to use in Step 3 to understand socio-technical systems.	**a)** Consulting partners at the Pilat PNR; snowball method; internet research. Mapping actors by categories (domains of activity). **b)** Exploratory interviews and participant observation.
3 	**Understand the determining factors of the practices:** Exploring the rationale behind actors' choices and actions on different scales (parcel, farm, food value chain, and territory), in particular related to the key existing technologies; analyzing actor networks and relationships.	Semi-structured interviews, participant observations, surveys for consumers, and elementary thematic, multi-scalar analysis.
4 	**Characterize the barriers and opportunities to innovation:** Determining the contributing factors to socio-technical lock-ins, and to alternative, emergent or innovative practices, in part through characterizing socio-technical system(s).	Cross-cut analysis of the results from the first three steps of methodology. Interest/impact analysis of actors with whom we conducted exploratory or semi-directive interviews. Mapping of actor networks with the help of program, *Obsidian*.
5 	**Share the results of the inquiry**: Presenting and discussing our analysis and results with key actors of the study zone, to enhance the validity of our claims, and to help catalyze the second phase of the research project.	Forecasting to the next phase, by presenting the results of the study to research participants and other relevant actors. A presentation and discussion of the results was scheduled for November 2022, to occur following the defense of the present masters thesis.

We complemented the five-step methodology with an additional step (in parallel to Step 1) to define a strategy for presenting our study to actors of the territory. This seemed necessary given controversy concerning our topic of research (pesticides) and the terms (‘*Zero Phyto Territory*’) used to describe it during a public meeting at the Pilat PNR office in January 2022, just before the start of our study. It appeared important that we be methodical, given our role in launching the Pilat chapter of Be Creative. Its reputation was key in its ability to achieve success: it relied on involving and collaborating with actors with different levels of interest in reducing the use of pesticides.

2.A. Methods for data collection

Our study was carried out using the following qualitative methods:

Project presentation strategy

To access research opportunities in the context of the controversial topic of pesticides, this entailed: (i) In all communications, choosing our words carefully, excluding obscure, ambiguous or judgemental language; (ii) Seeking to embody humility and openness to all viewpoints. We excluded ‘why’ and instead used ‘in what ways’ or ‘how’; (iii) Paying attention to non verbal communication (dress, physical posture, facial expression) to facilitate dialogue; (iv) Taking advantage of the ethnographic nature of our work and proximity with actors (living within our study zone) to gain trust and interest, and access research opportunities. We used contacts formed in multiple ways to connect with participants, and our knowledge of local customs to choose appropriate communication modes and contexts.

Exploratory interviews

We conducted a first round of exploratory interviews with actors identified through the help of research partners at the Pilat PNR, and then through the snowball method. Seeking to gain a comprehensive understanding and to integrate a diversity of perspectives, we prepared multiple interview guides to adapt to the type of actor interviewed, which we designed following a data collection protocol (Appendix A). In both exploratory and semi-directive interviews, we targeted actors related to viticulture as well as other dominant production systems in the Pilat Rhodanien (notably arboriculture), in order to gain a holistic view of the agricultural landscape of multiple productions in the territory, and to investigate the potential for cross-sector initiatives. The interviews that we conducted are summarized in Table 2.

Snowball method

Also called the ‘friends of friends’ method (Blanchet et al., 2001), the snowball method consists in asking research participants to recommend the next actors to interview to help answer the research questions. This method has proved particularly helpful to interview influential stakeholders, but not necessarily statistically representative samples. We consistently used this method, but complemented it with literature and internet research in order to diversify and broaden our sample.

Semi-directive interviews

To further investigate the subjects explored through the exploratory interviews, we expanded the interview guide, and included questions regarding networks of actors, and specific key existing

technologies (KET). Learning the viewpoints of different actors on KET was helpful to understand their potential in reducing chemical inputs, as well as the nature of socio-technical systems. We also sought to understand if and how the technologies played a role in how actors organized themselves. We used data saturation, continuing to interview until no new significant information emerged, in order to gauge when to stop. The interviews that we conducted are summarized in Table 2.

Participant observation

Conducted throughout both of the interview phases, these included, amongst others: work in vineyards and orchards; attendance of wine markets and farmers' markets; participation in a meeting for facilitators of farmer collectives aiming to reduce their use of chemical inputs; mechanical weeding tool demonstrations and technical field days; and political gatherings and conferences for the fruit industry in the Rhône valley. The purpose of conducting the participant observations was to gain perspective on actors' roles, activities (such as exchange of information), norms, relations, and networks. This information would be helpful for the characterization of socio-technical systems. We did our best to actively and appropriately participate in all events, for example, inquiring about, tasting and purchasing wine at fairs; taking part in workshops with agricultural technicians and coordinators of farmers' collectives; and sometimes helping to sell produce, animate workshops, or organize local events. The domains of activity and actor type that we came in contact with through participant observations are presented in Table 2.

Survey

We took part in the organizing committee and offered a stand at the 2022 *Pélussin* edition of the national Nature Festival (*Fête de la nature*). In addition to offering an artistic activity (decorating greeting cards with stamps made from vegetables and fruits), we invited passersby to fill out a questionnaire with 9 multiple-choice and/or short answer questions, titled "From field to plate" (*Du champ à l'assiette*) (Appendix B). The purpose of the survey was to assess the existing and potential roles of local consumers in food systems transition, by understanding their interest and impact in supporting a reduction of chemical input use, in general and in viticulture. We assessed this by designing questions that would help us gain insight into : (i) local consumers' habits related to food purchasing, including their choices regarding location of purchase, and preference for local and organic foods; (ii) their perspective on the consumer's role in the reduction of pesticide use, and (iii) if and how they were involved in actions to favor the reduction of pesticide use. We tested out the questionnaire with our colleagues at the Pilat PNR, and then integrated their suggestions for a final version to share with the public during the Nature Festival. We gained a total of 45 responses.

Table 2. Overview of exploratory interviews, semi-directive interviews, and participant observations conducted during four months of field work, organized by domains of activity and actor type. **For descriptions and a table with the full list of exploratory interviews, semi-directive interviews, and participant observations, see Appendix C.**

Domain of activity	Actor type	Exploratory interviews	Semi-directive interviews	Participant observations
Production	Wine producers	6	4	3
	Other producers	6	5	4
Technology and support	Agricultural technicians, advisors, coordinators of events and trainings	2	4	3
	Coordinators of farmers' collectives	1	3	1
	Suppliers of ag. equipment and inputs	0	2	1
Market	Vendor of local products	1	0	1
	Winegrowers' union	0	0	2
Civil-society	Members of local non-profit to promote organic food	1	0	1
	Association to promote organic agriculture	1	0	0
Socio-political	Coordinator in local branch of the national peasant agriculture confederation	1	0	2
	Territorial resource management specialists	1	4	3
	Anti-pesticide activists	2	0	1
	Directors of non-profits and associations related to agricultural development	0	2	2
	Employees at the Natural Regional Park	1	0	2
Total		23	24	26

2.B. Methods for data handling

Actor categories

We categorized actors with five 'domains of activity' (Casagrande et al. 2022). These were *production, technical support, market, civil society,* and *socio-political*. We added a sixth domain, *Be Creative project*, to implicate our research team and the diverse project partners. We kept track of all the actors in a spreadsheet, in order to: (i) provide an overview of relevant actors to interview and/or learn about through participant observation, gray literature or websites; (ii) strategize the prioritization of interviews; (iii) keep track of types of actors interviewed or not, in which proportion, and make informed decisions about whom to contact.

Stakeholder network mapping

We coded our interview notes by assigning a number to all actors and structures interviewed and/or mentioned as relevant in the study. This helped us organize and anonymize the data and create in-text references**.** For mapping, we used the knowledge management software *Obsidian.* It scanned our interview notes for actors' code numbers and other names that we tagged in double brackets, for example [[90]] or [[Rhône Chamber of Agriculture]]. A network map was created where lines are drawn between the actors who were mentioned in others' interview notes.

2.C. Methods for data analysis

Our data analysis followed three phases:

1) An inductive and global phase, to analyze the results of Step 1 and 2 of the STSA, to define the study zone and relevant food sectors and chemical inputs to investigate.

2) An elementary and in-depth phase, to analyze data collected in Steps 2 and 3 of the STSA, in order to provide:

A historical perspective of the development of the production systems and chemical input use in the study zone. Given the long-term nature of change in food systems, we found it relevant to provide a historical perspective on the events leading to the use of pesticides in wine production in the Pilat Rhodanien, to contextualize current practices and worldviews that maintain the path dependence on chemical inputs. The notion of path dependence emphasizes the influence of past choices, made particularly on the part of political institutions, on present decisions (Palier, 2010). We inquired about relevant historical events and developments with interview subjects as well as employees at the Pilat PNR, some present for more than 30 years. The historical perspective was crafted based on our findings of these actors' interpretations of the history of this region.

A description of the agronomic conditions, current plant protection strategies, the main alternative practices, emergent practices, and prophylactic measures used in viticulture at the time of research. We analyzed the influences on the use and reduction (or elimination) of chemical inputs on the parcel scale, and then on the farm, food value chain and territorial scales, using the following themes: technical/agronomic, economic, organizational and personal considerations related to the use and the reduction of chemical input use. The thematic analysis was based on the content of our semi-directive interviews and participant observation notes. The themes and some of the sub-themes explored in our analysis are listed in Table 3.

Table 3. Sub-themes that emerged in the interviews, used to structure the thematic analysis of plant protection strategies and influences on chemical input use.

Themes	Technical and agronomic considerations ⚙️	Economic considerations 📈	Organizational considerations ⏳	Personal considerations 🏠
Sub-themes	- Access to information - Contexts of exchange about practices - Practices for chemical input use and alternative approaches - Support from technicians at various agricultural structures - Norms and rules - Soil and climate	- Points of sale - Marketing strategies - Yield and profit - Quality labels and certification processes - Customer and client relations - Cost/benefit analyses of quality label certification processes	- Time constraints - Labor needs - Evolution of practices - Yield and storage capacity - Coordination efforts - Processes for quality label certification - Belonging to institutions, structures	- Relationship with neighbors, other producers - Knowledge sharing - Family history - Relationship to practice change - Values, as linked to land ethics - Mindsets, norms and rules

A description of the influence of relevant actors and structures on the reduction of chemical input use, in part through the analysis of key existing technologies (KET) as well as actors' interest and impact. This was based on participant observations and semi-directive interview data from a carefully selected sample of actors to represent a diversity of domains of activity and positioning towards KET. We investigated the following KET in the semi-directive phase:

1) Access to a tool for mechanical weeding of steep hillsides (which may not exist on the market).

2) Soil maintenance with vegetative cover (such as mulching, succulents, spontaneous or sown grass).

In the STSA guide, there is a strong emphasis on the analysis of technology use, to understand how this characterizes the STS, including how actors organize themselves. We found the use of specific technologies to analyze STS useful, yet limited: (i) Sometimes actors had technologies in common, but these were not the main elements structuring their network(s); (ii) The use of technologies alone did not reveal all of the characteristics of socio-technical systems; we found it necessary to investigate other topics than technologies, to understand actors' choices and the structuring of STS; (iii) Underlying this viewpoint is the assumption that actors are subjected to the technologies that they use. We found this to be an oversimplification of the influences on their practices, and were interested in complexifying the discussion of actors' agency and power relations. **For a table with the full list of KET identified in the exploratory phase, see Appendix D.**

There was also an emphasis in the STSA on assessing actors' interest and impact, a method originally used in the field of stakeholder management strategy to assess the positionality and potential role of different stakeholders in coordinated initiatives (Verzuh, 2005). For the interest/impact analysis that we conducted on the general question of the reduction of pesticides in agriculture (or specifically viticulture) of the Pilat Rhodanien, we scored actors using the criteria described in Table 4.

Table 4. Criteria used to assess actors' interest and impact on the question of the reduction, or elimination, of the use of pesticides in the Pilat Rhodanien.

Impact	Interest
Rating system: 1-3 scale for the following 7 criteria = /21 total A. Politics (bureaucratic, administrative, relationship to policies) B. Dissemination of technical knowledge and skill C. Dissemination of information, capacity for communications D. Organizational (ability to instill collective dynamics) E. Making agricultural equipment, work tools and/or labor available to allow reduction in pesticide use F. Financial (ability to obtain funds to allow reduction of pesticide use) G. Ability to influence change in perspective	**Rating system for farmers** (SMAGGA and ARDAB, 2021): 1 = Rejection 2 = Awareness 3 = Reflection 4 = Experimentation 5 = Integration **For non-farmers:**

	1-5 scale, nature of interest in political, personal, organizational, technical and economic terms

3) A cross-cut analysis phase, for which we reviewed results of the elementary and inductive analyses, to identify and characterize**:**

The socio-technical systems that influence chemical input use. Socio-technical systems were identified using the following criteria (Casagrande et al., 2022):

- Networks of actors, including influences amongst them such as decision making, knowledge sharing, and financial capacity;
- Norms and rules;
- Practices and technologies employed;
- Knowledge, skills and expertise;
- Relationship to the KET of plant protection (that we focused on in the semi-directive interviews), including opinions and controversial perspectives.

Socio-technical lock-ins to chemical input use. These are composed of a number of factors ('barriers') to reducing chemical input use. We matched these with corresponding:

Factors that enabled a decrease in or elimination of chemical input use ('opportunities'), ongoing in the territory of study at the time of research.

Potential innovations and innovation processes to "unlock" the lock-ins.

Further research needs.

2.D. Validity, reliability and ethical considerations

Our research approach was grounded in our intentions to listen attentively to the research participants, to honestly represent their perspectives on the complex research questions at hand, and to challenge injustice and incoherence. We followed methods that we considered appropriate and culturally relevant to ensure the integrity of our study. To achieve reliability, we followed the methodology detailed in the guide to socio-technical systems analysis, and described the way in which we appropriated it in the above methods section. We carried out our field work in a systematic way by following interview guides and a data collection protocol.

Researching and writing as co-authors, we shared many reflections on our distinct perspectives. We consistently reviewed and discussed each other's work. This helped us achieve consistency in our approach to the methodology and methods used. Our exchanges enhanced our capacity to observe and analyze the range of realities presented in the research. By iteratively reviewing our approach for data analysis, we

were able to both verify and be nuanced in our collective work. This was useful for the reliability of our research as well as our awareness of potential bias, assumptions and *aprioris*.

We solidified the reliability of our work by engaging in a number of research methods, which enabled us to read, hear, and sense information that we gathered in multiple ways. We interviewed a variety of actors to refine our understanding of how different stakeholders perceive the topics at hand. Conducting a large number of interviews enabled us to compare and contrast information we received from multiple actors on the same topics.

We aimed at being as strategic as possible in who we interviewed, when, and how, to thoroughly cover the topic with a limited amount of time. We chose the first interviewees with the help of agricultural experts at the Pilat PNR and our ISARA supervisors. We selected influential actors in contact with a large number of farmers to start our snowballing method. We stopped collecting data when it seemed that all of the influential actors recommended to us had been interviewed, and when we received little new information. We adapted our point of entry with multiple means: phone calls, emails, and direct visits. Straying from the snowball method at the end of our research, and selecting actors whose perspectives we assumed were lacking, enabled us to further widen our exposure.

To gain participants informed consent, we respected the following four essential elements: (1) disclosure (the adequacy of the information given by the researcher); (2) comprehension (the extent to which information is understood by the participant); (3) competence (the participant's cognitive or emotional capacity to give or withhold agreement); and (4) voluntariness (the absence of coercion) (Sim and Waterfield, 2019). We distributed a consent sheet to all interviewees, containing a description of our study and the research project, our data use and storage plan, and interviewee rights, such as the anonymization of all data (Appendix E). We orally presented the project and our study to participants prior to interviewing or surveying them, leaving ample time for questions. We provided our contact information and that of our ISARA supervisors. Only for a few exceptions was consent granted orally, over the phone. All consent sheets were scanned and sent to interviewees following our meeting, with an email warmly thanking them for their time, participation, and information and insights shared. Operational documents (contact sheets and interview guides), as well as research data (interview notes and recordings) were carefully classified and stored on the PNR server and the ISARA Be Creative Pilat research server. They will remain there for the duration of the Be Creative research project, until 2026. Translation from the original language of the data collected and the use of translated verbatims was acknowledged with research participants. We used a combination of dictionary and translation tools (*DeepL, Linguee, Wordreference)* as well as our own bilingual capacity to ensure the accuracy of our presentation of data and results derived.

2.E. Materials: The case-territory, Pilat, and its agriculture

The Pilat is a semi-rural area South West of Lyon with 56,000 inhabitants in 48 municipalities over 70,000 hectares, located in the *Auvergne-Rhône-Alpes* (AURA) region of central south east France, shown in Figure 2. The landscape is characterized by a semi-mountainous relief with a semi-arid section along the slopes of the Rhône river valley and a humid section along the high plateaus. Our research was concerned with the

north eastern section of the park called the Pilat Rhodanien, situated on plateaus and along the west side of the Rhône river, with steep valley hillsides exposed to strong southern sun exposure.

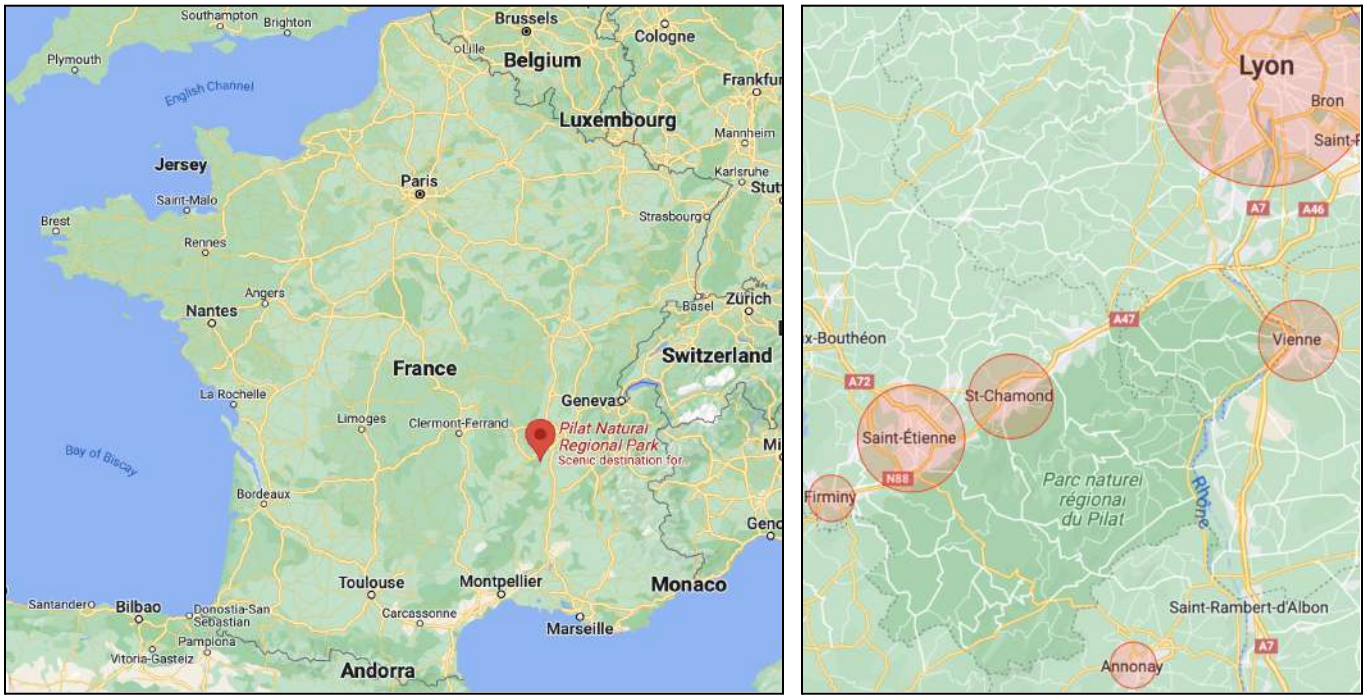

Figure 2. Maps of the Pilat territory's location within France (left), and surrounding urban centers (right). The circle size corresponds to the relative population size of each municipality (*Lyon* 520,000; *Saint-Étienne* 175,000; *Saint-Chamond* 35,000; *Vienne* 30,000; *Firminy* 17,000; *Annonay* 16,000). Source: Google Maps; INSEE.

Like many regions in France, the agriculture of the Pilat used to be known for mixed crop-livestock farms that integrated animal husbandry, vegetable gardens, fruit trees and grain growing. These diversified family farms supported food and territorial autonomy, prior to the existence of globalized food systems and world commerce. In recent history, the Pilat was a relatively poor territory, of majority peasant and working class families. In 1974 the territory was designated a Natural Regional Park (PNR), which brought major investments from the state to ameliorate the deforested and eroded landscape and improve public infrastructures.

The Pilat PNR has been considered a fertile territory for agroecological transition processes to take root due to its historical context, the presence of rich informal networks, as well as active formal structures exploring agroecology, notably farmers collectives coordinated by the PNR (Clément et al., 2019; Vandenbroucke et al., 2017; Dargazanli, 2019). The diverse agricultural production across the Pilat comprised well-established orchards, vineyards, animal husbandry, dairy, meat, grain production, and vegetable farming (see Figure 3). Approximately 2,000 active agricultural workers made up 3.5% of the working population (PNR du Pilat, 2012a), more than double the national average of 1.5% (INSEE, 2020). 42% of farms relied heavily on direct-sales for revenue, and the tendency was especially salient for small farms (PNR du Pilat, 2012b). Many farmers sell through markets, local producer-run cooperative food stores (numerous in the area), and on the farm.

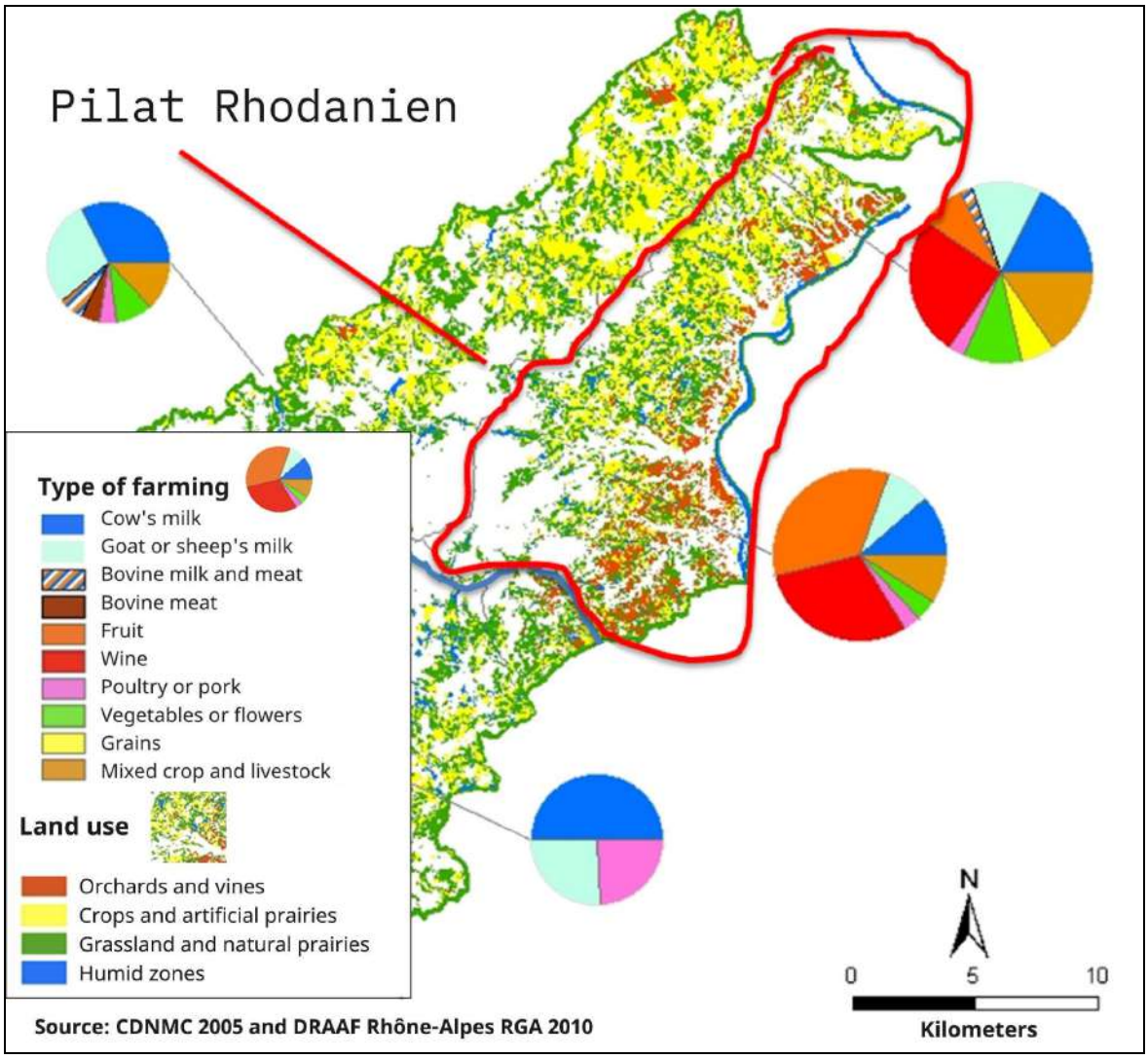

Figure 3. Map of land use and types of farming in the Pilat Rhodanien and two adjacent zones. The northern Pilat Rhodanien was dominated by wine production (25%), followed by dairy production and mixed crop and livestock farming (about 50% total), then vegetables, grains and orchards (20%). The southern sector was dominated by both wine (30%) and fruit (38%) production, followed by dairy and mixed crop livestock (about 30% total).

A study by Gallien et al., (2018) looked at political and social dynamics around water protection and agriculture, with the Pilat as one of the three study territories. The authors found that the winegrowers were making minor, often singular adjustments, described as "experiments to limit the use of chemical inputs on steep parcels, without communicating externally about it". They found that the Pilat fruit producers, on the other hand, were engaged in more formalized projects, collectively adhering to labels to communicate about existing sustainable farming practices. They "exchanged and experimented individually and collectively, their approach was displayed, and individual conversions to organic farming were increasing". Comparing these two sectors, the authors propose that they did not have the same dynamics around sustainable farming: the actors in arboriculture who sought to develop environmentally-oriented

marketing insisted on the need to publicize their actions, whereas the winemakers who benefited from the solid reputation of their prestigious wines did not express this need (Gallien et al., 2018). Overall, the authors concluded that despite the growing dynamics for environmental protection measures in both of these sectors, they did not observe actors operating under a "fundamental transition logic", which would entail the engagement towards major reconfiguration of agriculture and food systems.

With regards to addressing pesticide use beyond the farm scale, in 2015 employees at the Pilat PNR took part in the signing of a charter with municipal governments to establish "zero pesticide" management of city green spaces and cemeteries. In 2009, the Pilat Rhodanien was evaluated for use of chemical inputs within the arboriculture and viticulture sectors (Couturier-Boiton, 2009). After an analysis in 2010 of potable water quality in the Pilat Rhodanien revealed traces of multiple pesticides, notably weed killers[2], the Inter-regional Water Agency (*Agence de l'eau Rhône Méditerranée Corse*), the Pilat Rhodanien inter-municipality, the *Rhône* and *Loire* Chambers of Agriculture and the *Loire DDT* were the main actors to organize and coordinate surveys of farmers, agricultural advisors and retailers of agricultural products to further track and study the issue of non-point source pollution from agricultural run-off. The current use of pesticides as assessed in 2020 are summarized in Figure 4.

The communes with the highest application rates (red and orange) were along the Rhône Valley with a high density of vineyards and orchards. According to the Pilat PNR, pesticide treatments in the Pilat had decreased over the past 25 years. The average number of treatments effectuated per hectare per growing season (based on the calculated treatment frequency indicator, TFI[3]) remained significant in viticulture at 8.5 (national average: 15), and arboriculture at 20 (national average for apples: 18.5 for organic; 31.5 for non-organic) (DRAAF AURA, 2022). According to Solagro (2020), the institute which produces this map, the frequency of treatment can be used to interpret the risk of water, air and food pollution linked to the use of chemical inputs in agriculture. Given the high rate and consistent treatment in monocultures of grapevine, we chose to focus on this sector in our research. This farming system comprises perennial plants, which also facilitated the understanding of farmers' approaches to long-term maintenance, use and care for their parcels.

[2] Of the eight wells that contribute to 75% the potable water supply for the 14 municipalities of the Pilat Rhodanien inter-municipality, six were found to contain traces of pesticides. The results, from samples taken between 2009-2015, ranged from 0.01-0.80 micrograms per liter of atrazine (herbicide), simazine (herbicide), diuron (herbicide, banned in the EU since 2008), dicamba (selective herbicide), hydroxy-terbuthylazine, and imidacloprid (insecticide neonicotinoid) (Communauté de communes de Pilat Rhodanien and Antea Group, 2012).

[3] The treatment frequency indicator, TFI (from the French, *Indicateur de Fréquence de Traitements phytosanitaires, IFT*) is an indicator that allows for comparison over time or space of the use of synthetic inputs. It is calculated by the number of doses of plant protection product applied per hectare during a crop year:
TFI = (Dose applied / Dose of reference) X (Surface of the parcel treated/ Surface of the parcel total)
(Ministère de l'Agriculture et de l'Alimentation, 2018).

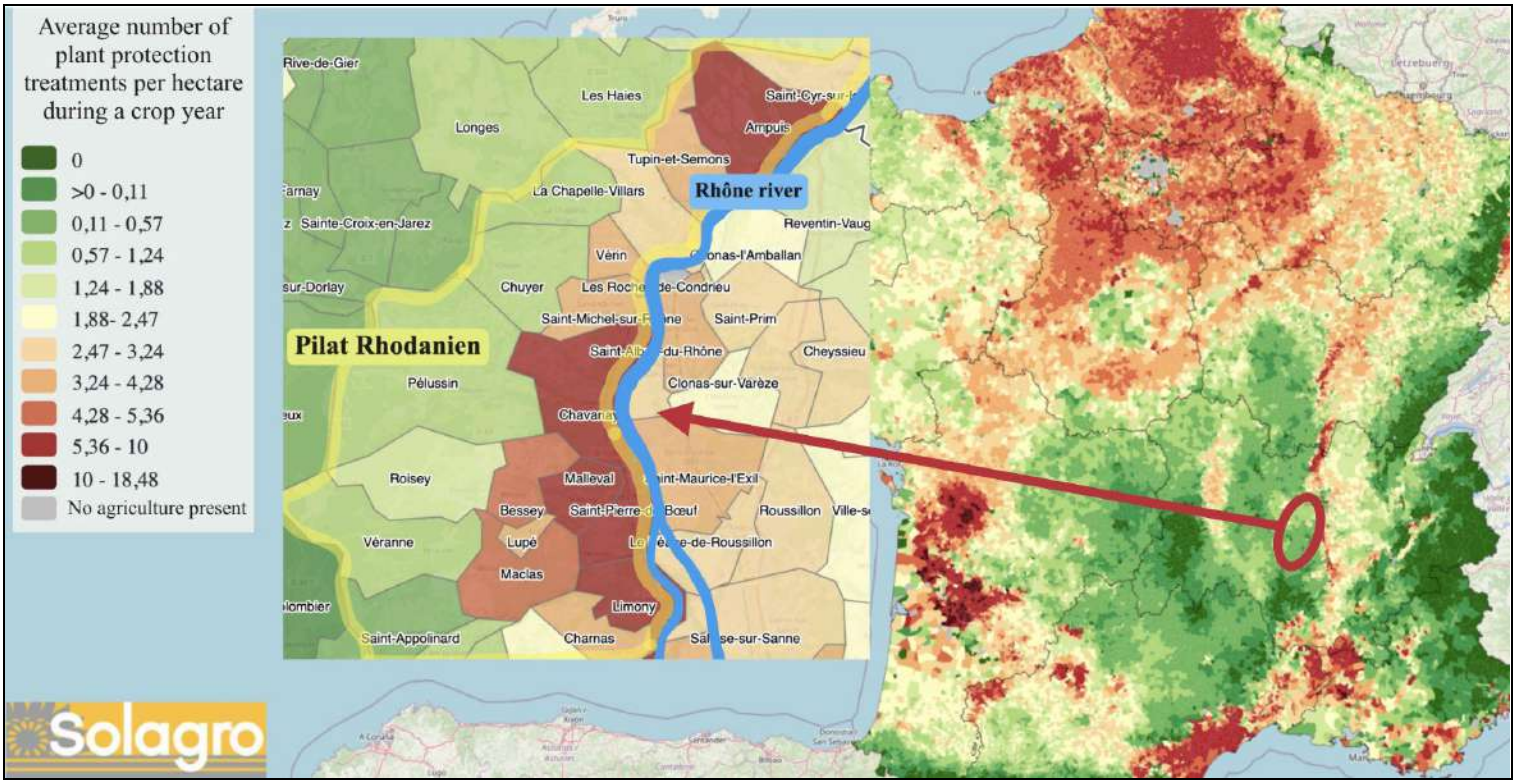

Figure 4. Map of the average number of plant protection treatments per hectare during a crop year in the Pilat Rhodanien. The number of treatments was counted for all types of agricultural productions, and for the use of multiple products (herbicides, insecticides, fungicides, seed treatments and others), though excludes methods of biological control (Solagro, 2020), which we learned were particularly important for orchard management in the territory.

3. Historical perspective: Wine production and pesticide use in the Pilat Rhodanien

Grapevines for wine production have been cultivated along the hillsides of the Rhône valley since the Roman era, over 2,000 years ago. The impressively steep slopes facing south east, visible in Figure 6, contribute to an early maturation of the grapes. Together with the sandy, shallow and highly-draining soil, this makes for a unique *terroir* that characterizes the high quality of these wines, yet also creates a challenging context for production. The wines of the northern *Côtes-du-Rhône,* some of the oldest in France, offer "homogeneity, prestige and quality" (Collombet, 2022). Technical writings concerning the terrain and grape varieties date from as early as the sixth century. Wine production in the Pilat Rhodanien reached its peak in the late 19th century, with grapevines cultivated on nearly every surface receiving sunlight (*Organisme de Défense et de Gestion de Côte-Rôtie*, 2022).

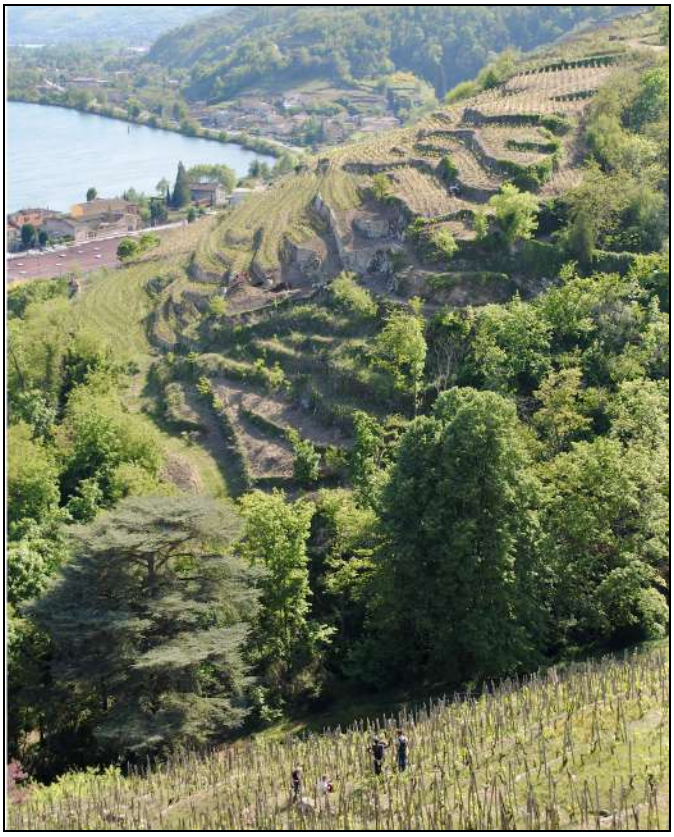

Figure 5. Photograph of the steep hillside vineyards in the geographical zone of *AOC Condrieu*, taken during the study period. Noteworthy are the terrasses variable in size, some with original ancient stone walls and other with recently renovated ones. The Rhône river is visible in the top left corner, as are residential neighborhoods immediately beneath the hillside plantations.

Starting in the early 20th century, wine grape cultivation declined in the Pilat Rhodanien. Growing industry in the Rhône valley contributed to the migration of workers to factories along the river, attracted by new working conditions and higher pay [75]. The first and second world-war also reduced the available workforce [75]. The arrival of tractors after the second world war facilitated agriculture on the plateaus, and less on the hillsides or dispersed parcels on terraces. This widened the gap in production costs between the plateaus and the valley slopes, a challenge which is still present today. The attacks of phylloxera, an insect in the aphid family, in the beginning of the 1900s was an additional factor leading to the abandonment of many parcels (Syndicat des Vignerons de l'AOC Condrieu, 2022).

Multiple factors in the latter half of the 20th century participated in the renewal of the wine sector. In 1974, glyphosate-based chemical herbicides arrived on the French market[4]. These and other chemical

[4] According to one winemaker interviewed, whose father played a central role in the "re-conquering" of the steep hillsides, sales representatives selling chemical herbicides left a small amount of diluted glyphosate in a glass during their meeting, and then drank it at the end, claiming that it was "clean, UV degradable, and water soluble, able to kill grass", but not cause harm to humans or animals [75].

inputs were sold to farmers eager for solutions to help cultivate the challenging slopes, and notably face water competition from weeds. Cultivating the hillsides became dramatically easier, faster and cheaper, thus leading to re-planting and renovation across the entire zone as shown in Figure 6, what the winemakers call today the "reconquering" of the hillsides. Wine producers interviewed described that their parents or grandparents left behind their polyculture, diversified farms that integrated animal and plant productions, to specialize in wine. The increase in new plantations and the rehabilitation of terraces and stone walls meant a high level of investments. This development was facilitated through the involvement of multiple actors: *SAFER*[5]*,* the *Pilat PNR,* an oenologic laboratory created by winemakers and the Chamber of Agriculture, and local politicians who generated significant public funding [5].

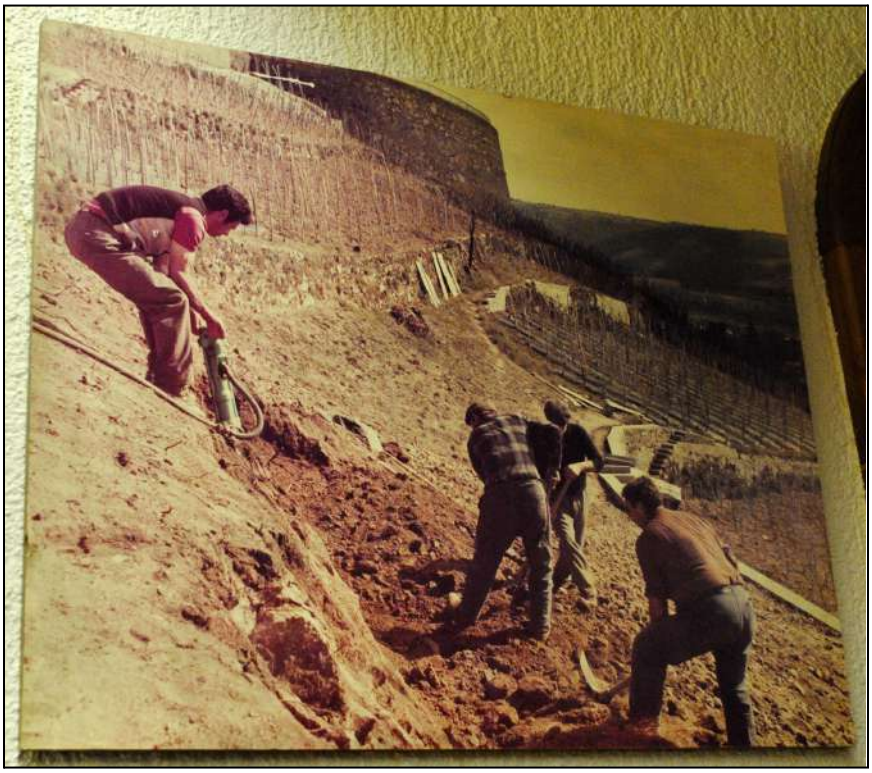

Figure 6. Photograph of workers renovating terrasses during the "reconquering" of the hillsides in the 1980s. (Source: *Domaine Georges Vernay*)

Economic incentives to produce the wine were enhanced not only by lowered production costs, funding opportunities and technical support, but also the possibility to sell the wine at high prices, thanks to labeling and a growing reputation. Between 1936 and 1956, vineyards of the Pilat Rhodanien were certified under *AOC* geographic indications (*Appellation d'Origine Contrôlée,* or Protected Designation of Origin, PDO, in English), a prestigious French label, overseen by the National Institute for Origin and Quality (*INAO*) and territorially managed by winegrowers' unions (*syndicats des vignerons*). The well-known *AOC* labels found within the Pilat Rhodanien are shown in Figure 7: *Côte-Rôtie, Condrieu, Château-Grillet* and *Saint-Joseph*. Wines holding these quality certified wines guarantee a stable and increasing selling price backed by consumer demand.

[5] *Sociétés d'aménagement foncier et d'établissement rural ;* Land development and rural settlement company.

At the time of research, *AOC* wine represented 71% of wine produced in the northern *Côtes-du-Rhône* region (which includes the Pilat Rhodanien) (Agreste et al., 2020). Almost all of the remaining wine production was labeled IGP, Protected Geographical Indication, a label which fetches lower prices. 13% of wine was *IGP* with the grape variety mentioned, 15% *IGP* without the grape variety mentioned, and only 1% without any geographical indication. Today, the vast majority of wine producers remain specialized in wine production, and terrains previously without vines planted are increasingly being converted to wine production in *AOC* and *IGP* labels.

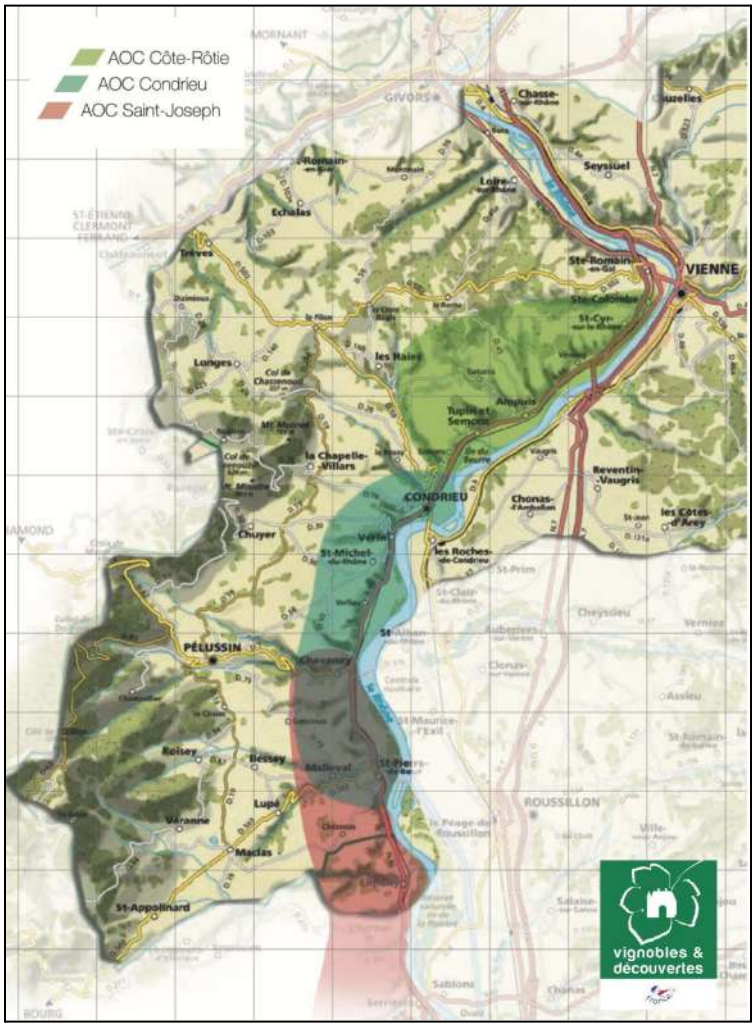

Figure 7. Map of the three main *AOC* geographic indications spanning the Pilat Rhodanien: *Côte-Rôtie* on 280 ha, *Condrieu* on 180 ha, and *Saint-Joseph* on 1,300 ha total, of which approximately 200 ha are found in the Pilat Rhodanien. Not shown is *Château-Grillet*, the smallest *AOC* in France, located on a single domain of 4 ha tucked into the north of the *Condrieu* zone (Source: (Vignobles et Découvertes, ND).

The vast majority of the hillsides on the right (West) bank of the Rhône river continues to be occupied by vineyards, except for some patches of forest along ravines and difficult to access terrain. This may be

explained by the prestige of the *AOCs* in the Pilat Rhodanien, making each parcel highly valuable for winemaking, with a market value as high as one million euros per hectare. This meant that passing on the domains to the next generation was a costly and serious affair, even when they remained within the family line. Producing grapes to make wine on this high value land seemed to be the only form of justifiable and economically viable production; farming other crops was considered impractical. Therefore, farmers rarely diversified their productions, nor planted supporting ecosystems such as hedgerows. The homogeneity of land use and the low species richness puts into question the resilience of these farming systems (Jacquet et al., 2022b) and the approaches taken to mitigate fungal outbreaks and lack of water pressure.

Crop protection in the vineyards of the Pilat Rhodanien since the early 2000s

Multiple recent phenomena have motivated winemakers of the Pilat Rhodanien to evolve their practices anew. A major development in the 1990s was the use of helicopters to spray chemical inputs, a technique which greatly facilitated pesticide use on the steep hillsides. Winemakers' became dependent on this strategy, hiring skilled pilots who came to know the parcels well, and who were able to treat up to 150 hectares in one day [103]. However, in 2012, spraying vines by airway was made illegal, therefore restricting the use of helicopters. The ban was made for multiple reasons (application drift, low targeting capacity, high cost, impact on surrounding environment), mostly due to complaints from nearby residents of air and ground pollution (Dauvergne et al., 2020). This restriction seemed to alter farmers' forms of coordination, given that the collectivized use of helicopter spraying services was a technology around which actors previously organized themselves in a significant manner. The use of oscillating cannons to project chemical inputs was the most common alternative method of treatment in the years following the helicopter ban (Syndicat Général des Vignerons Réunis des Côtes du Rhône, 2014). In our research, the most common method mentioned for spraying chemical inputs was to carry powder or liquid treatments in portable sprayers, strapped to workers' backs (spraying *à dos d'homme*). Growing reliance on this method, as opposed to spraying via airway, has had a strong impact on pesticide use, rendering it more tedious, time-consuming and expensive.

In the present research, we observed that the tendency towards decreasing or eliminating chemical inputs was slowed down by entrenched lock-ins, be they related to technical, organizational, political, economic or personal factors. The pesticides used today that were mentioned the most by winemakers were chemical herbicides and fungicides. Insecticides and other synthetic products were rarely mentioned, as many domains have been able to eliminate their use[6], due to either low pest pressure or the development and use of biological control methods. Our study thus focused on the use of herbicides and fungicides in wine grape cultivation of the Pilat Rhodanien, what farmers currently do to reduce or eliminate their use, and what enables or hinders changes in practices. In the results sections that follow, we explore farmers' practices and reasoning behind their approaches for crop "protection" as expressed during the interviews. By "protection" we mean the notion of controlling an abundance of unwanted fungal, insect or plant

[6] The IFT for insecticides was the lowest in the northern Rhône Valley compared to all 21 wine regions studied in a national survey from 2016 in the *EcoPhyto* Plan. The IFT for both fungicides and herbicides was reported as slightly below the national average (*Agreste* et al*.,* 2020: see Appendix F).

species. We start by describing our observations on the parcel-scale, and then zoom-out to the farm, food value chain, and territorial scales. The results culminate with an analysis of the socio-technical systems which characterize viticulture in this complex agricultural landscape.

4. Results and discussion: Influences on pesticide use in viticulture of the Pilat Rhodanien

4.A. Current practices related to the use and non-use of herbicides, on the parcel scale

Herbicide use in the grapevine parcels of the Pilat Rhodanien was explained as necessary to cope with the competition for water posed by weeds. The topography and soil characteristics (fast-draining, shallow, sandy, granitic, illustrated in Figure 8) were key factors behind this concern, making every drop of rain precious. Until recent effects of climate change, the grapevines planted on the hillsides of the Pilat Rhodanien received sufficient precipitation[7] throughout the vegetative season, to such an extent that irrigation was prohibited in the *AOC* contract specifications (*cahiers des charges*). Today, winemakers reported greater variability in rainfall rates from year to year, and generally drier and hotter summer seasons, which has led to increasing concern for water competition between the grapevines and the spontaneous vegetation that grows between and particularly along the row. According to a local commercial technician, *"10-15 years ago, 100% of the vineyards here used glyphosate, often two treatments per year. There were no restrictions back then. Today, it's only around 10-15% of the vineyard surface that uses glyphosate; about 150 hectares over the total 1,200* [in the Pilat Rhodanien]". [103] Some winemakers treat one row out of every two with glyphosate, as shown in Figure 8.

Figure 8. A vineyard on a plateau in the southern Pilat Rhodanien, mechanically weeded along the foot of the vines, with one out of two inter-rows treated with glyphosate (left). Fast-draining, granitic soils typical of the Pilat (right).

[7] In the Pilat Rhodanien, the average annual rainfall is between 750 mm towards Chavanay, to the south, and 830 mm at Ampuis, to the north (Météo France, 2013).

Alternative to chemical herbicides: Mechanical weeding

All of the ten winemakers plus three vine technicians interviewed considered mechanical weeding to be the most common alternative to chemical herbicides at the time of research. The topography of the parcels was one of the main factors to determine what was possible, and to inform farmers' choice of practices:

1. Tractors could be used for mechanical tillage in the place of spraying herbicides when parcels were on a continuous strip of land, on a flat enough surface, uninterrupted by drastic differences in level, and with enough space between each planted row. Tractor passages were sometimes supplemented by additional passages with a manual or electric hoe to weed closer to the vines. Winemakers weeded along the rows to protect against water competition, climbing plants, or the piercing of grapes by grass tips. The high density of vine stocks per hectare[8] was a factor that discouraged wine producers from managing their parcels to accommodate tractor work; decreasing the density would entail uprooting mature vines which still produced quality grapes.

2. Most of the vines on steep slopes were planted to be treated chemically, which made the parcels ill-adapted to tractor work, either because the rows were generally or partially too narrow, too steep, or divided into terrasses with stone walls, historical infrastructures which are strictly protected by *AOC* contract specifications (Article 6.2, Syndicat des Côtes du Rhône, 2011). In these cases, in addition to spraying from portable sprayers carried on workers backs (*à dos d'homme)*, weeding was done with small, manual and semi-mechanized tools, such as a plow attached to a motorized pulley (*le treuil)* to weed along the row from the bottom up (shown in Figure 9), a brushcutter, an electric hoe, or a standard manual hoe to weed closer to the vines.

3. Horse-drawn traction was a practice used primarily on flat, continuous terrain with minimal slopes. One of the farmers interviewed hired a specialist to work some of their parcels [75]. There were limited services offered for horse-drawn traction locally, though there was at least one active professional who commercialized his horse-drawn traction services exclusively for working in the vineyards of the Rhône valley.

4. When parcels were divided into terrasses too small or difficult to access with the motorized pulleys, then the only mechanical alternative to spraying *à dos d'homme* was using a hoe.

[8] One farmer highlighted that while planting the vines closer together lowered the yield per plant, it enhanced the quality of the grapes, since the vine stock must grow roots further to reach nutrients [58].

Figure 9. A mechanical weeding plow (left). Anna working the plow attached to a motorized pulley (*treuil*) along the vines (center). A worker operating a motorized pulley positioned at the top of the row to be weeded (right).

While some, and a growing amount, of wine production was done on parcels fit for tractor work, many parcels were too steep or difficult to access. Farming these parcels required significant amounts of human labor, especially for spraying inputs and mechanical weeding. This was a challenge for a number of reasons. Human labor was scarce: multiple domain managers reported that the demand for seasonal workers exceeded the availability. One winemaker reported that it was a competitive environment, to find skilled employees and to maintain them within the domain, particularly given that the pay was equivalent to other lines of work with similar demand but less extreme conditions [90]. An additional challenge regarding employment was the *CertiPhyto* license, required in France to legally spray inputs whether organic-authorized or synthetic, which only lasts five years and necessitates training which is limited [75]. Schooling options for learning about wine production were essentially non-existent in the territory. One farmer hypothesized that even a short training in agricultural high schools could enhance availability of a skilled workforce [13].

Some farmers felt ambivalent about hiring seasonal workers, considering the extreme work conditions and hardship to appropriately remunerate within their economic margins. According to one winemaker [184] certified organic on 100% of his parcels, working the terrain sloped to this degree with a hoe required 100 hours of work per hectare. According to another winemaker [52] interviewed who was doubtful about certifying his exploitation organic, there was too significant an increase in cost to pay workers for mechanical weeding and/or making more frequent passages with less toxic products, when compared to treating the vines with chemical weed killers and fungicides; he estimated it would be about five times as costly in work time. Farmers as well as technicians characterized this low-paid work, largely done by seasonal workers from Northern Africa and Eastern Europe, as 'modern slavery' (*esclavage moderne*). Other challenges were training the workforce with new practices, lodging the workers, and finding transportation solutions [35]. Multiple wine producers hired teams of specialized service providers with *CertiPhyto* licenses to pass through their parcels as a unit, which maximized the efficiency of spraying on foot, *à dos d'homme*.

Farmers mentioned practical challenges in working their parcels mechanically, notably regarding the use of tools. Some tools used for mechanical weeding could injure the grapevines, which were then more prone to fungal infection. Tools needed a fair amount of maintenance and repair. One farmer at a vineyard on 24 hectares estimated that 50% of the working time of one employee was dedicated to repairing tools [75]. Multiple farmers mentioned the lack of available and appropriate tools to effectively do mechanical labor on slopes, especially given the variability amongst plots within a single domain, and across domains, concerning soil quality, rockiness, and slope degree. There were machine repair companies which multiple winemakers hired to make adjustments to their tools.[9] These mechanics alone seem to be an insufficient source for repair and maintenance. Domains thus hired employees to specifically work on equipment and tools, from minor tweaking all the way to inventing and testing new configurations. Here again, farmers mentioned lacking sufficient competency and available personnel, especially for welding and other kinds of workshop infrastructure to make adjustments or build new tools. A few farmers made the hypothesis that tool suppliers were not interested in designing for the slopes of the Pilat Rhodanien, given the specificity of the demand and the relatively small size of the sector, which would limit sales potential.[10] *Atelier Paysan,* an organization that works with farmers to design and manufacture machinery and buildings adapted to sustainable farming methods, was an option that some farmers seemed to be aware of and find interesting, but which none had used.

An additional challenge in mechanical weeding was erosion of the soil, including the top, most fertile layer. Soil erosion was reported as a major issue, given the intensive mechanical work that some parcels underwent on the sandy valley hillsides. Farmers showed caution around their mechanical tillage coinciding with major precipitation events, particularly in the autumn. Some farmers told us that in the past, it was common for children to fetch eroded soil at the bottom of slopes, and bring it back up to the vineyards. This was obviously physically demanding and time consuming, and seldom practiced today; though it was reported that under extreme conditions, some winemakers and their families collected washed-away soil at the bottom of their parcels. To mitigate soil erosion, two farmers interviewed maintained spontaneous vegetation or planted a vegetative cover, such as green much, [31, 75], sometimes on one out of every two inter-rows. This was also done to enhance soil fertility and increase water infiltration by creating greater root systems.[11]

Emergent practices to address water stress: ground cover, vitiforestry, and sheep grazing

Ground cover using either living or dead mulch was one approach to face water competition from spontaneous vegetation. This was thought to minimize some of the challenges found in mechanical weeding, notably soil erosion. There were gains being made locally through experimentation, but with

[9] Local machine repair companies hired by the farmers interviewed include *Fatton, Collinet* and *Armellié*. A Swiss company, *Plumett*, also collaborated with some farmers for designing tools.

[10] During a mechanical weeding implement demonstration organized by *ARDAB*, the Organic Producers Association for Rhône and Loire, an organization that promotes organic agriculture in the two departments, we interviewed a tool designer and supplier at *Naturagriff*, who works on implements that function at a slow pace and optimize each passage by combining multiple actions.

[11] Superficially incising the soil between the rows also helped for water infiltration. For soil fertility, seed mixes sown in the inter-rows often included nitrogen-fixing plants.

limited results. An employee at a cooperative for the sale of agricultural equipment summarized the evolution of weed control practices, and gave his opinion on the complexity of the situation: *" From 100% chemical control not long ago, we're seeing a major shift to mechanical weeding. There used to be no tools for it. But it's far from being all beneficial: there are plenty of disadvantages. I'm persuaded that moving forward, vegetative ground cover is the solution. But we have to find the right kind of cover for different parcels' characteristics, and on the steep hillsides, for the moment, we haven't found it"* [103]. According to him, the cooperative was involved with experimentations using different vegetative covers, "*to support biodiversity, the environment; it's developing a lot in recent years".* We observed the following:

1. Farmers planted a vegetative cover consisting of plants with shallow root systems, to not compete significantly for available water [30]. Species used included orange hawkweed (*piloselle)*, thyme, and sedum, the latter visible in Figure 10. There was a consensus amongst research participants that sedum outperformed other kinds of vegetative covers when tested in the vineyards on the hillsides. Grapevine technicians at the Rhône Chamber of agriculture coordinated experiments since 2015 with sedum planted along the rows. A downside was its fragility: sedum cannot withstand foot passage. Some winemakers also found it difficult to seed or propagate directly in the fields. However, at least two local vegetable farmers successfully propagated sedum on fabrics, which were then transposed between vine rows [13]. Two farmers expressed concern over the lack of biodiversity in planting a monoculture cover of sedum or other beneficial plants [52, 31]. According to technicians at the Rhône Chamber of agriculture, work remains to optimize and facilitate implantation and to search for other non-competitive species. The Botanical Conservatory of the *Massif Central* and the *Pilat PNR* were involved in inventorying species present within local dry grasslands to determine if any could meet the requirements of rapid implantation, maximal coverage rate, low height development, perenniality of the implantation and absence of competition for water or nutrients (Chambre d'agriculture du Rhône, 2020)

2. Mulching was used to shade and suppress competing plants and restrain their growth, while reducing evaporation of ground moisture. Farmers experimented with straw from various sources, some from agricultural waste, such as rice, wheat, linseed, and silvergrass (*miscanthus)*. Mulching with miscanthus, according to a few winemakers and one technician, worked best. Mulching could be slow to put in place, but kept for up to three years if done rigorously [75]. A few farmers mentioned that a key drawback was the potential for fire hazard (sometimes dealt with by mulching only one row out of two), and one mentioned that it poses the risk of creating an environment for young trees to grow [31]. Additionally, some questioned the sustainability of the practice, given that mulches used were often not locally sourced. Some farmers also experimented with thick plant-based felted mats, shown in Figure 10, but reported that water slid on its surface and therefore did not sufficiently reach the vines [75].

Figure 10. Different strategies for vegetative ground cover: propagation of native sedum species (left); straw mulch (center); use of hemp-based felt mats with spontaneous vegetation in the inter-row (right).

Other emergent practices included :

1. **Vitiforestery (*vitiforesterie*)**, the intercropping of grapevines with trees, was used by one of the winemakers interviewed [74], and one other was interested in developing it [75]. The goals with this winemakers' approach were to minimize water evaporation, enable water infiltration and uptake, as well as shelter crops from wind, to lower water stress for the vines, and thus decrease the need for chemical herbicides. Fruit trees interspersed in the vines, aromatic essences in rows bordering the grapevines, and developing hedgerows and spontaneous vegetation around the perimeter of the parcel was also strategically developed to increase habitat for biodiversity and sheltering from strong winds. This was done in partnership with the Pilat PNR. It remained controversial due to concerns over water competition as well as long term maintenance of the parcel and organizational challenges arising from the harvest of multiple species [119].

2. **Sheep grazing in the vineyards** was a practice employed by one farmer that we interviewed, and at least one other farmer in the study zone. They used sheep to limit and control weed proliferation amongst the vines during the non-vegetative season. Farmers and technicians reported this solution to be effective [103, 74], but as soon as leaves and buds start to appear, the sheep pose a threat to the vines and the practice could no longer be used.

Prophylactic measures to deal with water competition

A few of the wine producers that we interviewed spoke of supporting the vines' innate ability to defend and support themselves in situations of water competition. This was discussed as a helpful complement to the alternatives to herbicides presented above. However, the following preventive or prophylactic measures were not perceived as sufficient on their own. One farmer with certified biodynamic vineyards sliced through the soil surface miniminaly to enable water infiltration [31]. Another planted green manure in between rows [103, 75], shown in Figure 11. Two of the farmers interviewed, and at least a few others in the study zone not interviewed, prepared and applied biodynamic fertilizers based on bringing robustness

to the plants at key moments in the vegetative and non-vegetative cycle [31, 36, 75, 103]. Rather than completely eliminating the competition from weeds, all of the above mentioned practices sought to make the vines more resilient in the face of water and nutrient competition. One farmer [13] pointed out that these kinds of practices were benefited by parcel proximity, in order to limit the amount of time spent visiting, observing and taking timely preventative measures to protect the vines. Another practice, albeit controversial amongst some actors, was preparing the soil to enhance the ability of the rootstock to spread widely when planting young grape vines.

Figure 11. A vineyard in *Condrieu* on the flat plateau, with green manure in full bloom (left). Close up of the green manure, composed of phacelia, pea, and fava (right).

4.B. Results: Current practices related to the use and non-use of fungicides, on the parcel scale

In the vineyards studied, the period of sensitivity to fungal growth occurred between bud break in mid-April and the start-of-ripening in mid-August (*Syndicat Général des Vignerons Réunis des Côtes du Rhône*, 2014). There were two main pathogens: grapevine downy mildew (*Plasmopara viticola;* in French *mildiou)* and powdery mildew (*Erysiphe necator;* in French *oïdium).* The risk of damaging fungal outbreak was relatively small when compared to other wine grape producing regions in France (Agreste et al., 2020). This was due to the fact that rain was scarce during the growing period, increasingly so due to climate change [103], and water drained easily through the soil and along the slopes. Low stagnation and humidity levels, often sunny conditions, plus a general tendency for consistent wind in the Rhône valley, created an environment non-conducive to the proliferation of fungal bodies [30]. Nonetheless, winemakers of the Rhône valley remained engaged in protecting their vines from fungal growth that did occur throughout the growing season. All of the grape-growers that we interviewed sprayed their vines, though two out of 10 wine producers told us that on exceptionally dry and hot years they avoided treating for fungal disease altogether. The frequency of treatment was highly variable depending on the precipitation events during late-spring and summer. Some winemakers made a mix of two or more products that were compatible, in order to target both grapevine downy mildew and powdery mildew with one treatment [52].

Alternative to chemical fungicides: The use of copper and sulfur- based products

Copper and sulfur based products were authorized for use in organic production, as opposed to chemical fungicides based on synthetic active substances, such as metrafenone. Chemical fungicides have a curative effect and can eliminate fungal bodies once they have already proliferated. On the other hand, copper and sulfur products are only preventive to fungal growth, and wash off with rainfall. This key difference meant that the farmers who depended on copper and sulfur (whether certified organic or not) sprayed their vines correlated with precipitation events. During rainy years, this could lead to a greater number of treatments compared to chemical fungicides. The difficult to navigate topography of the parcels and reliance on spraying on-foot increased the strain of using copper and sulfur products. A few winemakers also expressed concern over the negative effects of copper, as a heavy metal accumulating in the ground over time.

Emergent practices: Drones

A new approach for treating on sloped terrain, according to the majority of actors concerned by viticulture that we interviewed, was the use of drones to spray the grapevines. This emerging practice received considerable attention amongst wine growers and technicians alike, and its development and future implementation seemed probable. A vine technician at the *Ardèche* Chamber of Agriculture [119] was coordinating trials with drone specialists and farmers in the wine region directly south of the study zone (*Tain l'Hermitage)*. Some farmers in the Pilat seemed to be in close contact with this initiative, and many more were following the project development.

A number of actors said that, provided a low to moderate windforce, drones may be helpful to reduce the need for physical labor associated with spraying on steep slopes, while enabling precise treatment via aerial imaging and targeted maneuvering. Practical considerations remained because of high energy consumption, the need for trained pilots (complicated by the fact that wine producers often needed to spray at the same time) as well as the legality of spraying by airway (due to the ban on spraying via helicopters). Strong wind, often present in the Rhône valley, would also compromise the ability to fly and spray from drones with precision. Actors said that this practice would likely not replace spraying on foot, *à dos d'homme*, but could provide an additional method to decrease labor needs. In addition to drones, a few winemakers mentioned the potential of "smart" ag-tech approaches to help their vineyard management in the future, such as weeding robots [13, 58].

Prophylactic measures to deal with fungal growth

We asked farmers about their prophylactic measures to prevent infection of the grapevines by fungal growth. Their answers included pruning and attaching branches and stems on stakes as high as possible to enhance aeration, as well as clipping and carrying affected leaves out of the fields. One farmer also mentioned his adoption of a particular pruning technique which reduced damage to the vines, and associated fungal disease risks (*taille non mutilante)* [31]. According to him, this technique was rarely used in the Pilat but received attention in other wine regions. Some farmers used decision-aid tools based on

meteorological predictions, notably the softwares *RimPro and Decitrait.* Consulting these decision-aid tools assisted farmers in apprehending the vines' protection needs, such as when to spray to prevent fungal growth, as well as how to adjust the product dosage applied.

4.C. Discussion: Barriers and opportunities to reducing chemical input use on the parcel scale, and implications for the socio-technical systems analysis

In response to water scarcity, chemical herbicides were used to deal with visible symptoms, killing competitive vegetation adjacent to the grapevines to mitigate water stress that was already present on the parcel scale. Alternative approaches to chemical herbicides (most commonly mechanical weeding) largely stemmed from the same school of thought on dealing with competition and "protecting" the grapevines. Wine producers prioritized managing water competition to provide an immediate water supply, a shorter-term issue, over protecting their soils from erosion, with negative effects more visible in the long-term. This hierarchization presents a contradiction: in doing so, farmers gradually jeopardized the soil health and moisture retention capacity of their vineyards, resulting in potentially greater susceptibility to water stress. This contradiction in farmers' practices may exist due to the key lock-ins to industrial agriculture (IPES-Food, 2016), notably short term thinking, compartmentalized thinking, path dependency, and measures of success. Facing these lock-ins, and under these particular conditions, what can farmers realistically do to improve their practices? What is the real long term potential, and interest of farmers, to build soil fertility and water-holding capacity in these vineyards? Given that addressing soil erosion would be necessary to achieve long-term goals based on alternative practices associated with soil health and the rigor of the vines, this could be an important subject to treat when co-designing solutions with actors in the next phase of the Be Creative project.

As a partial response to these questions, we observed that farmers used prophylactic measures to ameliorate the conditions that could lead to water and fungal stress in the first place. Some were practiced widely across the vineyards in the study zone, notably aeration and attaching the vines to mitigate fungal growth. Other more marginal techniques were practiced by four out of the 10 winemakers interviewed, based on biodynamic practices, building the long term robustness and natural immunity of the vines, their root systems, and soil health in terms of fertility, microbial life, structure and ability to absorb, distribute and store water. The farmers who practiced these prophylactic techniques put greater emphasis on the connection between soil health, erosion mitigation, and their water management practices.

We propose that the actors who used more marginal prophylactic and emergent practices represent niche dynamics in the socio-technical system influencing chemical input use in the study zone. These measures, and the mindsets of farmers employing them, challenged the substitution logic underlying the mainstream technologies, herbicides and fungicides, and the main alternatives to their use, mechanical weeding and copper and sulfur products, respectively. Farmers using these measures showed a capacity to embrace complexity and biodiversity, considering the farm as a living ecosystem. In doing so, they embraced deeper and broader changes, which authors have argued is necessary to transcend the use of chemical inputs (Altieri et al., 1997; Wezel et al., 2020). However, while their practices held promise towards the

elimination of chemical inputs, they were not sufficient to ensure vine health and standard performance with the present water stress and fungal disease. Mechanical weeding and ground cover were still considered necessary techniques to continue using and developing.

Experiments for aerial treatment via drone seemed to inspire hope to reduce human labor needs, though the efficacy of this practice still needed to be proven. It remains uncertain to what degree drones could help reduce the use (in frequency or dosage) of synthetic fungicides. Recent tests permitted spraying only with organic-certified fungicides, which would likely remain the case were drones permitted for wider use. In this scenario, the greater adoption of drone-spraying could reduce the use of synthetic pesticides, were actors to use them exclusively for copper and sulfur-based products authorized in organic viticulture.

Much of farmers' efforts on reducing pesticide use have focused, since the 1980s, on the use of biological control (Aulagnier and Goulet, 2017; Rosset and Altieri, 1997).[12] The use of products and organisms commercialized for biological control (as alternatives to chemical control) can be understood as substitution logic (Maguire, 2004). We did not collect data on wine producers' use of biological control methods. This was primarily because we focused on the use of herbicides and fungicides, which are lesser-replaced by biological control than insecticides.

In terms of making informed decisions on plant protection treatments, it remains inconclusive how much the use of decision-aid tools contributed to reducing chemical input use, since much rests on the user and their interpretation. The models may assist farmers in realizing treatments solely in the event of high-risk conditions, though they may also lead farmers to maintain systematic, erroneous treatments in reaction to weather predictions which are not 100% certain. We heard this more from actors in other sectors, notably arboriculture technical support actors and fruit producers. It would be interesting to research further the current use of decision-aid tools in both the fruit and wine sectors to understand their potential role in facilitating the reduction of chemical input use.

When taken together, the present alternatives to chemical inputs seemed to be sufficient for the viability, and often thriving of the domains. Yet, given the challenging topography and soil characteristics found in the Pilat Rhodanien, the solutions that farmers adopted to limit the use of chemical inputs were often time-consuming, physically demanding, costly, and ecologically and socially questionable. Given the difficulties in maintaining a vine monoculture prone to thirst and fungal outbreak observed at the time or research: why do the domains of the Pilat Rhodanien persist in upholding their current production systems? For what reasons are domains able to sustain themselves? How much of a progress margin exists with regards to lowering the use of chemical inputs in an ecologically sound, economically viable, and socially just way?

[12] Biological control includes four families of non-chemical pest management: macro-organisms (introducing or conserving natural predators of pests); micro-organisms (introducing pathogens like viruses, fungi, parasites and bacteria, which stimulate plant defenses or impede pest insects); chemical mediators (releasing hormone or pherenome based products to disrupt pest behavior and reproduction); and natural substances like algae, minerals, and plant extracts, to boost the natural defense mechanisms of plants (Aulagnier and Goulet, 2017).

Part of the answer to these questions is found beyond the parcel-scale, in studying the influencing factors situated at the farm, food value chain, and territorial scales (Anderson et al., 2019; Triboulet et al., 2019; Wezel et al., 2016). These broader levels of context play a role in the maintenance and the evolution of current practices, and the nuances therein. Zooming out to broader scales helps to gain perspective on the stability of mainstream trajectories and the potential of niche dynamics to integrate and shift the regime and favor the reduction of chemical input use.

4.D. Results: Factors influencing the use of chemical inputs on the farm, food value chain and territorial scales

The following results are indirectly related to the research questions posed. They provide descriptions of phenomena within the wine sector related to the Pilat Rhodanien at the time of research. Understanding this was crucial to us as researchers working to grasp complex, non-visible dynamics among diverse actors in the study zone. Implications regarding the barriers and opportunities to reduce chemical inputs, as well as the socio-technical systems influencing their use are articulated in the discussion sections that follow.

Economic considerations with regards to reducing the use of chemical inputs: *AOC,* Organic, Biodynamic, and *HVE* labels of quality

***AOC* geographical indications:** The prestigious *Saint-Joseph, Condrieu* and *Cote-Rotie AOC* certifications brought stable demand as well as high prices for the wines produced in the Pilat Rhodanien: 20 to 100 euros per bottle domestically and up to ten times the price internationally. It was often reported that the demand was greater than what winemakers could supply.[13] The sale and promotion of the wine was facilitated through the existence of local markets and fairs organized by the winegrowers' unions.[14] These were long-lasting traditions: in 2022, the market of *Ampuis* saw its 93rd edition, and the wine market of *Chavanay* its 98th. While attending the *Ampuis* market during our research, we observed that it was a place for building the narrative and reputation of the wine, based on its associated *terroir* (its embeddedness in place and time, and natural and cultural history). For example, the main hall featured long banners with drawings of local vineyards, the steep hillsides, large rocks and adjacent wild brush. These displays complemented the personalized narration of wine tastings by wine producers and/or salespeople, who exhibited a variety of maps, oenotourisme opportunities and other marketing materials on their tasting counters, shown in Figure 12.

[13] Some domains more than others had a strong export orientation: one of the large and highly prestigious domains interviewed sold 50% of their wine within France, and exported 50% of their bottles to 130 different countries [90].

[14] In Spring 2022, there were 68 domains present at the local wine market of *Ampuis*, representing *Côte-Rôtie, Condrieu* and *St-Joseph AOC,* out of the approximately 140 domains present in the territory.

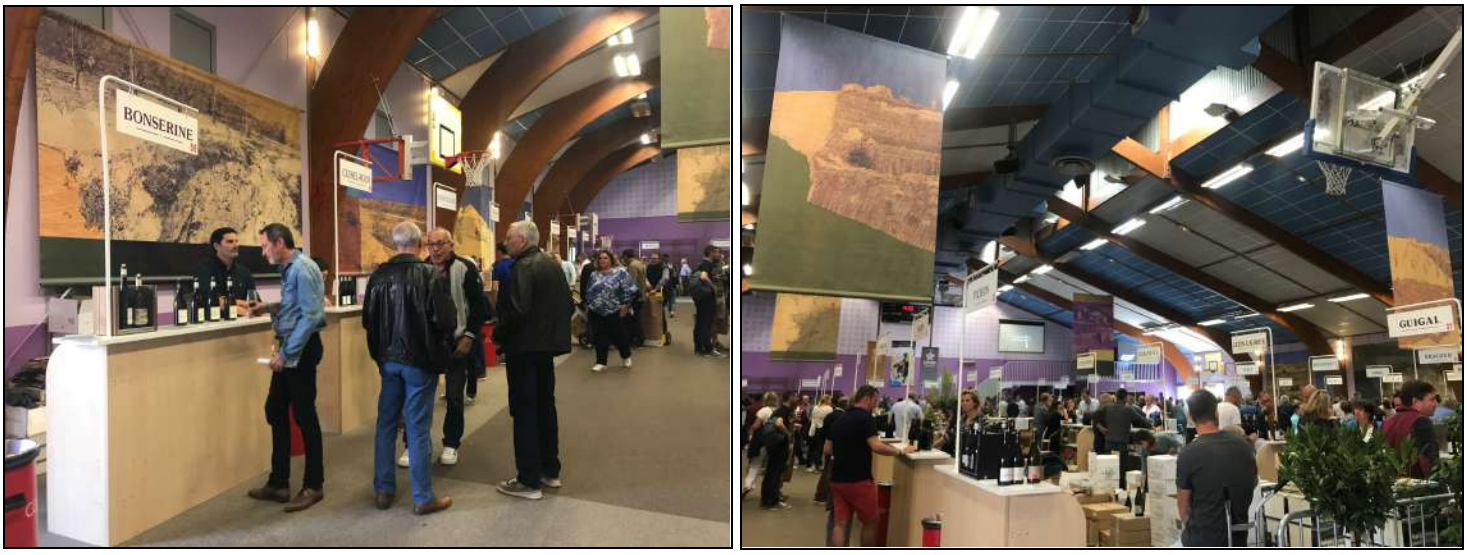

Figure 12. Tasting counters at the well-attended 93rd annual *Ampuis* wine market, held in a municipal gymnasium, decorated with artistic banners featuring the natural heritage of this wine region (left; right).

To label their wine *AOC*, wine-producers had to adhere to contract specifications, some of which mandated practices related to the use of chemical inputs. One specification called for the use of either "treatment products" or "mechanical tillage" to control spontaneous vegetation, in order to preserve the characteristics of the environment which constituted a fundamental element of the *terroir (Syndicat des Vignerons des Côtes-du-Rhône*, 2011). The use of irrigation was prohibited, adding to the constraints regarding water availability for the vines, and thus potential dependence on chemical herbicides. Yet the contract specifications were not mentioned during our interviews as a barrier to reduce herbicides, and multiple wine producers that we interviewed in *AOC* production were not hindered from trying out alternative practices, such as ground cover, mulching, or the use of biodynamic preparations. A second clause specified the type of grape varieties that could be cultivated.[15] This eliminated the option to plant varieties with greater resistance to fungal disease, which would require fewer or no fungicides to be applied during the growing season.

Organic and Biodynamic labels of quality: Some of the farmers we interviewed produced wine that was both *AOC* and organic or biodynamic certified. Certifying wine as biodynamic was only possible after having certified organic first. We were told that while organic wine used to have a poor reputation, this had shifted in recent years. Nonetheless, it was controversial whether or not winemakers felt the need for additional labeling to better commercialize their wine. Given the high demand for *AOC*, other labels did not necessarily add much to the market value of the bottles. The size of the vineyard was an important consideration, since transitioning to organic production entailed a certain capacity for investment in equipment and labor force [30]. It was reported by a vine technician at the Rhône Chamber of Agriculture

[15] *Côte-Rotie* wine must primarily be composed of *Syrah* grapes, with up to 20% *Viognier* grapes authorized; Condrieu must be 100% *Viognier*; St-Joseph is composed of *Syrah* for the reds (with up to 10% *Roussanne* or *Marsanne*), and *Roussanne* and *Marsanne* for whites (PNR du Pilat, 2018). The use of other varieties, or these same varieties in other quantities, is currently prohibited.

that “large” domains for the territory (on 30 to 40 ha or more) were less easily converted than medium-sized domains (on at least 8 but no more than 20-25 ha). Some winemakers held the perception that additional costs in producing organically outweighed the profit margin that came with the certification. There were funding opportunities to cover conversion costs[16], but these did not alter the equation, given that conversion costs were insignificant in contrast with the new operation costs. Private investments sometimes occurred for the larger, more visible and world-renowned domains [30].

Still, of the 10 winemakers interviewed, six told us that they had transitioned or were transitioning their production to organic agriculture in response to current and future buyer and consumer demand, citing French markets though also at the European level and abroad. Of the 10, three winemakers interviewed had already certified biodynamic, and one other was in full reflection on adopting biodynamic methods to certify in the coming years, even if the vineyard manager on his domain was skeptical about the efficacy of the methods.

Figure 13. Tasting tables at one of four host sites of the 2022 Organic Winemakers’ Festival, intimately located in the vinification barn surrounded by stainless steel barrels (left). Attendees mingling and tasting wines (right).

Similar to *AOC* wine producers' participation in the *Chavanay* and *Ampuis* markets, organic and biodynamic producers had privileged access to the Organic Winemaker’s Festival, founded in 2014, two years after the formalization of the organic wine label in Europe. In 2022 the festival was organized at four wineries in the Pilat, two of which we observed and are shown in Figure 13. It appeared to us as a convivial space for exchanging and tasting exclusively organic and biodynamic high quality wines, drawing participants from multiple departments across the region. With its annual organization over the past few years, dynamic

[16] A Chamber of Agriculture viticulture technician [30], who routinely shared information about available funding, told us that In recent years, the Region *AURA* allocated funds towards the purchase of new equipment for conversion to organic agriculture. *AURA* also financed 80% of the work time of Chamber of Agriculture technicians. The region offered partial reimbursement for certification costs the first two years of transition. The PAC offers an additional 350 eur/ha/year for the first five years [30].

marketing[17], and growing reputation, the market enhanced the visibility of the organic wine movement amongst consumers, wine professionals, and wine producers alike. Wine producers expressed that this was an important outlet to sell their wine, demonstrate its quality and the added value of organic and biodynamic practices. Beyond economic gain, this was a place to mingle, taste wine, and talk about production methods using zero chemical inputs.

***High Environmental Value (HVE)* label of quality:** A number of wine producers certified their wine *HVE*, a recent and widespread development, motivated by the French law *Loi Egalim* passed in 2018. *HVE* certification entailed a limited use of synthetic chemical inputs. The fewer treatments made per hectare per crop cycle on a given exploitation, compared to the previous annual regional average treatment frequency, the higher the score farmers would receive towards their *HVE* certification. This was easier to obtain and much less demanding than organic certification, according to technicians and farmers interviewed. The certification process for winemakers in the Rhône Valley was facilitated by the wine industry interprofessional association, *InterRhône*, via collective certification, which decreased the investment made on behalf of each domain [30]. According to the director of operations at a highly prestigious domain on 70 ha, "*It was rather easy. It was just necessary to complete one training, followed by the formal administrative procedure*" [90].

Organizational considerations with regards to reducing the use of chemical inputs: what potential for coordinating efforts ?

By and large, domains functioned as independent businesses, self-organized production and selling units. All of the domains interviewed maintained their own vinification workshop, wine cellar, sometimes a tasting room, and in one case housing for seasonal workers. Domains rarely shared tools amongst themselves, for organizational and practical purposes, nor did they share labor, or any of the above-mentioned facilities. They did not coordinate around cooperative structures, such as *CUMA*[18] for the sharing of tools or vinification facilities.

Coordination amongst winemakers happened in large part through the *AOC* winegrowers' unions. The unions were responsible for: upholding the *AOC* contract specifications together with the *INAO*; protecting the *AOCs* from counterfeit; promoting the wines (for example through organizing markets); and providing collective technical assistance, for which they partnered with the organizations *InterRhône*, the Technical

[17] While the *AOC* markets' websites were minimalist, the Organic Winemaker's Festival site was lush with pictures of grapevines and wine producers, accompanied by descriptions of the winemakers, their work and the specificities of their domains. It also contained descriptions of the reasoning behind the choice to produce organically, and what the specific practices and certification requirements entail.

[18] *Coopérative d'utilisation de matériel agricole*; Cooperative for the use of agricultural equipment.

Association of Côtes du Rhône Septentrionales (*ATCR*[19]) and the Rhône and Loire Chambers of Agriculture. *InterRhône* was involved in parallel initiatives for the coordination, promotion, and development of all *AOCs* of the *AURA* region. Other groups of actors structuring wine production in the research sector were the Wine Sector Committee (*Comité de Filière Vins*) and *AURA* Wine Committee (*Comité Vins AURA*), which both brought together a number of influential actors to orient wine sector politics and decision-making on a national level. They collaborated on the Regional Wine Sector Plan (*Plan Regional Filière Vin*), which held a significant grant package.

At the time of our research, the coordination and services offered by regionally and nationally-reaching structures (such as *InterRhône* and the *AURA* Wine Committee) did not focus on reducing chemical inputs, nor other goals for environmental stewardship, such as soil health or biodiversity maintenance. Based on their communications materials and operational documents, both *InterRhône*'s mission and the Regional Wine Sector Plan focused primarily on developing market opportunities, valuing economic growth and an export orientation. An exception was grants for farming equipment offered in the Plan, though it was not required to enable organic production. The Chamber of Agriculture and the *ATCR*, on the other hand, did direct some of their efforts toward developing environmental goals and the reduction of pesticide use through technical support [30, 13]. With regards to the key actors in the *AOC* winegrowers' unions, we were not able to schedule an interview with any of the current president/producers or other staff members at the unions. We did interview a former president of the *Chavanay* winegrowers' union, a historical, local union not specifically associated with *AOC,* which focused on issues of real estate, new winemakers in the territory, and marketing the wine.

Other organizational initiatives related to vineyard care and chemical input use were led by local political structures and non-profits, notably the inter-municipalities and related partners. These actors worked in service of wine producers and other farmers to tackle challenges not typically addressed in wine sector organizations. One initiative connected unemployed individuals with farmers seeking help to work the vines; another aimed at using waste materials to produce compost and mulch; these were both coordinated by the V*ienne-Condrieu* inter-municipality. This same inter-municipality, with a five-year agriculture strategy, also coordinated a project with local wine producers and fruit growers to mitigate the risk of hail damage, a serious issue in the territory. The *Pilat Rhodanien* inter-municipality in contrast, did not have an agricultural officer but had recently launched an agricultural commission at the time of research. It was involved with the Loire Chamber of Agriculture and a handful of other territorial partners in a watershed management study and action plan to mitigate pollution from pesticide run-off in the potable water supply.

[19] The *ATCR* is the Technical Association of *Côtes-du-Rhône Septentrionales*. In addition to regular meetings which gathered many of the approximate 140 winemakers in the Pilat Rhodanien, the *ATCR* distributed a weekly "bulletin" with recommendations for vine protection strategies throughout the growing season. Every week field observations were carried out by advisers from the Chambers of Agriculture on a network of reference plots. The observations fed a bulletin at the regional level *(Bulletin de santé du végétal)*, and recommendations were also detailed in the *ATCR* bulletin distributed to local winegrowers. This included information on phenological stage, the presence of bio-aggressors in the vineyards, and prophylactic methods. Recommendations provided reasoning for treatments with conventional products as well as products authorized in organic agriculture. Meteorological data were also consulted to define optimal application periods (Syndicat Général des Vignerons Réunis des Côtes du Rhône, 2015).

Technical considerations with regards to reducing the use of chemical inputs: access to knowledge and technical support

The recent and dynamic development of organic production, at the time of our research, was expanding available support with regards to access to technical knowledge and problem-solving amongst farmers and technicians, both through informal and organized exchanges [13]. Technicians at the Chamber of Agriculture provided accompaniment and technical help, enhancing support networks for farmers via workshops, field days and training sessions [30]. Technical advice from the Chambers of Agriculture for organic and non-organic production was organized collectively to reduce the cost for the members of local producers' technical association, the *ATCR*. An important source for many farmers was a weekly bulletin with recommendations for plant "protection", prophylactic measures and pesticide use, throughout the vegetative season. Technical training by *ATCR* recently included soil erosion and green mulch, both related to mitigating negative effects of chemical input use.

Additional technical support was provided by *ARDAB,* the Rhône-Loire Association for the Development of Organic Agriculture. This non-profit had recently hired a vine technician to support winegrowers in organic conversion and production. However, this work was based in the *Beaujolais,* a sector north of the Pilat. Employees at a cooperative for the sale of agricultural equipment, shown in Figure 14, also worked closely with farmers, often accompanying them as they experimented with new products and practices in the vines, such as vegetative ground cover, or new chemical protection products. A long-time, locally-based commercial technician [103] at this cooperative worked closely with over 200 wine-producers in the Pilat. An opportunity in reducing chemical inputs was that this influential actor took interest in various alternative and emergent practices. This actor was solicited to provide readings of information provided by *Weenat*, an application providing data from multiple weather stations in the territory. This was used with decision-aid tools to predict potential infection of fungal disease. He reported that the salaries of cooperative salespeople were not impacted by the type of inputs that they sold, whether authorized for organic agriculture or based on synthetic chemicals. In this gmway, the viability of the cooperative relied on the perennity of members and their continued business, rather than sales of particular inputs.

Figure 14. Viticulture equipment for sale at a local branch of the agricultural cooperative, *Oxyane.*

Farmers commonly reported exchanging with producers external to the territory, coming into contact through visits to other domains, domestically or abroad, markets, conferences and schooling, widening their understanding of winemaking practices through relationships with former classmates and colleagues. Farmers reported that it helped them expand their perspectives with regard to technical and organizational practices beyond the confines of their immediate context, including with regards to practices that are emergent and lesser known. Some farmers however mentioned the difficulty of transposing certain practices observed beyond the Rhône valley, due to differences in vine variety, soil type, climate and other specificities. Technicians also communicated amongst each other to exchange resources and explore innovations.

Personal considerations with regards to reducing the use of chemical inputs: willingness and resistance to change

All of the domains that we studied were family-owned and operated, and had been this way since their inception three or four generations ago (and sometimes longer). When presenting the domains they worked on, interviewees often started with a summary of their family's farm work over the decades, sometimes with an analysis of the way in which historical events had influenced their production choices. Multiple interviewees expressed deep ties with the history of the domains, the land, the vineyards and the wine, as well as profound respect for their family's work and history, entwined with the evolution of the agricultural landscape. Winemakers spoke of their commitment to the viability of the domains, so that they could be passed onto future generations. A winemaker producing on one of the oldest domains in the sector said during an interview : ''*You have to be in love [with winemaking]; it's not a job, it's a life.*'' [75]

Winemakers were inclined to find solutions to cope with challenges in organic viticulture, particularly if producing with fewer or no chemical inputs could sustain their domain economically. When this was the case, they expressed "accepting" risk as part of their evolution of practices. When reducing the use of chemical inputs was perceived to be technically challenging (or impossible) and incur too high a cost, their

primary preoccupation remained in wine making and selling, not in researching new plant "protection" methods. One farmer we interviewed was not particularly interested in shifting his practices, since using chemical inputs had both contributed to his family domain's flourishing, and was an integral part of their crop protection strategy for decades [102].

Farmers expressed that social acceptance and societal pressure were influences on their choice to integrate alternatives to chemical inputs, as well as their morale. Some winemakers felt inclined to officially certify organic in order to gain credibility amongst their peers and clients. Others spoke of media, political discourse and changes in regulation on a national and local scale (often brought about by concerns over water quality), as well as shifting consumer demand as key factors in their practices. Pressure to reduce spraying chemical inputs was present through local residents' complaints. Farmers reported being harrassed in their fields by passer bys, and neighbor's virulent disapproving of spraying, conflicts which they sometimes sought to avoid by changing the products they used, and frequency of treatment. This was not a simple question, however, given that using organic fungicides often required more passages in the field, and observers could equate any spraying with the use of toxic pesticides [90, 13]. Farmers' concerns over the negative impact of chemical inputs on their health and that of their families also affected their decision to reduce or eliminate their use.

Some winemakers interviewed were fearful about experimenting with completely new practices, or reducing the use of fungicides because of the risks involved in losing the crop. When vines were planted anew, farmers aimed to keep them for 60 years, which made a very narrow margin of error for jeopardizing vine health. Several farmers mentioned that the cost of re-planting was especially high given the fragility of young vine stock and the task of manœuvering the steep slopes. A wine technician at the *Ardèche* Chamber of Agriculture understood farmer's conservatism to be linked to family pressure. She reported hearing wine makers say '*this is what my father taught me, I can't bear to take risks*' or '*if I mess up in the vines, my brother will judge me*'. Wine producers thus tried out new approaches on small parcels, to balance their fear of risk-taking with their desire to experiment [119]. One interviewee described the reduction of chemical inputs in terms of mentality: "*The more that we are sure [of our practices], the more that we will be able to reassure ourselves*" [90].

4.E. Discussion: Barriers and opportunities on the farm, food value chain and territorial scales related to chemical input use

The barriers and opportunities to reduce chemical input use were multi-faceted and nuanced. Winemakers' commitment to the viability of their domains and land-based practices inspired some to reduce their use of chemical inputs, while others deemed them indispensable for the economic viability and agronomic legitimacy of their production. There has been an increasing movement to certify organic amongst winemakers in the Pilat Rhodanien, yet producers and technicians alike reported that technical "dead ends" remained, related to the steep hillsides and the increased labor, time and energy costs to cultivate without chemical herbicides and fungicides.

Wine producers questioned the value of additional quality labels. The *AOC* brought significant advantages on the food value chain scale, thanks to the wines' reputation, loyal clientele and steady business, overshadowing other labels of quality (organic, biodynamic, *HVE* etc.). Even so, gaining certification for the latter still seemed to generate some additional market opportunities as well as reputation enhancement. With regards to wine production under the less prestigious geographic indication *IGP,* we did not gather sufficient results to compare the crop protection strategies associated with, and perhaps distinguishing, *IGP* from *AOC*. On the territorial scale, there was a growing tendency to convert flat parcels on the plateaus outside of *AOC* zones into less prestigious vineyards, notably *IGP*, which could potentially allow for more production with low or no chemical inputs given the accessibility by tractors for mechanical weeding.

To compensate for the high degree of specialization in these systems, wine producers could collaborate with other types of farmers to facilitate their access to resources for alternative practices, such as sheep to graze the parcels, horse-drawn traction, and other plant and animal resources for soil amendment or parcel care, like developing vegetative cover. Communication between winemakers, the Loire Chambre of Agriculture, and officers and resource management on the territorial scale had occured due to concerns for the pollution of potable water by pesticides and crop protection from extreme weather events. The strength and efficacy of these collaborations for future and continued efforts to decrease pesticide use, and to scale out efforts already made, is not understood in the present results and should be explored in the next phase of the research project.

Regarding the recent, sharp increase in vineyards labeled 'High Environmental Value' (*HVE*), it was questionable whether this label indicated that a "conversion" process was undergone, as often understood with organic agriculture. The fact that farmers received points based on multiple categories, just one being the frequency of their pesticide treatments compared to a regional average, left room for exploitations to maneuver their chemical input use to receive enough points to certify, yet without significant pressure to change or reduce their use. The *HVE* label might also divert consumers' away from organic products, which could decrease the incentive for farmers to certify organic and uphold more stringent restrictions on chemical input use. At the same time, some farmers who were certified *HVE* pointed to its merit in highlighting efforts they had already made to lower the use of pesticides, all the while providing a safety net in case their crops endured an infection that could be remedied by the use of active substances not authorized in organic agriculture. This was especially valued in a context of climate uncertainty. There were thus both pros and cons to *HVE* labeling with regards to the reduction of chemical inputs.

In upholding the prestigious labels associated with this unique *terroir,* wine producers gained economic and social benefits, though they did not come without a cost. In addition to paying a membership fee to the *AOC*, farmers had to follow contract specifications, which mandated many of their practices.[20] While this was not mentioned in our interviews as a major constraint to change chemical input use, we posit that

[20] Regulated practices include plantation density, pruning, trellising, vegetation size, percentage of dead or absent vines, maturity and harvest criteria, as well as yield permitted, targeted at 40 hectoliters (hl) per ha, and limited at 60 hl/ha (Syndicat des Vignerons des Côtes-du-Rhône, 2011) compared to the national average of 57 hl/ha in 2019.

the norms, values, history, accepted knowledge and practices in *AOC* production and outlined in the contract specifications affected farmers' decisions around their chemical input use.

4.F. Discussion: Socio-technical systems influencing chemical input use in viticulture of the Pilat Rhodanien

Support for winemaking in the Pilat Rhodanien seemed relatively well structured by a few key organizations offering a number of financial, technical, administrative, communications and sales support mechanisms, within a localized framework connected to broader regional coordination. These influential actors[21] had strong ties to the *AOC* unions. The concentration of decision-making power and resources by a few key, large and interconnected organizations, at least at first sight, constituted a non-negligible base for potential coordination around specific goals. At the time of our research, coordination offered by these key actors did not directly focus on reducing chemical inputs, nor environmental stewardship more broadly speaking. Most key actors focused on developing market opportunities, and did not seem to hold a strong stance on production practices. The web of influence of the various organizations and key actors within them, their governance structure, funding streams and norms remain minimally understood within the results of our research. Further research would need to be done to better grasp the existing potential of these institutions for organizing efforts towards reducing the use of chemical inputs.

We propose that the socio-technical lock-ins related to chemical input use found in wine production of the Pilat Rhodanien were upheld by a socio-technical regime anchored in the *AOC* geographical indications. The socio-technical regime captures the broad community of social groups and their alignment of activities, base›d on established practices and associated rules, that stabilize and preserve the status quo (Geels, 2011; Geels and Schot, 2007; Markard et al., 2012). We hypothesize that the *AOC* geographic indications were the primary arenas which structure the networks of actors who perpetuate the practices, rules, values and norms that drive the status quo in wine grape cultivation. Upwards of 90% of the winemakers in this sector belong to the *AOC* winegrowers' unions [58].

The main strategy for producing wine and receiving benefits of farming these lands is to adhere to the *AOC* requirements, which help to guarantee a profitable return on investment. *AOC* membership provides a whole set of privileges: a stable market, locally and internationally, guaranteeing the sale of wine at a good price; opportunities for selling at renowned and long-standing local markets; coordinated technical support through organizations tied to the *AOC* winegrower unions; the inclusion within associated social circles; the belonging and association with a long-standing heritage; and likely other privileges and dynamics which we were not revealed in our research. The norms associated with *AOC* were first defined during a period when few considered pesticide use as problematic. At the emergence of the *AOC*s in this region (and presumably elsewhere in France), wine production systems were conceived to favor pesticide use, in the case of the Pilat Rhodanien, to facilitate the "reconquering" of the steep hillsides. Seeing the

[21] *InterRhône*, the Technical Association of Côtes du Rhône Septentrionales (*ATCR*), the Rhône and Loire Chambers of Agriculture, the Wine Sector Committee (*Comité de Filière Vins*), *AURA* Wine Committee (*Comité Vins AUR*A) and the Regional Wine Sector Plan (*Plan Régional Filière Vin*).

embeddedness of pesticides in these prestigious wine productions, and the path dependence that continues today, helps to explain why the use (or non-use) of pesticides remains a topic that can be difficult to address with actors loyal to the *AOC* productions.

Representing the winemaking traditions of the northern Rhône valley seemed to tie winemakers to a communal project, interweaving family and territorial history. Their connection to cultural and natural heritage provided a platform for social cohesion and belonging. Even if the *AOC* were structured around specific products of *terroir,* they should not be taken for granted in the meaning that they bring to the territory and to the dynamics between local actors. These structures represent multiple elements which converge and diverge: physical places; certification labels; shared production, vinification and selling practices; unions based on shared interests; technical associations; and common history and preservation of heritage. The different actors representing the *AOC* in the Pilat Rhodanien, though linked by the geographic indication, expressed a unique relationship and varying level of involvement to all of these aspects. **For a more in-depth description of the socio-technical regime dynamics, the actors involved, and their roles in upholding the socio-technical regime, see Appendix G.**

Socio-technical niche dynamics: a pathway for lowering dependance on chemical inputs?

Discussed in the results were three emergent practices for grapevine maintenance: developing vegetative ground cover and mulching (as alternatives to herbicides and mechanical weeding), and the use of drones to reduce time consumption and arduousness of fungicide application, and potentially decrease TFI. These practices and the actors introducing them into the territory may initially be thought of as niche dynamics, given that they are currently emerging, relatively uncommon, and investigated by actors who were engaged in finding solutions to decrease chemical inputs. Some actors placed more hope on the use of drones, others were more preoccupied with ground cover, and others again with biodynamic preparations. While these innovations represent opportunities to change farmers' practices around pesticide use, they are not involved in a radical restructuring of production systems at the farm scale, nor a radical shift in farmers' orientation towards vineyard health and resilience in the face of disease and climate change. Aside from cultivating a vegetative ground cover, which could have longer-term effects on farmers overall weed management and crop protection, drones and mulching present superficial fixes which do not offer a strong potential to transform the pesticide-lock-in.

The results present other emergent approaches, such as vitiforestry, grazing animals in the vines, prophylactic measures and preparations geared towards harmonizing soil health and vine robustness. These practices were still perceived by some as radical, ungrounded in scientific evidence, and contrary to "conventional" methods of protecting the vineyard. Nonetheless, we argue that these approaches and the niche dynamics around them represent potentially transformative engagements on the part of winemakers, to open the way for a lesser degree of dependance on chemical inputs, as well as the strengthening of alternative social networks, especially in terms of growing collaborations between more diverse actors in the territory. We observed that the winemakers who experimented most with reducing chemical input use while improving soil health and grapevine robustness had greater open-mindedness to

risk taking. They also had greater sensitivity to the toxicity of pesticides and the threats that they pose to human and ecological health.

Some wine producers in the socio-technical niche that we propose seemed especially aware of their influence on other producers in the area. Some worked more on their own, though it appeared they all knew, at least minimally, of each others' work. Some were friends, and others had collaborated on the preparation of biodynamic treatments or the creation and organizing of the Organic Winemakers' Festival, activities which appeared to be instrumental in the consolidation of this niche. The Organic Winemakers Festival held an important place in supporting production associated with the niche dynamics. It played a role in structuring the movement towards organic wine consumption in this region, providing a platform for selling, celebrating and defending organic and biodynamic production. In this way, it enhanced networking opportunities for actors partaking in the socio-technical system associated with the niche dynamics. It also provided a platform for these actors to exchange information around production practices.

A number of other actors who we met and interviewed supported the vision and practices of this wine production niche, amongst them a vine technician at the Chamber of Agriculture of Ardèche, an employee of *ARDAB*, a commercial technician at *Oxyane*, and a tool supplier at *NaturaGriff*. These actors mentioned the necessity to move away from a recipe-based, reductionist approach to farming (focusing on a symptom and its remedies without considering the broader context for the problem or the solution), towards one that is knowledge-intensive, experimental, iterative and site-specific. Just like the farmers interviewed, they implied that this was a different approach to farming than 'conventional' and even organic agriculture on its own, given its holistic nature and the emphasis on ecosystem health, rather than damage mitigation or individual technological fix.

Three of the four farmers we identified as partaking in this niche were especially talkative (with whom we had our longest interviews), eager to share their understanding of best practices. They experimented with a number of techniques, including ones that were novel for the Pilat Rhodanien (such as vitiforestry, planting hedgerows, testing drones, mulching with thick hemp mats, and practicing non-mutilative pruning). Common practices among these actors included using biodynamic preparations, such as plant-based fertilizers, stimulants, natural fungicides and fermented slurries (*PNPP, préparations naturelles peu préoccupantes)*, sometimes made with local ingredients. One farmer planted green mulch between the rows, rolled over to provide nutrients to the soil. These wine producers emphasized the importance of observing and analyzing the vineyard, land, soil and microbial life, as well as having knowledge of its historical legacy and biophysical conditions. More so than others, they framed the farming of their vines as the management of an ecosystem.

We do not mean to imply that other wine producers did not have strong knowledge of their land or a long-term vision for their vine management. One wine producer at a large, prestigious domain labeled *HVE III* spoke of his interest in better understanding and favoring soil microorganisms that would be beneficial to grapevines to improve mechanisms of nutrient uptake and mineralization [90]. However, we observed a lesser degree of consideration of the vines as part of a whole living ecosystem amongst winemakers on

vineyards that were not certified organic or biodynamic, compared to the producers associated with the niche dynamics. Some of the actors involved in technical support that we interviewed focused on individual technological solutions and treatment at the parcel level, and less on contextualizing farmers' practices within broader considerations related to the farm, agroecosystem, and food value chain [30, 101]. This was at least the focus that they shared the most with us, when asked about potential for change in the use of chemical inputs. **For a more in-depth description of these dynamics, the actors involved, and their roles in developing the socio-technical niche, see Appendix H.**

Zooming out, it is possible that the social, political and/or economic dynamics generated to support the elimination of pesticide use within the vineyards of the Pilat Rhodanien, (and under particularly challenging topography), could serve as an example for other *AOC* winegrowers' unions throughout France. In this way, we propose that a specific *AOC* winegrowers' union (or a few adjacent ones within a territory, like the Pilat Rhodanien) could represent a socio-technical niche within the national *AOC* network and governance. We see potential for this, given the shifting dynamics towards organic and biodynamic production in the territory, and also that the president (newly appointed, during the research period) of *AOC Condrieu* is one of the actors we interviewed who was engaged in alternative practices (vitiforestry, vegetative ground cover, and sheep grazing the vineyard) [74].

5. Results of the survey "From field to plate" (*Du champ à l'assiette*)

We surveyed 45 attendees of the 2022 Pélussin Nature Festival, primarily adults above drinking age. Of the 40 who replied that they drank wine, 55% said that organic wine was a priority for them; 17.5% answered that it was moderately a priority; and 27% said that it was not. Responses about consumers' purchasing habits in general showed a strong tendency towards organic and local products (Figure 15).

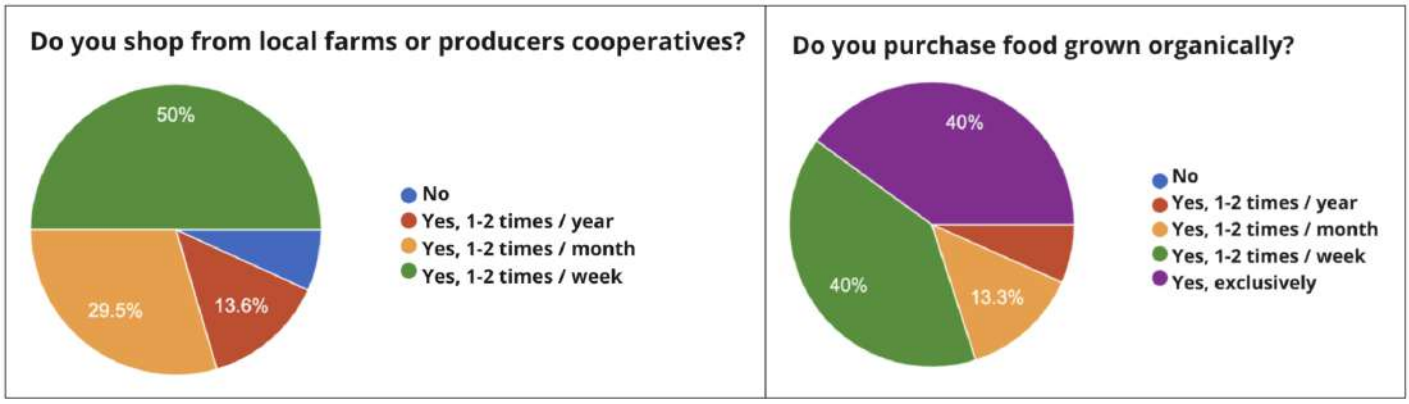

Figure 15. Results of survey questions on consumer purchasing habits.

Survey participants bought food at a variety of shopping outlets. The most common were independent organic grocery stores, followed by producer-run cooperative stores, closely followed by outdoor markets and supermarkets (Figure 16).

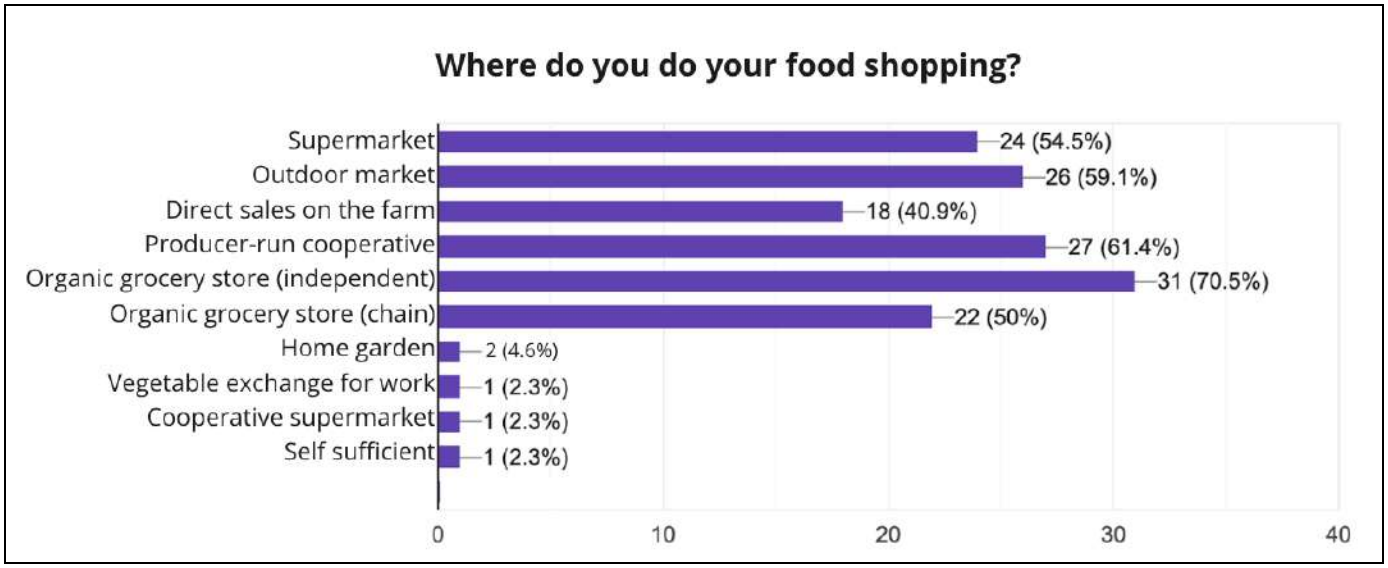

Figure 16. Results of survey question on where consumers did their food shopping.

Vegetables and fruit were the products that were most prioritized by consumers in their purchases of organic produce. Grains, dairy products and wine were also a priority for about two thirds of the respondents, and buying organic meat was also preferred by about half (Figure 17). We did not collect data regarding eating habits, such as vegetarian or vegan diets, which might have informed consumers' questionnaire responses.

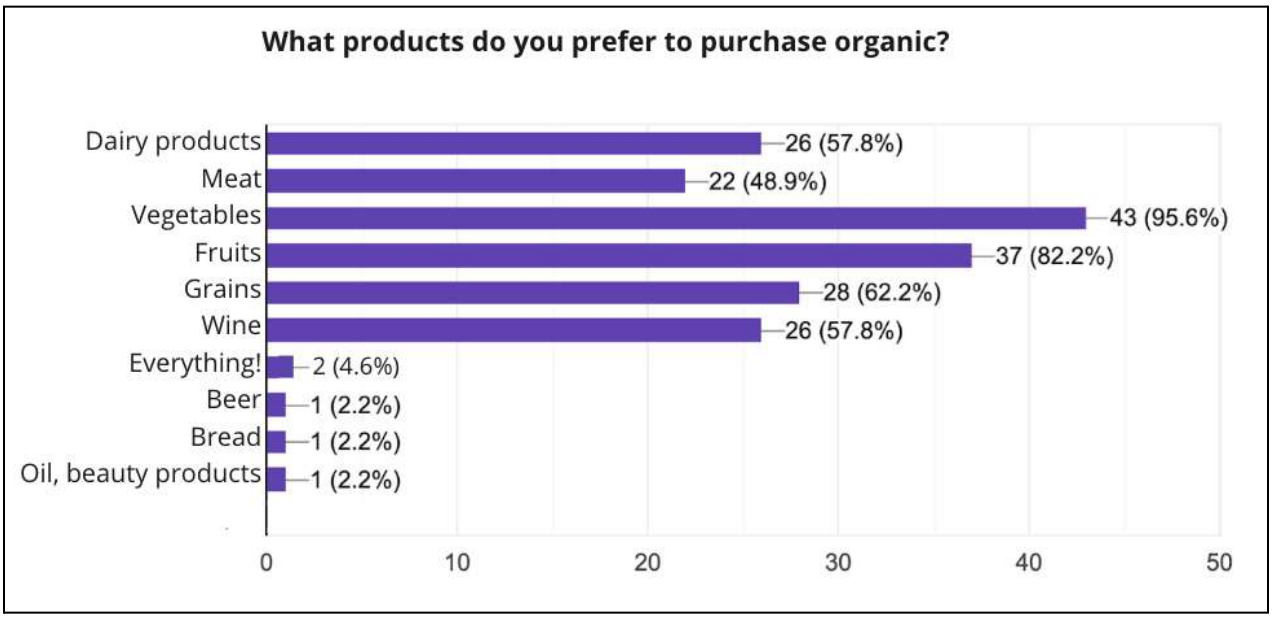

Figure 17. Results of survey question on the products that consumers preferred to purchase organic.

When asked if they thought that consumers have a role to play in the reduction of pesticides, the majority of people said yes (Figure 18). Six said that this was by choosing which producers, brands and supply chains to engage with; six said favoring organic products in their purchases; two said gardening without

pesticides; two said boycotting non-organic foods; two said communication, word of mouth and activism to preserve the planet; one said changing consumption patterns to shift the kinds of agricultural production systems that could exist; one said purchasing responsibly produced goods; one said gaining the courage to go talk with farmers directly; one said eating insects; and another said by creating regulation at the national level.

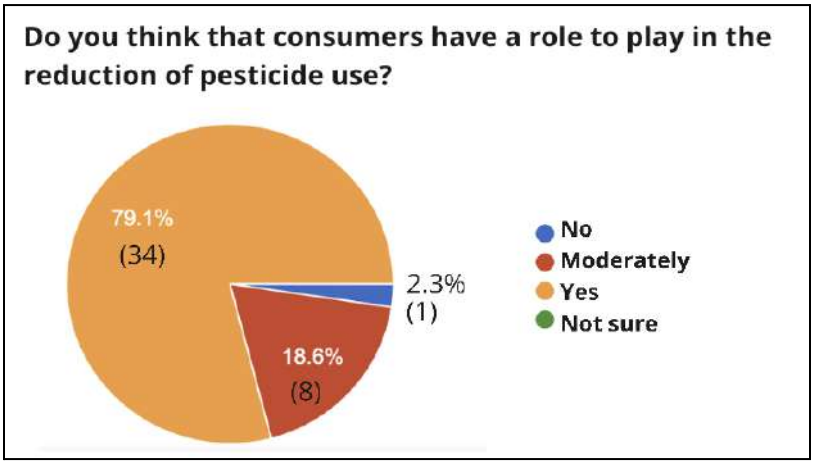

Figure 18. Results of survey question on the role of consumers in pesticide reduction.

When asked if they took any actions to reduce the use of pesticides, the vast majority of people said yes (Figure 19). Among them, 16 said that they did not use pesticides in their gardening; eleven purchased organic food or supported local, organic farms; five ate exclusively organic food; four talked to people about issues with pesticide use and/or were engaged in activism. Individuals reported the following actions: buying directly from farmers; favoring ladybugs and other natural predators as alternative plant protection methods while gardening; permaculture gardening; cultivating food on living soil; composting and using compost in their garden; and not purchasing products from mainstream brands.

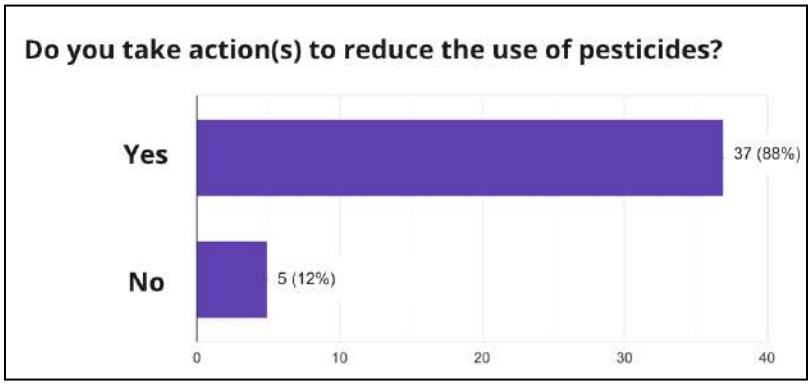

Figure 19. Results of survey question on whether consumers took action on pesticide reduction, or not.

5.A. Discussion of the survey

The majority of people surveyed at the *Pélussin* Nature Festival expressed that they consistently purchased organic food. Buying wine that was organic was not as much a priority as buying other food products organic, but it was still considered a strong to moderate priority for about 75% of the people surveyed. While about half of the survey participants said that they shopped at supermarkets, they also visited stores distributing organic and/or local foods, and a few participants grew some of their own food. Overall, the surveyed participants showed high appreciation of organic and local products, including wine.

The majority of participants considered that consumers have a role to play in the reduction of pesticides. An even larger number expressed that they were themselves involved. What this meant was diverse, ranging from consumption choices, to gardening, to awareness raising. While the involvement of some local actors may have had a greater influence on pesticide reduction, such as by activism, many of the actions cited, like consumption choices, were uncoordinated and not directly related to the active reduction of pesticide use. Therefore, at first glance, the potential impact of survey participants seemed weak.

The picture is slightly different if we see this group of actors as a socio-technical system, favorable to reducing chemical inputs through coordinated action.[22] The Nature Festival attracted individuals known for their involvement in local community organizing and activism (which we encountered in a number of our participant observations). Several of them were part of the steering committee of a local non-profit involved in promoting organic food through public awareness-raising events, and a yearly organic food fair. Others were involved in organizing the Organic Winemakers Festival or the Nature Festival itself. Based on the survey, this group might be considered a socio-technical system, with shared rules and norms (regarding food purchasing), knowledge (about the negative effects of pesticides), practices (consuming and/or promoting organic food) and networks (which we know exist, notably via involvement in event organization). The potential impact of these actions, however, even if coordinated, seems limited, and bound to the local scale. More data is needed to assess whether this really is the case; we find it difficult to characterize a socio-technical system with limited information based on a single topic. Given wine's shelf-stability and diverse sales channels that reach consumers far beyond the local scale, broader data collection is also necessary to assess the role of different consumer groups in the market development for wine produced with low-to-no chemical inputs.

The results of our survey echoe national trends of consumer appreciation for organic food in France. According to studies of the French Agency for the Development and Promotion of Organic Agriculture, organic food is highly popular in France: 85% of people are in favor of organic agriculture development, 26% declare that they have the intention of consuming more organic food and 16% say that they eat

[22] This is presuming that coordinated civil-society actors can be particularly effective agents in change processes, which several authors have argued to be the case. Notable examples can be found in literature on the *Ceinture Alimentaire Liégeoise* initiative (Baguette, 2015; Bousbaine and Bryant, 2016; Feyereisen and Stassart, 2017; Marcq et al., 2015; Pleyers, 2013).

organic food every day (FranceAgriMer, 2019)[23]. As evident in Figure 20, in France alcoholic drink sales have been on a constant rise for the past decade, evolving from 369 million euros in 2012, to 1296 million euros in 2021 (AgenceBIO, 2022). The appreciation of organic food has been accompanied by a rise in organic farming, the surface area of organic farms in France doubling between 2015 and 2020, now about 10% of total agricultural land (ORAB AuRA, 2019). This trend is also visible in Rhône Valley wine, where organic vineyard surface is on a steep rise: an increase of 17% from 2018-2019, and 21% from 2019-2020 (InterRhône, 2021; see Figure 21).

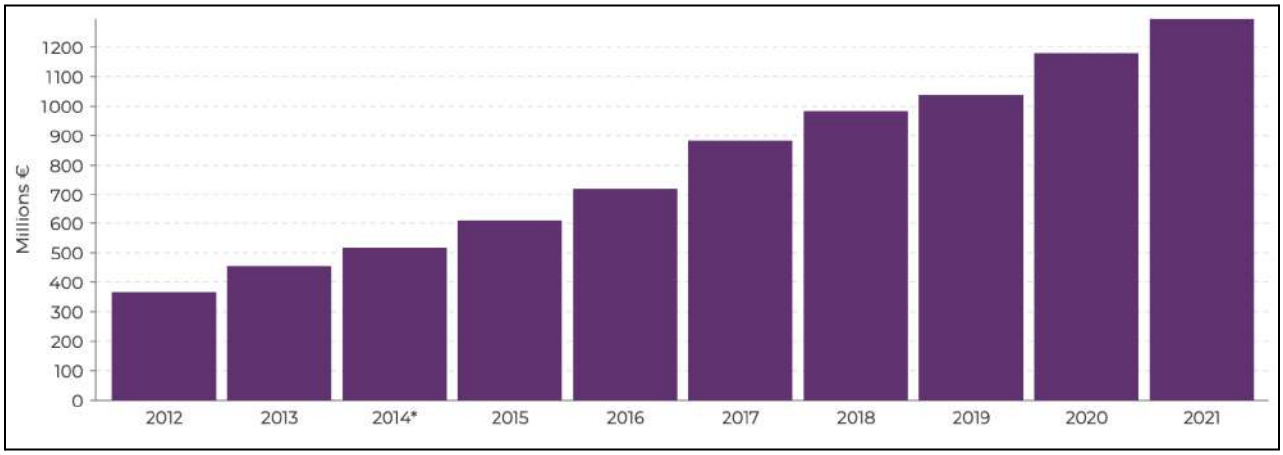

Figure 20. The evolution of organic alcohol sales in France from 2012 to 2021, accounting for the restaurant industry since 2014, and public meals since 2009 (AgenceBIO, 2022).

30% of wine, and 46% of organic wine in France is exported to other countries (Neiman, 2018. As illustrated in Figure 22, wine produced in the Rhône valley is primarily exported to Germany, Britain and the United States (InterRhône, 2021). Studies regarding the evolution of consumer habits of these populations could be helpful in designing innovations to support organic or other zero pesticide viticulture systems.

[23] A study in 2021 by the French agency for organic food, Agence BIO, showed that the number one reason to consume organic food was for “the preservation of one’s health” (61% response rate). This was followed by the “preservation of the environment”(48%), “greater availability of organic products in sales locations”(39%), “social and ethical reasons” (38%), “better taste”(37%), “animal well-being”(34%), “family habits”(17%), “having children”(15%), and “the discovery of new products” (12%) (AgenceBIO, 2021).

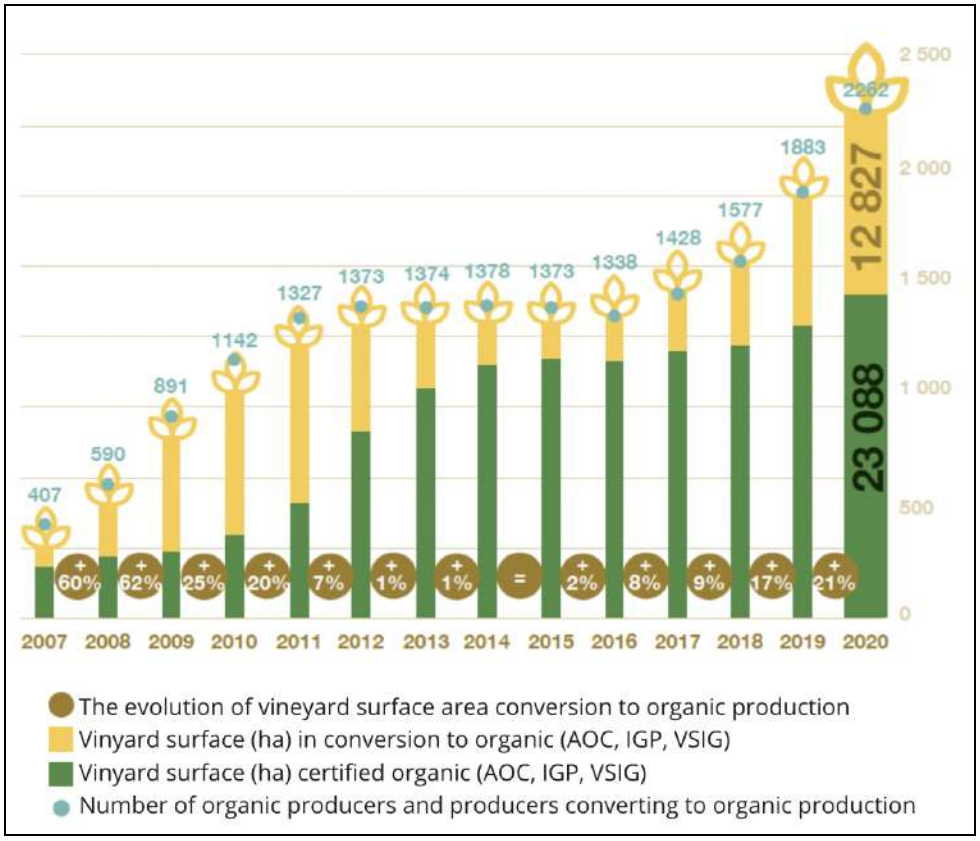

Figure 21. Evolution of vineyard surface area and number of organic producers in the Rhône Valley (AOP, IGP and without geographical indication), 2007-2020. (Source: InterRhône, 2021).

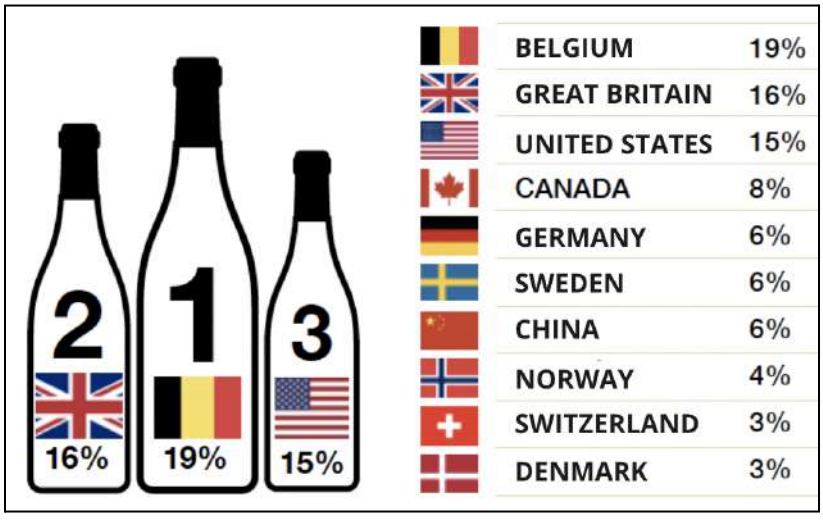

Figure 22. Top countries of export for Rhône Valley wines in 2021 (Source: InterRhône, 2021).

6. Actor network mapping

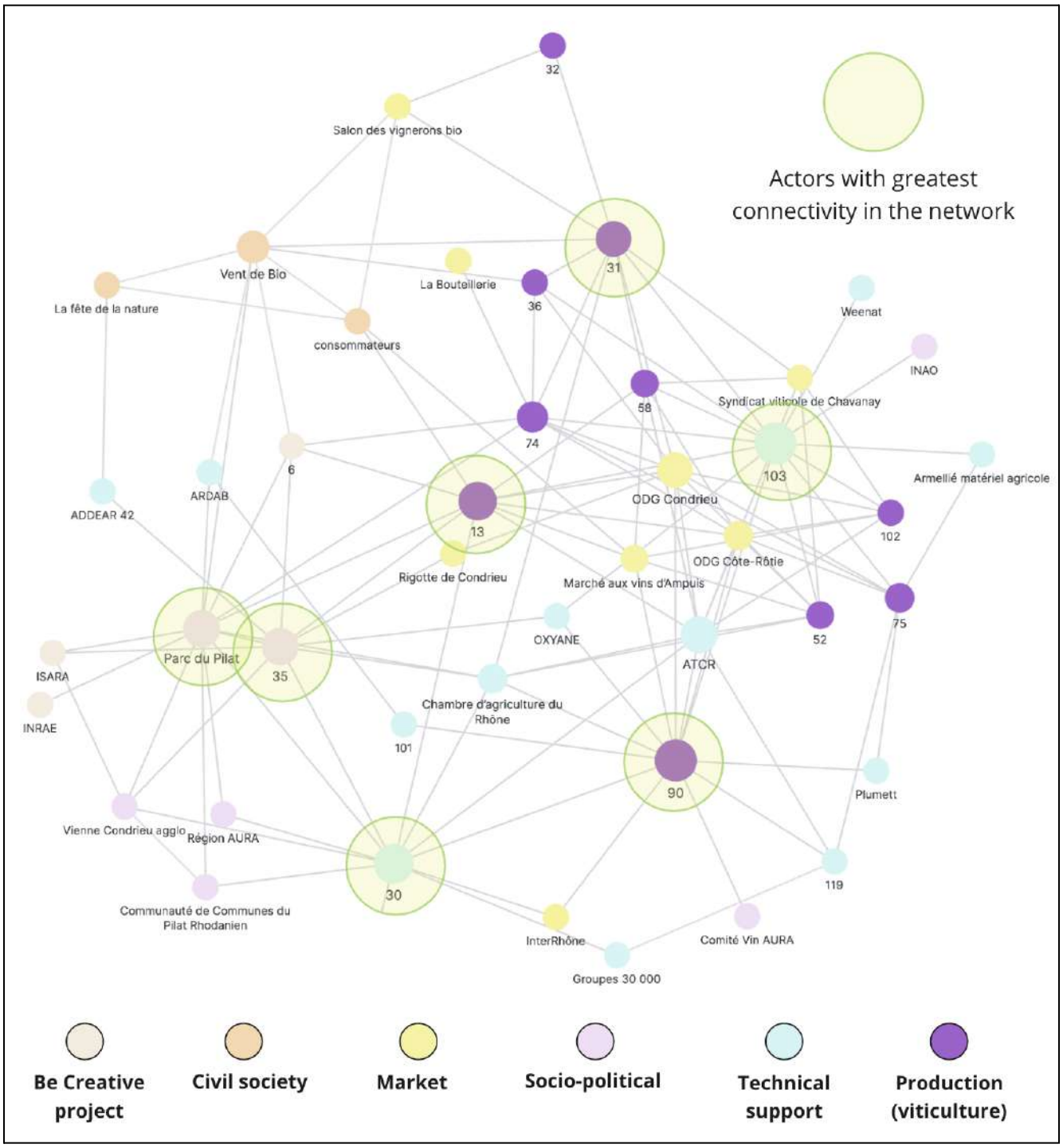

Figure 23. Actor network map organized by domains of activity: yellow for market, orange for civil society, blue for technical support, pink for socio-political, purple for wine production, and beige for Be Creative project partners. Lines are drawn between the actors who were mentioned in others' interview notes. The larger the dot size, the more links were made between that actor and other actors' interviews. Beneath the dots are actors' anonymized code numbers, or the names of key structures and organizations related to the actors interviewed. (Created with *Obsidian* and *Miro*).

The actors with the highest level of connectivity in the network map that was generated from our interviewee sample, shown in Figure 23 above, are: (i) socio-political actors related to territorial agricultural development at inter-municipalities [35] and the Natural Regional Park [Parc du Pilat]; (ii) technical support actors at the Chamber of Agriculture [30] and a cooperative for agricultural equipment sales [103]; (iii) wine producers themselves, notably the operations manager for the largest domain interviewed [90], the president of the *ATCR* (technical association) [13], and a producer of biodynamic wine [31].

The network map also helps to demonstrate the socio-technical systems that we propose are influencing the use of pesticides in viticulture in the Pilat Rhodanien, represented in Figure 24. The winemakers connected with the niche dynamics in the territory [31, 32, 36, 74, 75] have greater connectivity with civil-society actors and less-mainstream market actors. The winemakers more closely tied to the socio-technical regime [13, 52, 58, 90 and 102] have greater connectivity with the *AOC* market actors, Chambers of Agriculture, and the winemakers' technical association. Most importantly, what is visible here is the high level of overlap between regime and niche; there is connectivity between all of the winemakers and certain technical support, socio-political, and market actors who hold and represent the meeting spaces (physical and normative) related to the production of these wines of prestige and quality.

There are many limitations with an actor network analysis of this kind. Attempting to visualize social connections amongst a diverse group of actor types is not a simple task. A bias was introduced related to practical aspects of data collection: the more time spent with each actor, the more connections potentially identified. While a map of this kind helps to show which actors have more or less connectivity with others, their positionality (alliances or conflicts) is not directly taken into account (Brugha, 2000). In this way, the map should be complemented by the results of the interest/impact analysis and our descriptions of the socio-technical systems.

Assessing and visualizing the diversity of actor types also poses a challenge. There are different levels of detail that can be used, from individual roles and stakeholders to broader actor groups like “consumers” or entire organizations. For example, we considered the Pilat PNR as a single actor (except for certain specific employees) when in fact there are multiple different roles, offices, and departments involved. Exploring “roles” may be interesting to assess diversity in actor networks: roles imply identity and relevance grounded in particular tasks, relationships to others, and certain situations (Hall et al., 2017). We noticed that the same individual may have a role as a winemaker while also playing a role in a regional wine market, a technical association, or in a winegrowers’ union. Multiple roles may complement or conflict with each other, and they may influence actors’ perceptions and relations.

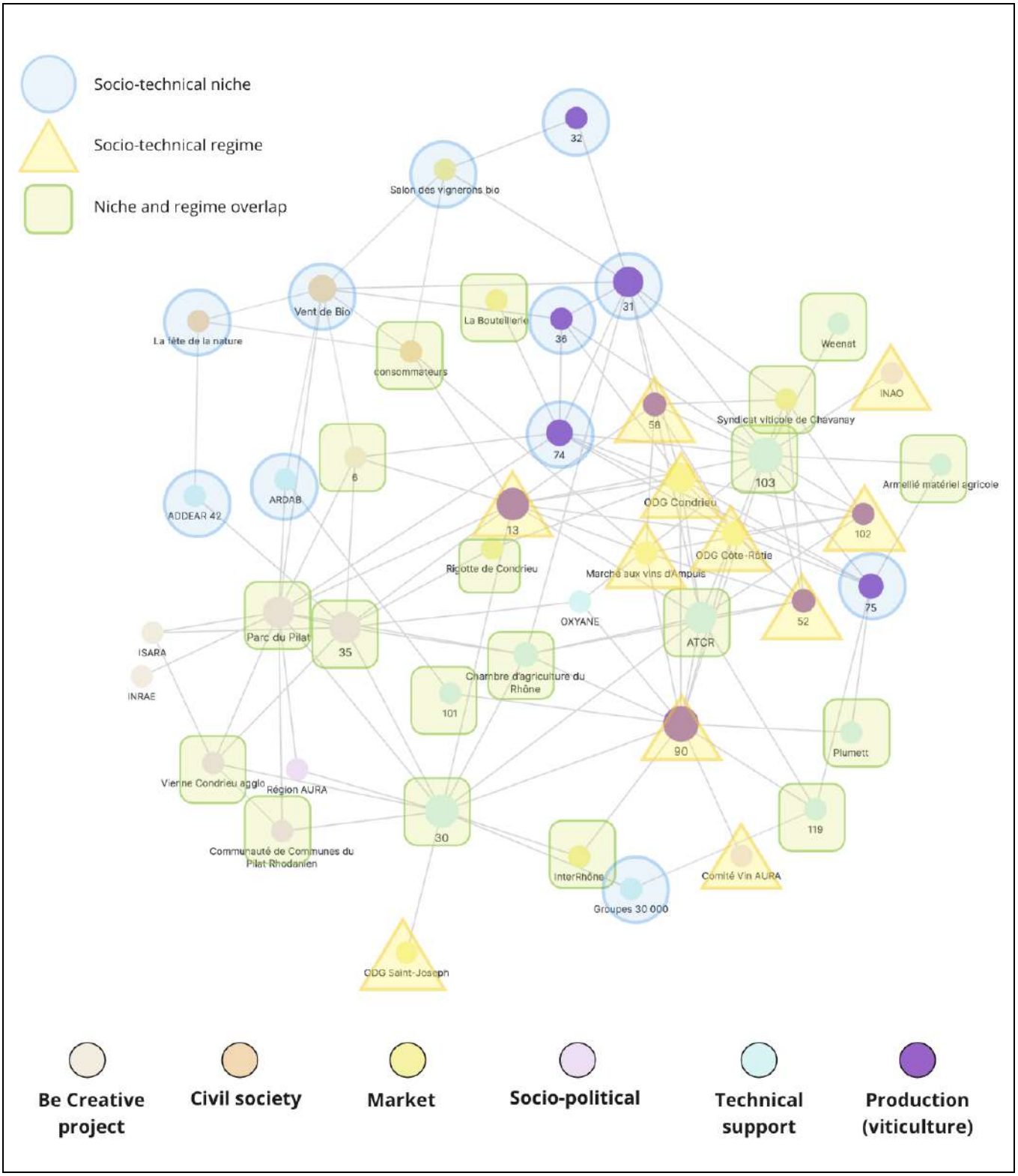

Figure 24. Actor network map showing the actors and structures related to the socio-technical niche, regime, or both, related to the reduction of chemical inputs in the Pilat Rhodanien. (Created with *Obsidian* and *Miro*).

7. Interest/Impact analysis (IIA)

This section analyzes our research sample with regards to actors' interest in reducing chemical inputs, and their potential impact in this endeavor. We aim to derive conclusions regarding the content of our study, and what this means for the future of the research project. These findings cannot be used, however, for generalizable conclusions about the interest and potential impact of actors in France, the region, or even the Pilat Rhodanien. Mapping the interest and impact of a larger sample of actors within, and outside of, the territory would likely yield different results.

The 'interest/impact analysis' (or 'interest/influence') is one of several 'stakeholder analyses.' These have different roots, amongst which policy development, management and development. Findings from these analyses serve as a means to devise strategies to involve different stakeholder groups, receive their input, assess threats and opportunities for achieving a goal, including conflicts of interest and potential alliances. It has also been used to retrospectively evaluate a process, to elucidate problems that may have arisen (Brugha, 2000). Other than being useful for analysis, it is also an action-oriented, operational tool.

The actors that we interviewed represented a range of interest and potential impact in lowering chemical input use. Most of them had high interest and medium potential impact. Others had a strong interest and varying degrees of potential impact. In other words, most actors whom we interviewed were convinced that chemical inputs should be reduced, and had something to gain in changes being made in this direction. Their ability to contribute to this goal however varied. Of all the actor types, the market actors were the most difficult to reach, get responses from, and schedule interviews with. We assume that these actors have a significant influence on the value chain, but potentially low interest in reducing chemical input use. In general, we lacked contact with actors who had high potential impact but low interest.

Key stakeholders in change-making processes typically have a combination of high interest and impact (top right quadrant of the graph). Looking at Figure 25, we identify these actors as the agroecology development officer at the Pilat PNR [6], our research partner in the Be Creative project; the director of a non-profit whose mission is to support the development of organic agriculture [11]*;* and a commercial technicien at a cooperative for agricultural equipment sales [103]. Close behind are two wine producers and domain managers [13;31]; an inter-municipality agricultural officer [35]; and a vine technician at the Chamber of Agriculture [30]. This is a heterogeneous group, within different domains of activity, which may imply both opportunities (access to a variety of resources, knowledge, perspectives) and limitations (conflicting agendas; differences in norms). It is important to nourish relations with these key actors, and find ways to collaborate with them in a synergistic manner. Including both high impact, high interest actors, as well as high impact, low-interest actors, in decision-making processes has proved helpful in gaining project support from such actors, and heightening their interest (Faysse, 2006).

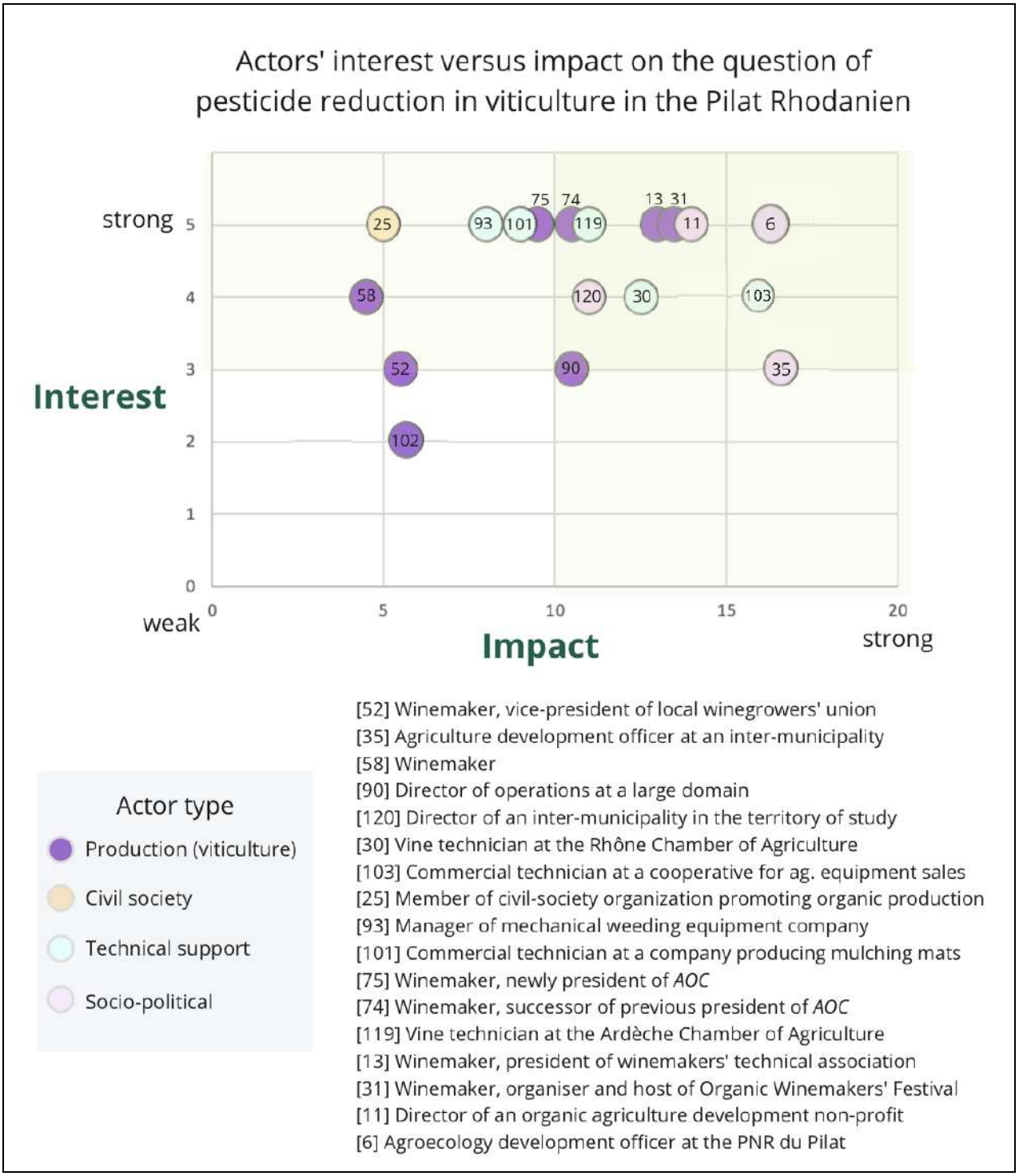

Figure 25. Interest/impact analysis of interviewed actors on the question of pesticide reduction in viticulture in the Pilat Rhodanien. The ranking criteria used used are provided in section 2.III.

There are many limitations to an analysis of this kind. One is the subject of analysis, which was the general interest and impact in reducing chemical inputs. The analysis would look differently if the role of these actors were assessed in the context of a specific, concrete project designed to help reduce the use of

chemical inputs, such as the invention of a new tool for mechanical weeding, influencing regulations regarding drone use, or enhancing farmer knowledge-exchange opportunities. The ranking of actors was relative, and the selection biased, based on the group of actors that we sampled and the insight that we gained through limited time in their company. It may seem odd to assign a numerical value to an individual's interest or impact on such a complex question. However, this perspective serves as a tool to help put into relation the different actors' potential agency for changemaking, and to interpret who to potentially collaborate with on different kinds of initiatives.

The actors ranked with higher potential impact correspond with the same set of actors who had the highest connectivity in the actor network map (Figure 23). This is not a coincidence, given that multiple criteria on which actors' impact was ranked have to do with interactions in social, economic and political arenas. In addition, Figure 24 suggests that the actors who we propose form a socio-technical niche are not so disconnected from those who form the socio-technical regime (as discussed previously, in the context of the *AOC* geographical indications and their prevalence in the territory). The map shows that there are some actors who serve as the connectors between these two socio-technical systems.

Bui et al. (2016) showed that niche and regime actors can collaborate, even if they have radically different visions about sustainable agriculture and food. Understanding the overlap between niche and regime, and identifying the key actors who maintain these links, may be useful in the facilitation of agroecological transition in a given territory. Schut et al. (2015) argue that successful niche development is in fact dependent on compatibility with the assumptions, practices, and rules of existing regimes, which can then facilitate its development and diffusion. We hypothesize that it is at least in part thanks to actors in a position of high connectivity between niche and regime that this kind of compatibility is possible. They may play a key role in initiating and/or coordinating the scaling-out of niche innovations for the reduction of chemical inputs.

8. Socio-technical lock-ins related to chemical input use in viticulture of the Pilat Rhodanien

The following four-fold table presents the results of our cross-cut analysis (Table 5). The first column characterizes "barriers", factors that participate in socio-technical lock-ins to chemical input use in wine production in the Pilat Rhodanien. The second column characterizes "opportunities", existing factors that address the lock-in factors and contribute to enabling a decrease or elimination in chemical input use. The third column describes potential innovations and innovation processes to "unlock" the socio-technical lock-ins. Innovations were discussed with interviewees, our research team and amongst the two of us as co-researchers. Some are also inspired by scientific articles and gray literature. The fourth column lists suggestions for further research, such as remaining questions related to the research objectives, as well as information needed to fulfill operational and/or experimental initiatives in the next phase of the research project. To the best of our ability, we reference specific actors with whom to collaborate on certain innovation processes and/or further research. The identification of these actors was facilitated by the analysis of socio-technical systems related to viticulture in the territory, which is presented in the following discussion section.

Each lock-in barrier, opportunity, innovation and research need has been marked with its corresponding scale(s) and theme(s), as follows:

Scales → Parcel 🌾 | Farm 🚜 | Food-value chain 🛒 | Territory 🏞️

Themes → Economic 📈 | Personal 🏠 | Technical and agronomic ⚙️ | Organizational ⏳

Table 5. Results of the cross-cut analysis, presenting a synthesis of barriers to reducing the use of chemical inputs, as well as corresponding opportunities, potential innovations and further research needs and questions.

Socio-technical lock-ins to chemical input use, and contributing factors "BARRIERS"	**Existing factors "OPPORTUNITIES" that address the barriers and contribute to enabling a decrease or elimination in chemical input use, in the territory during research**	**Potential INNOVATIONS to "unlock" the socio-technical lock-ins**	**Further RESEARCH NEEDS, ex. knowledge gaps in research, and information needed to fulfill operational and/or experimental initiatives**
1. **Stress on the grapevines due to limited water availability and concerns regarding spontaneous vegetation was handled using chemical herbicides on at least 10-15% of the vineyard surface area in the Pilat rhodanien (PR). The stress was intensified by the challenging:** **-topography and historic infrastructures** (steep slopes, terraces) **-soil characteristics** (shallow, sandy, highly-draining) **-scarce rain** during the growing period, increasingly so due to climate change. Alternatives to chemical herbicides **had limitations** that made their use **less attractive to some wine producers than using chemicals:** **(A) Mechanical weeding was the most widely used alternative to spraying chemical herbicides.** When too difficult or impossible by	(A) Mechanical weeding tools that eased work on steep slopes (ex. plow attached to a motorized pulley) had been increasingly used over the past 5-15 years. 🌾⚙️⏳ (e,h) Vienne-Condrieu Agglomeration was involved in coordination efforts to help with labor shortage, and the reuse of waste materials. 🏞️⏳ (B) The development and implementation of emergent practices was facilitated by the proximity of wine producers and already existing exchanges in their networks. Techniques, used by a few wine producers, such as incising the soil, using biodynamic fertilizers, and green mulch, enhanced water infiltration. The use of sheep to graze the vines during the non-growing season occurred on a minority of the	(a) Restructure the vineyard architecture, ex. decreasing the density of grapevines on steep slopes to better manoeuver with mechanized weeding tools; renovating terraces and/or surrounding passages for better accessibility by small tractors and/or motorized pulley equipment. 🚜⏳⚙️ (a,b,c,d) Develop and make accessible better tools: Collaborate with tool suppliers, manufacturers, designers, research/education institutions, and/or *Atelier Paysan,* an organization that works with farmers to design and manufacture machinery and buildings adapted to sustainable farming methods. This was an option that many farmers seemed to be aware of and find interesting, but which none had used. 🛒⚙️⏳	- Understanding beneficial soil microbiota for these grapevines; the relationship between living soil and water retention capacity; and how to enhance microbial life through new techniques, such as fertilizing practices. (a,b,c,d) Doing archive research, possibly at the *Musée Gallo-Romain*, in nearby city Vienne, to determine whether tools and practices which were used in the past, would be appropriate for present wine production. Then help implement these solutions. (d) Assessing the offers and capacity of local machine repair and fabrication companies to get involved in innovation processes: *Fatton, Colinet, Amellié;* as well as agricultural equipment companies *NaturaGriff* (for mechanical weeding tools), and *Sothexto* (for plant-based mulch mats).

tractor, it had to be done on foot, with a hoe or mechanized plow and pulley system, which required: (a) more strenuous work 🚜⏳⚙️ (b) more time 🚜⏳ (c) greater costs 🚜📈 (d) suitable tools, which were lacking, because of low availability on the market, insufficient labor for repair or modification, and low to no coordination amongst actors in the territory to address the issue. 🚜⚙️⏳ (e) hiring more workers, difficult due to the strenuous work conditions, competition from better paid work in the valley, and a lack in nearby viticulture training. 🚜⏳📈 **(B) Emergent practices for facing water stress** (including vegetative ground cover, mulching, sheep grazing) **were often not as accepted as chemical or mechanical weeding,** as they: (f) had shown questionable agronomic results 🌾⚙️ (g) were not mentioned in the contract specifications of the *AOCs* 🛒⏳⚙️ (h) were not the subject of coordination efforts that could lead to upscaling. 🏞️⏳	vineyards, and showed promising results. 🚜⚙️⏳ (f) The Rhône Chamber of agriculture, Botanical Conservatory of the *Massif Central* and the Pilat PNR were involved in finding suitable plants for ground cover. 🏞️⚙️ (f) An experienced commercial technician at a local cooperative for ag-equipment sales was involved in experiments for ground cover, and was motivated to continue researching the potential of this alternative to herbicides. 🏞️⚙️ (f) The Pilat PNR had supported the implementation of a vitiforestry system. 🏞️⚙️ (f) Collaborations with nurseries were ongoing, to help with ground cover propagation, such as growing sedum on mats. 🛒⏳ (g) Wine producers did not mention that AOC contract specifications hindered their capacity to use new methods. 🛒⏳	(e) Organize buses to bring agronomy, oenology, or other agricultural studies students from surrounding municipal centers to the vineyards for volunteering in the vines during peak work times. 🛒⏳ (e) Open a viticulture section in nearby agricultural schools. Create opportunities for students to learn about and get involved in local wine production. 🏞️⏳ (e) Enhance working conditions. This could be done by surveying local workers, to learn about their needs, sharing a synthesis with, and possibly accompanying wine producers in the implementation of improvements. 🛒⏳ (e) Pay workers higher wages. 🚜⏳📈 (g) Make sure that AOC contract specifications are not a threat to wine producers' ability to use vine protection strategies that are not currently in the books. If they are, work with INAO and AOC unions to update contract specifications, so that they permit a greater variety of vine protection practices. 🚜🏞️⏳⚙️ *	(e) Assessing: Is it economically feasible for wine producers to pay their workers more? What is the return on investment (through worker retention, better motivation, or simply, the presence of workers vs. not having any help)? Could this engagement from domains help enhance the marketing of individual domains or even *AOCs*, if these were the first fair-trade *AOC* wines? Which groups of individuals or institutions would have the capacity and will to help this change occur ? ***INNOVATIONS CONTINUED** (f) Continue research on suitable vegetative ground cover. This could be done with winemakers, the *ATCR,* the Rhône Chamber of agriculture, Botanical Conservatory of the *Massif Central* and the Pilat PNR. Complement this by looking at literature based on other areas of the world (such as vegetative cover used in California vineyards), which could help inform experiments locally. Look into *Avena fatua*, which might die off before summer dry spells. Work with Thorenap to find technical solutions regarding hemp mats. 🛒⚙️

LOCK-INS	OPPORTUNITIES	INNOVATIONS	RESEARCH NEEDS
2. **Copper and sulfur products (CSP) were the most accepted, widely approved-of alternative to chemical fungicides but had qualities that made them less performative.** For both options, when on steep or difficult to access slopes, application occurred on foot (*à dos d'homme*). CSP washed off and needed to be reapplied after rainfall. During rainy years, this could lead to a greater number of treatments compared to chemical fungicides. More necessary treatments meant: (a) more **strenuous work** 🚜⌛⚙️ (b) more **time** 🚜⌛ (c) greater **application costs** 🚜📈 In addition, (d) concern over the **accumulation of copper** in the ground, 🌾⚙️ (e) risk for more **hostility on the part of neighbors and passers-by** towards wine-producers. 🚜🏞️🏠	- Little rain and low water stagnation and humidity in these vineyards was non-conducive to the proliferation of fungal bodies. 🌾⚙️ (a,b, possibly c) Drones received attention (as an alternative to performing some of the fungicide spraying on foot) amongst wine producers and technicians (***see lock-in #6***). 🌾⚙️ (a,b,c,d) Prophylactic measures to prevent fungal growth were widely accepted and used. Other more marginal techniques helped build grapevine and vineyard health in the long-run. 🌾🚜⚙️🏠	(a,b,c,d) Enhance opportunities for knowledge exchange/dissemination in collaboration with local organizations (such as *ARDAB, ADDEAR, Pilat PNR*, inter-municipalities, Chamber of agriculture, *ATCR*, research institutions) and the winemakers interviewed who have experience and insight on marginally practiced but promising techniques, such as those based on biodynamic practices, to help build the long term robustness and natural immunity of the vines, their root systems, and soil health (fertility, microbial life, structure and ability to absorb, distribute and store water). 🏞️⌛🏠 (d) Enhance knowledge dissemination about biochar properties and how to use it, and access to biochar if necessary, with agronomists. 🏞️⌛⚙️ e) Launch initiatives to educate the local public about spraying practices (film screenings, panels around fields and in public spaces) in partnership with a Chamber of Agriculture, unions, and/or the Pilat PNR. 🏞️🛒🏠	(a,b,c) Understanding the use of decision-aid tools specifically for fungal outgrowth in these vineyards, and their role in farmers' decisions for the use of fungicides versus CSP. (a,b,c,d) Doing tests with structured water (*eau structurée*), which might help diminish required doses of chemical inputs. This could be done in collaboration with *Oxyane*, and/or researchers.

LOCK-INS	OPPORTUNITIES	INNOVATIONS	RESEARCH NEEDS
3. **Through their choice of chemical protection strategies, wine producers, potentially because of short-term thinking, prioritized preventing water competition over mitigating soil erosion, even though in the long-run, less erosion** would mean greater water retention and fertility, conditions to **better prevent thirst and disease amongst vines.** Reliance on mechanical weeding worsened soil erosion. 🚜🏠⚙️⌛📈	- To mitigate soil erosion, two farmers interviewed maintained spontaneous vegetation or planted a vegetative cover, such as green much, sometimes on one out of every two rows. 🌾⚙️ - Certain emergent practices, such as ground cover and sheep grazing, mitigated weed competition, while also reducing soil erosion, when compared with mechanical weeding. 🌾⚙️	- Enhance opportunities for knowledge exchange/dissemination regarding measures mitigating and/or preventing soil erosion in partnership with farmers and organizations such as *ARDAB, ADDEAR, Pilat PNR*, inter-municipalities, Chamber of agriculture, *ATCR* and/or research institutions. 🌾⚙️🏞️⌛ - This lock-in might stem from deeper problems, notably short term thinking, compartmentalized thinking, and measures of success (IPES-Food, 2016). To tackle this, shifts in mindset need to occur. This could happen through the dissemination of knowledge regarding the (ecological, agronomic, economic, and social) trade-offs involved in various vine "protection" strategies in the long-run. A change of paradigm would be best supported if all actors of the food-chain were involved to influence the understanding of and support for sustainable viticulture. It might be most strategic to work with *InterRhône, AOC* unions, and professionals involved in marketing *AOC* wine. 🚜🛒🏞️🏠⌛	- Assessing to what extent the soil fertility and water retention capacity can be feasibly improved in these cropping systems, due to the soil characteristics at present. - Assessing to what extent mitigating soil erosion and building soil fertility would help the water-holding capacity of these soils,[24] and what the interest of farmers is in making these efforts.

[24] While the valley hillsides hold mostly sandy, granitic soils, there are soils with greater clay content in the northern PR.

LOCK-INS	OPPORTUNITIES	INNOVATIONS	RESEARCH NEEDS
4. ***AOC* contract specifications imposed requirements that may have factored into farmers decisions around chemical input use:** (a) the use of either "equipment for the application of treatment products" or "mechanical weeding" to control spontaneous vegetation; 🌾⚙️ (b) which grape varieties to cultivate, excluding the option to plant resistant varieties; 🌾⚙️ (c) the maintenance of terraces, walls and other historic infrastructure, limiting farmers' ability to modify parcels for mechanization; 🌾⚙️ (d) prohibited irrigation. 🌾⚙️	- Wine producers in *AOC* did not tell us that they were hindered by the contract specifications from trying out alternative practices, such as ground cover, mulching, or the use of biodynamic preparations. However, we did not specifically ask about this, which leaves the correlation and causation between the contract specifications and their practices up open for discussion. 🚜⚙️	- Through multilateral dialogue, involve local and territorial partners to inspire *AOC* unions and *INAO* to change the contract specifications so that these allow for a greater diversity of practices, including those that help reduce the use of chemical inputs. Provide the necessary support for this to occur. 🛒🏞️⏳ (a,b,c,d) Help restructure AOC unions' governance to enhance their democratic structure, and producer's ability to have a say in defining contract specifications. 🛒🏞️⏳ ** **RESEARCH NEEDS CONTINUED** (b) Assessing appropriate fungal and drought resistant grape varieties for wine making in the PR, under these specific topographic conditions and soil characteristics. (a,b,c,d) Learning about the governance structure and functioning of AOC unions, and how easy it is for producers to weigh in on decisions regarding contract specifications.	- Assessing whether winemakers feel that the *AOC* contract specifications, or other production norms held within their networks, enforce the use of chemical inputs? - We were not able to schedule interviews with any of the current president-producers or other staff members at the winegrowers' unions. This would be an important entry to better understand the key actors and governance in the local *AOC* winegrowers' unions, and how the contract specifications are understood in relation to chemical input use practices. (c) Finding out about wine makers in this region or on other similarly steep vineyards with experience modifying historic infrastructure such as terraces to improve the mechanical weeding capacity of their parcels. (d) Finding out whether winemakers on these hillsides would be interested or even open to the idea of irrigating their grapevines, and if this would be beneficial to the specific parcels within domains where winemakers still employ the use of chemical herbicides.

LOCK-INS	OPPORTUNITIES	INNOVATIONS	RESEARCH NEEDS
5. **There was limited coordination to reduce chemical inputs:** (a) There were no and never had been viticulture EcoPhyto groups (*DEPHY* or *30,000*) in the territory. 🛒⏳⚙️ (b) Wine producer-led efforts focused on access to certain technical knowledge and market development, but potentially left out enabling factors to reduce chemical inputs, such as access to labor, or the fabrication and use of new tools. 🛒⏳ (c) Cohesion amongst the wider landscape of territorial actors remained limited, in this wine sector largely developed around self-organized domains who seldom collaborated with other types of farming operations[25]. 🏞️⏳	(a) There was recent and dynamic development of organic production, expanded support to access technical knowledge and problem-solve amongst farmers and technicians, through informal and organized exchanges, notably via the *ATCR*. 🛒⚙️ (a) An EcoPhyto group, coordinated by a vine technician at the *Ardèche* Chamber of Agriculture, had existed since 2016 in a territory immediately south of the PR (*Tain Hermitage*); *ARDAB* in 2022 started a EcoPhyto group with winemakers in a territory immediately north (*Beaujolais*). 🏞️⚙️⏳ (a,c) Farmers exchanged with producers external to the territory, expanding their perspectives on technical and organizational practices. 🛒⚙️⏳ (b,c) Local inter-municipalities and non-profits worked in service of wine producers to tackle challenges not typically addressed in the wine sector. 🏞️⏳ (c) Coordination amongst winemakers occurred via *AOC* unions, and the organization /participation in markets. The Organic Winemaker's Festival enhanced cohesion amongst organic producers. 🛒⏳📈	(a) Establish an EcoPhyto group (ex. *DEPHY, Groupe 30,000*) in the PR. 🛒⚙️ (b) Actors from inter-municipalities and Chambers of Agriculture lead initiatives to support territorial-wide collaborations with different actors holding common and synergistic missions, geared towards job creation, awareness raising around organic viticulture, and decreasing pesticide use. 🏞️⏳ (a) Many EcoPhyto programs result in open source studies and technical documents. This could represent a helpful resource for wine producers. It might be interesting to organize a session, for example in collaboration with the *ATCR* and/or a Chamber of Agriculture, to show these resources to farmers, and possibly to constitute independant working groups. 🛒⚙️ (c) Innovations presented throughout this table could help enhance coordination of actors across the value chain. This includes the design and use of shared tools, events, re-structuring *AOC* governance, re-defining *AOC* contract requirements to include a broader scope of allowed plant protection practices. 🛒⏳📈⚙️	(a) Who would be an appropriate coordinator for an EcoPhyto group in viticulture of the PR? (a) Is the establishment of an EcoPhyto group something of interest to current winemakers in the territory, potentially those who are on the fence about organic certification, and are seeking greater accompaniment? (a) Would an exchange and support group of this nature be of value to these winemakers who are already well-connected via existing structures (*ATCR,* winegrowers' unions both *AOC* and *Chavanay*)? (a) What kinds of documents resulting from EcoPhyto groups would be of most interest and useful to wine producers in the PR?

[25] An important counterexample is the collaboration between winemakers and goat cheese producers for an annual wine and cheese tasting festival in *Condrieu*, which saw its 35th edition in 2022. Called *la Fête du Vin et de la Rigotte*, this festival celebrates two local geographic indications*: Condrieu* white wine and *Rigotte* goat cheese.

LOCK-INS	OPPORTUNITIES	INNOVATIONS	RESEARCH NEEDS
6. **Drones** might help reduce the use (in frequency or dosage) of chemical fungicides and herbicides, and face spraying constraints on sloped terrain. **Concerns which limited their adoption remained** with regards to: (a) practical considerations (high energy consumptions, the need for trained pilots) 🚜⚙️⏳ (b) technical challenges (the need to complete treatment by spraying on foot; spraying precision with wind) 🌾⚙️⏳ (c) the current legal framework, which did not permit spraying by airway (aside from permitted trials using organic-authorized products, like CSP). 🛒⏳	(a,b) Drones received considerable attention amongst wine growers and technicians. Their future implementation seemed probable, especially to spray organic-certified products (ex. CSP). A vine technician in *Ardèche* was coordinating trials. Recent tests permitted spraying only with organic-certified products, which would likely remain the case were drone use legalized. This could, down the line, make using CSP for fungal control more viable, over chemical fungicides. Drones would likely not replace spraying on foot, but could help decrease labor needs on steep slopes. 🚜⚙️⏳	(c) If drones are able to become a feasible and sustainable tool for winemakers, and give the ability to decrease the use of fungicides while helping ensure the viability of domains, rally AOC unions, InterRhône, inter-municipalities, PNR Pilat, politicians, to enable their legal use. 🛒⚙️⏳	(a,b) Continued trials with drone companies and pilots, Chamber of agriculture partners and others are necessary to assess the efficacy of spraying the vineyards of the Rhône valley via drones. (a,b) All practical considerations need to be addressed to make drone use truly viable. Research and outreach would be helpful to assess opportunities for future development, as well as their use being granted full legal status.

LOCK-INS	OPPORTUNITIES	INNOVATIONS	RESEARCH NEEDS
7. **Certain prophylactic measures** (biodynamic preparations, careful soil incision, vegetative covers, pruning techniques) held promise to lower fungicide and herbicide use, and to potentially mitigate erosion in the long-run. However, they **had limited adoption**, due to: (a) being insufficient on their own to protect vines in the short-term 🌾⚙️ (b) a lack of initiatives and coordination to upscale these practices. 🛒⏳	(a) These measures, and the mindsets of farmers employing them, challenged the technical fix underlying chemical input use, and the substitution logic behind their prevalent alternatives (mechanical weeding and CSP). When implemented with care, they seemed to offer both short-term and long-term mitigation of water stress or fungal disease. 🚜🏠 (b) Multiple wine producers interviewed were rather new to, or in reflection about the adoption of, the use of biodynamic preparations in their vineyards. 🚜⚙️ (b) One experienced and well-respected biodynamic farmer was open to sharing his knowledge, given fair exchange. 🛒⏳	(b) Establish a biodynamic wine producers' technical group based in the Pilat Rhodanien, for the exchange and sharing of knowledge, techniques, tools and equipment for biodynamic preparations and other relevant prophylactic measures, that are not yet well-accepted or recognized in the territory. 🏞️⏳⚙️	- Is there existing research regarding the benefits and drawbacks to these kinds of prophylactic practices, particularly related to their role in reducing chemical input use? If this is a research gap, is there interest among the scientific community in supporting experiments in the PR as part of the Be Creative project ?

LOCK-INS	OPPORTUNITIES	INNOVATIONS	RESEARCH NEEDS
8. Diversifying production systems (research suggests) may be a factor in “unlock-ing” pesticide lock-in. **Wine production in the PR was characterized by monoculture, on the parcel, and usually farm scale.** This was due to: (a) the very high land value, which was justified by the economic return from cultivating grapes and making prestigious *AOC* wine. 🚜📈 (b) the topography and soil characteristics which made cultivation of other crops less viable (or unviable), under current, mainstream perceptions of this agricultural landscape. 🛒📈🏠⚙️⏳	(b) Agronomic benefits from agroforestry systems, together with available financial and technical support to implement this practice (ex. by Pilat PNR) incentivized some farmers to integrate hedgerows and/or diversify the species within their parcels (such as the planting of fruit trees and/or aromatic plants). 🚜⚙️⏳ (a,b) The highly diversified farming landscape of the Pilat territory offered opportunities for collaboration. 🏞️⏳ (a,b) Institutions, such as the Pilat PNR and inter-municipalities offered opportunities for oversight and accompaniment in cross-sector collaborations. 🏞️⏳	(a,b) *ARDAB*, Chambers of Agriculture, *Pilat PNR* and inter-municipalities enhance opportunities for synergistic collaborations across farming sectors. Examples are having animals (chickens, sheep) graze and fertilize the vines, using local manure, mulch and compost, growing vegetables and/or fruit, mushrooms amongst vines. 🛒🏞️⏳ (a,b) Accompany new winemakers in the region during their installation process with access to knowledge and mentorship to plan and experiment for the future of their vineyards, integrate agroforestry techniques, and diversify their cropping systems. 🛒🏞️⏳⚙️	(a,b) Are there successful domains with diversified vineyards, such as including multiple (resistant) varieties, multiple species (perennial or annual) within the production, and/or a vineyard with complex architecture (non-monoculture)? (a,b) What is the potential of collaboration with other farm sectors ? Is there interest in this? Which producers would be interested in participating ? (a) Learning more about the real estate market of these agricultural lands, how value is accrued, and what the generational financial turnover process entails, to best navigate economic margins around investment and payback periods.

LOCK-INS	OPPORTUNITIES	INNOVATIONS	RESEARCH NEEDS
9. **Organic conversion was not entirely enticing to all producers because**: (a) they held the impression that *AOC* wine bottles did not fetch a higher sale price with other labels, and therefore additional production costs were not compensated for 🛒📈 (b) producing organically was more costly than producing with chemical inputs 🚜📈⏳ (c) transitioning to organic production entailed a capacity for investment in equipment and labor force, which was most viable for medium-sized domains (8-25 ha), and sometimes difficult for smaller or larger domains 🚜📈⏳ (d) available financial aid for the conversion process was insufficient to compensate for the additional costs from producing organically. 🛒🚜📈⏳	(a) French consumers had a favorable perception of organic food, and the consumption of organic alcohol had been on the rise for a number of years. 🏞️📈🏠 (a,b,c) A tight network of individuals, involved in local civil-society, were highly in favor of organic food, believed that consumers ought to play a role in reducing pesticide use, and were active in a variety of ways. 🛒🏞️⏳📈 (a,b,c,d) Organic and biodynamic labels were pursued by winemakers for better market opportunities, social acceptance, and personal health reasons. 🚜🛒📈🏠 (a,b,c,d) Farmers expressed that social acceptance and societal pressure influenced their morale and their choices to integrate alternatives to chemical inputs. 🚜🏠 (a) Many wine producers reported going organic in view of future consumer demand. 🛒📈 (a) The annual Organic Winemakers Festival enhanced the visibility of the organic wine movement amongst consumers, wine professionals, and wine producers, an important outlet to sell organic wine, demonstrate its quality and	(a) Organic and biodynamic producers sell their wine at a higher price than they previously did. They receive the necessary support to do so, from marketing experts, oenotourisme specialists, graphic designers, local newspapers, economic advisers, etc. 🛒📈 (a,b,c) Consumers support organic production by organizing festivals and fairs, to sell and promote organic wine, and crowd-funding for initiatives that encourage organic production. 🏞️📈⏳ (a) A more in-depth market study is conducted, to determine the size of the organic market for the AOC wines, the market most appropriate consumers to target, and how/what to communicate when promoting organic and/or 0-pesticide wine, as well as the most strategic price points to target when selling the wine. 🛒📈 (d) The region *AURA*, PAC, *InterRhône* offer new subsidies and/or loans to enhance the investment capacity of wine producers who have domains that are too small or too large, to easefully make the necessary investments for converting domains to organic and/or biodynamic production. 🏞️🛒📈⏳ (c,d) Enhance opportunities for private investments that	(a) Would organic and/or biodynamic *AOC* producers manage to sell their bottles at a higher price? What is necessary for this to happen easefully? (a,b,c,d) Assessing the real difference in cost between organic and non-organic production on these hillsides per hectare, taking into account all of the many factors that transitioning to organic production entails, in order to be able to estimate the investment needs per domain, and to find investors and/or sponsors for the organic transition. (a) Conducting in-depth market research: what are consumers' perceptions of organic wine, and *AOC* wines, in France and countries where the *AOC* wines are exported ? Would it be strategic for producers to sell their wine at a higher price ? How can they enhance their communication or selling strategy?

	the added value of organic and biodynamic practices. 🛒🏞️📈🏠 (a,c,d) The HVE label, with less demanding criteria, may have somewhat incentivized farmers to reduce the use of chemical inputs, though this was not strongly confirmed in the research. *InterRhône* facilitated collective certification. 🛒📈⚙️ **	support organic transitions and production, in coordination with *InterRhône*, *AOC* unions, and individual domains. 🚜🛒📈 ** **OPPORTUNITIES CONTINUED** (c,d) Private investments sometimes occurred for the larger, more visible and world-renowned domains. 🚜🛒📈	
LOCK-INS	**OPPORTUNITIES**	**INNOVATIONS**	**RESEARCH NEEDS**
10. **A few large and interconnected institutions[26] held much of the decision-making power and resources concerning viticulture in the northern Rhône valley, which includes the Pilat Rhodanien. Their influence extended to national-level decision-making.** This could have a positive or negative effect on reducing the use of chemical inputs, depending on the norms and objectives that they advocate. At the time of research, these institutions did not use their power to **support the reduction of chemical input use:** (a) their coordination efforts did not focus on reducing chemical inputs; 🛒⏳ (b) they did not hold a strong stance on best production practices. 🛒🏠	(a,b) The Chamber of Agriculture and the *ATCR* did direct some of their efforts toward developing environmental goals and the reduction of pesticide use through technical support. 🛒⚙️	(a,b) Launch a territory-wide environmental protection initiative focused on the reduction of pesticides in viticulture by means which are co-created and approved by the wine producers, backed and co-funded by various actors such as the Pilat PNR, the *Compagnie Nationale du Rhône* (CNR), and key regional wine institutions (see footnote) 🛒🏞️📈⏳ (a,b) Influence these key institutions so that they allocate resources and efforts to promote, encourage and support sustainable production practices. 🛒🏞️📈🏠	(a,b) How much power do these regional organizations really hold in decision making on a local scale, within the *AOC* winegrowers' unions, and individual domains? (a,b) These institutions and their missions were hard to fully decipher through gray literature, and we did not interview their employees. Confirming the goals of these institutions, and how they are developing. (a,b) What would be the most effective ways to influence the agendas of these large institutions?

[26] *InterRhône*, the Rhône and Loire Chambers of Agriculture, the Wine Sector Committee (*Comité de Filière Vins*), and the *AURA* Wine Committee (*Comité Vins AURA*).

LOCK-INS	OPPORTUNITIES	INNOVATIONS	RESEARCH NEEDS
11. The economic, technical, organizational, cultural and social support around **producing *AOC* wine created a comfortable environment** and access to privileges which lead producers to uphold and perpetuate certain norms, values, mindsets, goals, imagination, know-hows, forms of organization and production practices. **Technical support was either informal or collectively organized, through a few key institutions** (*Chambre de l'agriculture du Rhône, l'ATCR*) with ties to the *AOCs*. This left little space for more marginal and experimental practices, while stabilizing and reinforcing existing production norms. This **de-incentivized some producers from stepping out of traditions and innovating towards organic or other more sustainable productions.** 🚜🏞️⏳⚙️	- Multiple interviewees expressed deep ties with the history of the domains, and profound respect for their family's work. Their commitment to the domains' viability inspired them to find solutions to cope with challenges in organic viticulture. 🚜🏠 - The support, stable demand and high prices for the wine, created a comfortable and supportive environment for winemakers to take risks and try new practices. 🛒📈⚙️ - Wine producers tried out new approaches on small parcels, to balance their fear of risk-taking with their desire to experiment. 🚜⚙️🏠	- In part, what ties AOCs together, and directs their production practices, is the imaginary surrounding wine production. To structurally alter wine production practices, and the deeper layers of what keeps production practices in place, new narratives would need to emerge. 🏞️🏠 - Expose wine producers to domains who have radically changed their production practices, for example through field trips, film screenings or public, informal discussions. 🚜🏠	- To what extent are producers, supporting institutions (*InterRhone*, governmental structures, wine shops) and individuals (consumers) ready to embrace new stories about good production, and what it entails to promote new practices? Who are the best allies to support the diffusion of these narratives, who have willpower and influence? - What are the appropriate contexts, and languages (ex. technical vs. storry-telling) to bring deeper questions on the table, about the meaning of successful production? For farmers: Would film screenings, radio shows, inspiring conversations with innovative wine producers, a graphic-novel (a popular media format in France), a collective field trip or a conference be helpful?

8.A. Discussion of the four-fold table: from socio-technical lock-ins to potential innovations

The above four-fold table presents a theoretical exploration of innovations to help address key lock-ins, with limited consideration for their implementation. Some of the lock-ins presented above need more research to consider what kinds of innovations best respond to each situation and actors' needs. Innovations vary in implementation threshold, which would be helpful to assess in selecting lock-ins to tackle, for example in terms of resource needs, collaboration possibilities and available time. Lock-ins and opportunities were both largely addressed in preceding discussion sections. The following discussion zooms in on the innovations and the further research needs proposed above.

Unlocking the lock-ins: the need for parallel design interventions

The table content highlights the need for parallel design interventions (PDI, *innovations couplées*). PDI are innovations that are designed in a coordinated way, across sectors that are usually managed independently (Jeuffroy and Meynard, 2021). These innovations are not only technological, with respect to cropping systems or food processing, but also related to organizational and institutional reform (Casagrande et al., 2022). Meynard et al. (2017) explain the necessity of developing parallel design interventions in both agricultural and agri-food sectors, so that new productions can respond to business strategies and consumer demand, while ensuring a fair price for farmers. PDI seem necessary to us given the multiplicity of factors that form lock-ins, and the links that exist among them. They rest on multi-actor collaborations, as suggested by the innovations that we propose. This echoes Jacquet et al. (2022) who call for the mobilization of vast and diverse stakeholders along the entire food value chain in the move towards zero-pesticide agricultural systems. Assessing the impact that each actor has the potential to bring to a project could be helpful for identifying synergies and fruitful opportunities for collaboration.

Our results will support the following phase of the Be Creative research project, grounded in emergent methodologies for multi-actor co-design (Jacquet et al., 2022a; Pelzer et al., 2020). These participatory initiatives may be taken as central in agroecological transition itself. This echoes the High Level Panel of Experts on Food Security and Nutrition (HLPE)'s agroecological principles, which include the co-creation of knowledge, participation, synergy, connectivity, and reducing, or eliminating dependance on outsourced inputs (2019). The research project is positioned to take on a catalyzing role in building relationships with actors in the territory towards agroecological transition, as it has been represented by Agroecology Masters students, in partnership with an employee dedicated to agroecological development at a Natural Regional Park.

Designing innovations: the role of mindset shifts and knowledge systems

Certain innovations might be harder to implement because they aim to address a greater number of systemic and pervasive issues at once. This challenge is part of getting to the roots of problems, in view of dismantling the hold of dominant, largely techno-centric strategies and narratives held by government and industry. Such narratives often underlie socio-technical regimes, revolving around notions of "sustainable intensification", efficiency and competitiveness (Ingram, 2018). Some of the innovations that we found aim to tackle such deeply embedded barriers, and revolve around encouraging mindset shifts, involving specific kinds of actors (such as technicians) or actors along the whole food value chain (from farmers to consumers).

The importance of mindset in reducing chemical input use is in line with existing literature on the subject. In long-term sociological research on the reduction of chemical inputs in French agriculture, Lamine (2017) identified that the rediscovery of meaning in their work, gaining greater autonomy (in decision making, in defining their production strategy, and in input use), and acknowledging risks associated with pesticide treatments were central in farmers undergoing processes of eliminating their use of chemical inputs. For other actor types, in our research, common influencing factors for supporting and getting involved in

pesticide reduction efforts were improving resilience in the face of climate change, biodiversity loss, and winemakers' interest in changing their practices.

Several authors conclude that mindset shifts can happen through projects revolving around knowledge-creation and/or dissemination (Geels, 2004; Ingram et al., 2015; Morgan, 2011; Smith, 2006).[27] In the viticulture of the Pilat Rhodanien, actors involved in niche dynamics had shared goals and interests. This has been found to be a good base for their willingness to learn together, experiment and create new ideas and innovative practices (Knickel et al., 2009). Findings in other studies have demonstrated that these new kinds of learning initiatives might receive limited support from "formal" (regime) knowledge systems in agriculture, because of their potential to destabilize the mainstream (Knickel et al., 2009). This is complex in the Pilat Rhodanien, given, on the one hand, the potentially helpful overlap between niche and regime and, on the other, the differences in mindset and goals that still exist amongst actors.

In studies on knowledge and innovation, Hekkert et al., (2007) concluded that developing knowledge and learning mechanisms is at the heart of innovation processes, while Smith (2006) wrote that in any innovation, lessons are generated and disseminated. In our work, we looked at knowledge dissemination of a technical kind, typically involving exchanges between farmers and technicians, sometimes (though not always) related to innovation processes. Exploring other conceptualizations and kinds of knowledge dissemination might be helpful to examine transitions that occur via innovatis !on processes. One such reading was performed by Raven et al., (2011) who, drawing from Callon's (1986) concept of 'translation', detailed how mindset shifts occur through knowledge dissemination within a network of actors.[28] These conceptualizations could be useful in understanding transition processes that may occur through participatory processes in the second phase of the Be Creative project.

9. Discussion: Interpretations, limitations and future implications

With the ambitious and complex goal of understanding influences on the use of chemical inputs, and how to reduce or eliminate them in specific production systems, we were consistently met with the question: at what cost? and to whom? What are the expected consequences on the entire agroecosystem (including human and non-human actors) of the adoption of alternatives; and how can these be better predicted, shaped, and/or mitigated ? For example, greater reliance on mechanical weeding in these vineyards on steep slopes often meant the need for more manual laborers, which winemakers solved by hiring migrant workers, a phenomena which they called 'modern slavery'. Some cases of pesticide reduction saw the possibility for higher erosion rates, and compromised water and nutrient retention. Not anticipating the

[27] According to Roling and Jiggins (1998), in the context of agriculture and food systems, knowledge systems are composed of an epistemology, a belief about the way people interact with their environment; a set of practices for agro-ecosystem management; ways of learning about agroecosystems; ways of supporting such learning; helpful institutional frameworks and actor networks; and finally, conducive policy contexts.

[28] In 'translation', actors define the problem at hand, translating previous experiences and perceived opportunities into a new expectation (*'problematisation'*). Then, they arouse other actor's interests (*'interessement'*). Expectations are then translated into operational items. Successful *interessement* involves 'enrollment', in which actors accept to take on new positions in the network, and engage in a process of experimentation and learning. The final step is 'mobilization of allies', involving knowledge dissemination amongst a wider group of niche and regime actors.

unintended consequences that may come with change in food systems is a dangerous foresight to overlook, as shown in Guthman's (2004) work on paradox in organic food standards.

Actors' perceptions of the difference between organic agriculture and an agriculture without pesticides is an important distinction that we ought to have investigated to a greater extent. From a scientific point of view, organic production should not be confused with an agriculture of zero pesticides. In France, organic means that there are no synthetic molecules in use, but it does not exclude the use of products based on "natural" substances that are active, concentrated, and potent, with potentially disturbing effects on biodiversity, including human health (Jacquet et al., 2022b). Nonetheless, we encountered a number of actors in our research who clearly associated organic agriculture with the non-use of pesticides. This difference in opinion may be due to a simple difference in definition and connotation with the terms "organic" and "pesticides"; as well as the fact that a multitude of farming models exist under the organic certification standards. Were we to have adopted a stronger political ecology lens, we might have run a discourse analysis to better understand the precise use of these terms and the claims and social impacts that actors uphold with their use.

Outside of viticulture in the Pilat Rhodanien, there were more pervasive and deeply enmeshed socio-technical lock-ins to pesticide use occurring. This was the case for the territory's fruit production, most notably modernized orchards planted for table apples.[29] In arboriculture, eliminating the use of synthetic chemical inputs meant a drastic restructuring of the farm enterprise, economically, organizationally and technically, as well as the creation of new products, markets and therefore food value chains, which followed new logics and norms (such as diversified, human-scale, peasant agriculture). Winemakers, on the other hand, saw the possibility and achieved vineyard management without the use of synthetic chemical inputs, using essentially substitution logic and alternative practices that were rather widely accepted by mainstream production norms, usually on productions certified as organic.

For the long-term viability of their domains, and to avoid dependence on mechanical weeding and/or copper and sulfur based products that are strongly tied to organic production, winemakers should consider adopting prophylactic and emergent practices associated with the niche dynamics that we identified, which show promise for vine health and robustness without chemical inputs. To deal with the lack of water and competition with weeds, the practices that we observed in the study zone included vegetative ground cover of different varieties; planting hedgerows, trees and other aromatic species amongst the vines (vitiforestry); grazing sheep during the non-growing season; planting green manure in the inter-rows; incising the soil surface; and preparing the ground before planting new vine stock. To deal with fungal disease, we observed the use of drones to spray copper and sulfur based products; applying biodynamic fertilizers; carrying affected plant matter out of parcels; using particular pruning techniques (*non-mutilante*); and consulting climate-based decision aid tools. Our findings lead us to believe that it is none of these practices alone which allow farmers to reduce or eliminate their use of synthetic chemical

[29] We conducted an equivalently in-depth study focused on arboriculture during the same research period, but do not treat the majority of the results in the present masters thesis. Our intention was to compare and contrast the two sectors in terms of influences on chemical input use and potential for change, towards agroecological transition.

inputs, but rather the enhanced and more intimate observation, involvement and contact between the winemakers and the agroecosystem of their vineyards.

Perhaps given the urgency of our research topic, the vast majority of actors whom we contacted, even in the event of extreme time pressure, carved out a time to meet with us. It is possible that our partnership with a familiar local institution, a national research institute and a nearby, well-reputed agronomy school, as well as our young age and 'foreign' origins, as many told us, helped us gain access to research opportunities. Maybe actors felt a responsibility to interview with us, given the pressing topic of our research. It is also possible that we were advised to speak with individuals who were already in favor of pesticide reduction. Still, we take it as a sign of hope that mindsets are shifting, and that even after believing in and using certain practices for decades, individuals are motivated to change. In any case, the warmth with which we were received, the many hours spent sharing stories about plants, the history of a landscape and its people, and the encouragement and hope placed in our study, leads us to believe that there are many allies in these efforts, and that the time is ripe for change.

Niche and regime overlap, promise for agroecological transition?

The classical MLP conceptualization proposes that the regime and niche are two entities that form and develop distinctly. In our thesis, we challenge this notion by exploring overlaps and interdependencies that exist between the two, which has been under-examined in the literature (Elzen et al., 2012; Vlahos et al., 2017). This is something that was particularly relevant in our case-study, and became central to our analysis, even if the niche dynamics that we identified were still perceived by some as radical, ungrounded in scientific evidence, and contrary to better-known methods of "protecting" the vineyard. Rotmans and Loordbach suggest that niches may emerge from within a regime, and not only at a micro level (2009). The overlap between niche and regime is important given that networks, norms, rules, practices and knowledge that the two share determine the interactions that exist or could develop (Ingram et al., 2015). In our research, the overlap that we witnessed between the regime and niche in viticulture of the Pilat Rhodanien may help facilitate the scaling-out of emergent practices and strategies for vineyard care that were not adopted by the majority of winemakers loyal to the socio-technical regime.

Further research needs to meet political ecology goals

By integrating a political ecology lens in our analysis, we sought to address power relations influencing the use of chemical inputs. For foundational sociologist Callon (1984), understanding power relations means "describing the way in which actors are defined, associated and simultaneously obliged to remain faithful to their alliances". It is what "permits an explanation of how a few obtain the right to express and represent the many silent actors of the social and natural words they have mobilized". Based on the first quote, we managed to explore power amongst actors whom we interviewed, and associated institutions, through the use of socio-technical systems theory. However, looking at the second quote, we believe that our analysis could have gained from a more in-depth account of 'silent actors'.

Our interviewee selection was performed with research partners at the Pilat PNR, two ISARA supervisors, and the snowball method. As illustrated in the interest/impact analysis this led us to focus on particularly influential actors, who are in the position to mobilize resources, and represent others, considered as 'experts'. We did not challenge these recommendations: these were often actors that were representatives, coordinators, or individuals sought after for their knowledge on viticulture, and who were in contact with large numbers of farmers. They helped us gain access to relevant information. However, in taking for granted the 'expertise' of these actors, we did not sufficiently seek out, give voice to, nor account for farm workers (seasonal or salaried) and other less influential individuals in these production systems. We also did not significantly, at least explicitly, integrate the perspective of non-human actors. Political and economic systems are shown to be underpinned and affected by the non-human actors with which they are intertwined (Robbins, 2020). Non-human actors could include other species living in the agroecosystems of study, as well as non-living entities (such as technologies) that play a role in structuring actors' decisions and the practices that they hold. Other important groups of actors which we left out of our study were the 10% of producers who do not produce wine under the *AOC* structures, as well as grape producers who do not vinify their grapes (which is a minority, and perhaps overlaps with the non-*AOC* producers).

It was not a quick process to analyze our data and gain a sense of the regime and niche dynamics. We were thus not able to get deeper insight into key features of these networks as defined in political ecology. One of these features would be decision making power in the governance structures of different institutions that frame mainstream wine production. More research needs to be done on who is (and is not) represented and included in decision making; where and at what scale decisions are made; how power relations influence regime dynamics and the prospects for niche innovations; and what checks are in place to qualitatively evaluate the representativeness and fairness of potential transition processes (Lawhon and Murphy, 2012).

Multi-level perspective analysis using the territorial scale: opportunities, challenges and limitations

The theoretical framework and ethnographic methods used in our study enabled a focus on the phenomena specific to a territory, including the relationships amongst actors, to uncover socio-technical regime and niche dynamics. We gained perspective on landscape-level pressures via academic and gray literature and looked at trends in the local and national wine-market to take into account the food value-chain. Still, a deeper inquiry into landscape pressures in the context of pesticides and related topics (such as land use, transmission of farm ownership, and policy and market trends at the national or EU levels) would have enriched our understanding of chemical input use in the Pilat Rhodanien, as well as the agency of territory-related actors. It might have also deepened our grasp of the extent to which actions led at the territorial level can feasibly promote agricultural and food systems transitions, and what changes rely on actions at broader scales. Collaborations with actors involved at the regional scale, in other territories, or at the level of the food value chain, could be helpful to tackle challenges that are beyond the scope of Pilat Rhodanien actors alone.

These research limitations highlight an assumption found within the Be Creative research project itself: that the barriers and opportunities to reduce chemical input use at the territorial scale can be understood via the study of the territory, and addressed via targeted actions. In a highly centralized country such as France, in which agriculture is regulated at both the national and European level, the extent to which this is a viable strategy is questionable. The focus on the territorial scale may have led us to exclude a more in-depth analysis of the impact of 'landscape elements' as defined in MLP.

To analyze consumption trends in the study zone, we conducted a survey of a group of consumers, mostly local to the Pilat Rhodanien or in the not so distant surroundings. Our findings show a limited view into the social landscape of the territory since these consumers held a strong bias towards organic and local consumption. The role of this group of actors as part of the socio-technical systems network, though, inspires hope when considering the promise of coordinated civil-society efforts for food systems transition (Feyereisen and Stassart, 2017; Marcq et al., 2015; Pleyers, 2013). More data is needed to fully comprehend barriers and opportunities linked to consumers' habits, perceptions of organic wine, and their potential role in food and agricultural transition to support low to no pesticide systems.

10. Conclusion

Our research focused on the role of social networks, norms, values, knowledge systems and practices involved in maintaining the historic, familial and deeply-embedded winemaking enterprises in this landscape characterized by prestigious *terroir* and significant (though decreasing) reliance on chemical inputs. We identified actors in these social networks who play diverse roles in the territory related to chemical input use and reduction. It was necessary to conduct a multi-scalar analysis, looking at the parcel, farm, food value chain and territory, to characterize the complex socio-technical lock-ins to pesticide use. The regime that we identified was tied to specific geographical locations and protected labels anchored within the Pilat Rhodanien territory. This area formed the study-zone, making the analysis of the territorial scale especially relevant. This echoes Vlahos et al. (2017), who found that applying the MLP at a limited scale was appropriate when looking at a spatially dependent regime. The "territory" creates boundaries, fostering the proximity of a diverse range of actor types, the regularity of their interactions, and depth of relations. The territory is a space for the meeting and intertwining of political, economic and social structures from the local to regional level. Even so, too strong an emphasis on territories and local politics may leave out the consideration of narratives held and actions taken at broader levels (national and international).

Existing studies have shown that the entire territory of the Pilat (defined geographically by the Park's boundaries) has already been considered to hold promise for agroecological transition processes to occur (Brochet et al., 2015; Clément et al., 2019; Couturier-Boiton, 2009; Vandenbroucke et al., 2017). This is especially true if comparing the Pilat to other regions of France that remain highly specialized in their agricultural production systems, and have strong industry-level socio-technical lock-ins, such as Brittany and Champagne (Meynard et al., 2018). Social dynamics in the Pilat also make it well suited for agroecological transition, notably the presence of well-connected, informal actor networks, as well as active formal structures exploring agroecology, such as farmers collectives coordinated by the PNR (Dargazanli, 2019), as well as non-profit organizations and collective multi-sector food and farming

initiatives. The proximity to significant consumer groups in surrounding urban centers is also a comfort to farmers seeking to diversify their productions and experiment with new products and marketing.

Crafting a historical perspective was helpful to contextualize viticulture in the Pilat Rhodanien within the wider history of socio-technical trajectories. Looking at recent evolution in the sector informed our understanding of what was driving chemical input use at the time of research. We wonder what the effects were, and continue to be, of the near abandonment of the vineyards during the 20th century, followed by the resurgence under a brand new production logic anchored in the use of pesticides. How did this evolution transform the traditions, knowledge, know-hows, tools, and modes of organization built over the centuries preceding it? To what extent did this temporal gap in land-use affect farmers' knowledge of the land, ecosystems health and how to best work within the agroecosystem, including in the context of unprecedented climate change? Investigating the answers to these questions may serve as a fruitful basis in the design of innovation processes.

The wicked problems that contribute to pesticide lock-ins take root in numerous settings, one being the complex and opaque relations between chemical companies and agricultural politics. Farmers are commonly faced with a double standard, simultaneously placed as victims to these complex political relations, and also blamed for the use of chemical inputs. It is a gross simplification to place both so little or so much responsibility on farmers, and a misnomer to say that they alone are dependent on pesticides. We observed that it is entire food value chains, from field to plate (or wine glass), that rely on the mechanisms of control and homogenization that synthetic chemical inputs offer. Lamine (2017) described this as the current agri-food systems' "perpetual desire to reduce product variability, through calibration, quality criteria, industrial processing, etc." An 'agroecological' agri-food system might instead embrace diversity, and even make diversity productive (Bell et al., 2008). In experiments with Agroecological Crop Protection (ACP; Deguine et al., 2021), a significant decrease in the use of pesticides occured not as an "objective" but rather as a positive side-effect of the establishment of healthy agroecosystems (Deguine et al., 2015). This kind of holistic approach can support agroecological transition because it creates conditions conducive to long-term, significant change processes that reconfigure the essential elements and connections within agriculture and food systems (Anderson et al., 2019; IPES-Food, 2016).

Agroecological principles emphasize the importance of decreasing reliance on inputs and their substitutions (Wezel et al., 2020; HLPE, 2019). Simply changing agronomic practices should not be the only indication that an agroecological transition is occurring. The reduction of chemical inputs, by way of innovation processes that dismantle powerful socio-technical lock-ins, reorganizes relationships across multiple scales. While this presents an enormous challenge, it may also lead to a host of opportunities that enhance existing production and distribution systems, in social, technical, ecological, and economic ways. To forecast the next phase of the Be Creative research project, we proposed potential innovation processes that may further help reduce and/or eliminate pesticide use in the vineyards of the Pilat Rhodanien. Many of these rest on multi-actor collaborations, as well as diversifying current and future winemakers' access to knowledge exchange opportunities and possibilities for collaboration. We see great potential for the establishment of healthy agroecosystems in and surrounding the vineyards of the Pilat Rhodanien, where a significant reduction in pesticide use occurs as a positive outcome of coordinated efforts.

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Appendices

A. Data collection protocol

1. Presentation of the project and our study

- Agroecology Masters students (Anna Hirson-Sagalyn and Lucy Zwigard) at the Norwegian University of Life Sciences.
- We're working as a pair within a research project named Be Creative, coordinated by INRAE, started in 2021, and carried out on 10 territories in France.
- We began our internship in February 2022, focusing on viticulture and arboriculture in the Pilat Rhodanien.
- Under the supervision of professor-researchers at ISARA: Hélène Brives and Florian Celette.
- In partnership with the PNR du Pilat: Caroline Champailler and Michel Jabrin
- Research question: to understand what influences the use or non-use of chemical inputs.
- Looking at technical, organizational, economic, social factors, as barriers and opportunities to change in chemical input use.
- Interest in exploring how farmers could organize themselves to collectively reduce the use of chemical inputs, based on the notion of the importance of the "territorial scale".
- The final objective of the project is to find solutions and support the actors of the territory in order to significantly reduce (or eliminate) the use of chemical inputs, while maintaining and promoting the performance of the farms and the entire food sectors.

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2. Key definitions and terms for the research questions

What are the socio-technical systems* involved in the implementation of key technologies** for plant protection, and what characterizes them***?

*Socio-technical system: a stable network of actors, characterized by common practices, knowledge, technologies, collective representations, norms and rules (Geels 2004). It is configured by the innovations that have been disseminated, and selectively supports the practices and artifacts that are consistent with its functioning. Thus, we observe the effects of increasing returns to adoption because the more a technology is adopted, the more attractive and efficient it becomes (network effects, learning effects, economies of scale, collective representations, synergies with other technologies) (Casagrande et al. 2022).

**Key technologies chosen for the research in viticulture

- Access to an appropriate tool to perform mechanical work on steep slopes (which may not exist on the market).
- Ground cover as alternative to chemical herbicides: mulching (hay, wood chips), ground vegetation (low water-competing plants, such as succulents).

Technologies: the combination of the (i) agricultural techniques, (ii) material artifacts, and (iii) knowledge and skills necessary to achieve a certain objective (Casagrande et al. 2022).

***To characterize the socio-technical systems:

- Networks of actors, including influences amongst them such as decision making, knowledge sharing, and financial capacity;
- Norms and rules;
- Practices and technologies employed;
- Knowledge, skills and expertise;
- Relationship to the key existing technologies for plant protection (that we focused on in the semi-directive interviews), including opinions and controversial perspectives.

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3. Data collection objectives for the exploratory interviews:

The role(s) of the actor, as well as the role(s) of the structure to which they belong, within agriculture of the Pilat, and particularly the viticulture sector of the Pilat Rhodanien:

i. What influences and interests do they have in the evolution of the food value chain, particularly with regard to the use of chemical inputs?
ii. How do they perceive the use of chemical inputs, and the products for which chemical inputs have been used?
iii. Who and what influences their work and choices? In what way, to what extent?
iv. If relevant: What they know about viticulture (production, sector, territory):
    1. Particularly concerning the current, main challenges in the sector.
    2. The use of chemical inputs in grapevine production: evolution, and what currently influences or could influence their use (rates of treatment, types of products).
    3. Why the use of chemical inputs? To solve what problems? Are there other solutions? What makes it difficult to do without them?

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4. Exploratory interview guide:

Nature, positionnement, rôle de l'acteur + système socio-technique

- Pouvez-vous nous présenter votre activité au sein de …?
    - *Follow up sur des points intéressants, notamment sur arbo / viti*
- Avec qui, quels partenaires, êtes vous amené à travailler dans vos missions de … (ex. *Développement de l'agriculture sur le territoire)* ? par exemple, en ce qui concerne l'entretien des sols // la biodiversité // la transmission du foncier ?
    - De quelle manière, et à quelle fréquence ?
    - *Si utile :* quotidiennement, de manière hebdomadaire, mensuelle, annuelle ?

En viticulture :

- Quels sont d'après vous les enjeux principaux pour les viticulteurs du Pilat rhodanien aujourd'hui ?
- La réduction des PPs en viti, est-ce un enjeu sur lequel vous et/ou d'autres personnes au sein de … travaillez ? Est-ce une priorité?

    - Si c'est le cas : Quelles sont vos principales stratégies ?
    - Avec qui travaillez-vous au sein de ces initiatives ?
- Quand vous conseillez les agriculteurs sur leurs enjeux, dans quelle mesure est-ce que vous parlez des produits phytos ?

Perception de l'utilisation des PPs et ce qui influence ou pourrait influencer leur taux d'utilisation

- Quels sont, d'après-vous, les facteurs qui influencent l'utilisation ou non des PPs?
    - Les facteurs peuvent être techniques, sociales, organisationnelles, économiques, politiques, psychologiques…
- Quels sont les facteurs qui d'après-vous, **actuellement,** contribuent à leur réduction voir leur élimination ?
- Quels sont les facteurs qui **pourraient** contribuer à leur réduction voire leur élimination ?

❄ **Boule de neige:** Avec qui, d'après-vous, devrions nous aussi nous entretenir pour en apprendre plus sur la situation viti aujourd'hui dans le Pilat Rhodanien, et sur l'utilisation des PPs dans ces filières ?
Seriez-vous en mesure de nous passer leurs contact, voir de nous mettre en contact avec eux ?

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5. Data collection objectives for the semi-directive interviews:

In addition to the objectives above for the exploratory interviews, the semi-directive interviews aim to collect data to help answer the following questions:

- What are the socio-technical systems that frame chemical input use in the Pilat Rhodanien ?
- What characterizes these socio-technical systems ?
- What are the barriers and opportunities to reducing or eliminating the use of chemical inputs in the viticulture of the Pilat Rhodanien ?
- Do/could key technologies ((i) access to an appropriate tool to work on steep slopes, (ii) mulching and ground vegetation) enable reducing the use of chemical inputs, and for what reasons ?
- What are the necessary changes for lowering/eliminating the use of chemical inputs ?
- What enables or hinders these changes to take place ?

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6. Semi-directive interview guides

I. For winemakers:

DESCRIPTION DE VOTRE ACTIVITÉ en tant que *producteur*

- AOC/IGP/VdP // cépages
- Surface totale
- Surface en bio : conversion en cours, où labellisé depuis quand ?
- Espaces non-cultivés ou non-traitée
- Nombre de personnes employées
- **Mode(s) de vente ?**
- **Enjeux principaux** aujourd'hui ?
    - Comment abordez-vous le problème du manque de **main d'œuvre** ?

DESCRIPTION DE VOTRE ACTIVITÉ en tant que *directeur / coordinateur / président* etc.

- **Rôle**, responsabilités, missions : consistent en quoi ?

- **Qu'est-ce qui vous inspire** à prendre ce rôle au sein de …

ORGANISATIONS // RÉSEAUX

- **De quel(s) réseaux faites-vous partie ?** Mise en vente // Échange // Partage de matériel // etc.
    - Quel est votre rôle dans ces réseaux? Responsabilités ?
    - Quel rôle ces réseaux / organisations jouent-ils pour vous ?
- **Initiatives** (dans vos réseaux) **en lien avec la réduction des phytos** ?

INFORMATION

- **Échange(s) sur les pratiques** : comment, avec qui, de quelle manière, dans quel contexte ?
- Comment vous **informez-vous** sur les meilleures **pratiques de protection des cultures ?** (lectures, visites d'exploitation etc).
- Adhérez-vous à / tenez-vous des parcelles de référence pour un **bulletin de santé végétal // bulletin phyto** ?
- Utilisez-vous des outils d'aide à la décision ? Si oui, lequel(s) ?

STRATÉGIES / ÉVOLUTION DE L'ENTRETIEN DU SOL

(1) DANS **l'INTER-RANG:**

a. Quelles **stratégie(s)** employez-vous actuellement pour **l'entretien de l'inter-rang ?**
    - **Désherbage chimique** ?
    - **Travail mécanique** ? Si oui, **quels outils** ? **TR**
        - Pioche, treuil, cheval…
        - Comment trouvez-vous **la main d'œuvre ?**
    - **Enherbement** spontané // semé ?
    - **Entretien du sol avec couverture** : paillage, couverts végétaux (quelles espèces ?), pelouse sèche, plantes grasses, enherbement spontané / semé ? **TR**
    - **Approches prophylactiques ?** ex. Pâturage des moutons

(2) SOUS LES **RANGS** :

a. Quelles **stratégie(s)** employez-vous actuellement **pour l'entretien du sol ?**
    - **Désherbage chimique** ?
    - **Travail mécanique** ? Si oui, quels outils ? **TR**
        - Pioche, treuil…
    - **Entretien du sol avec couverture** Paillage, couverts végétaux (quelles espèces ?), pelouse sèche, plantes grasses, enherbement spontané / semé ? **TR**
    - **Que pensez-vous de [telle pratique]** ? A**vec qui échangez-vous** sur / **pratiquez-vous ces tech** ?**TR**
    - **Approches prophylactique ?**

(3) **ÉVOLUTION** de l'entretien du sol

- Au cours des années, de quelle manière avez-vous fait évoluer vos pratiques ?
- Qu'est ce **qui vous a motivé à les faire évoluer ainsi ?**
- **Comment souhaitez-vous** les faire évoluer davantage ?
    - Que pensez-vous de la perspective de produire sans aucun PPs ?
- En ce qui concerne **les pratiques qui permettent de diminuer l'utilisation des PPs** :
    - Qu'est-ce qui **favorise** la diminution de l'usage des PPs ?
    - Qu'est-ce qui **bloque** // **de quoi auriez-vous besoin** ?

- **Quel type de soutien actuellemen**t // **Soutien non reçu et souhait**é pour améliorer la protection des cultures, ex. intégrer des nouveaux cahiers des charges ?

CONVERSION À L'AB ?

- **Comment s'est passé / se passe** le passage au bio ?
- **Quels sont les défis principaux** (techniques, organisationnel, économique…) auxquels vous faites / avez fait face dans la transition ?
- Avez-vous vu faire évoluer les pratique d'autres **autour de vous, voir des voisins** ? **Qu'est-ce qui a motivé** ces transition d'après vous / ce qui vous parait compliqué ?

(s'il faut rebondir sur les TR pour aborder ces sujets:

Viticulture : tech révélatrices (**croyez-vous en ces solutions ?** Les pratiquez-vous // comptez-vous les pratiquer ? // **avec qui échangez-vous** sur / pratique-vous ces tech ?) :

1. **Accès à un outil adapté aux sols en pente** (qui n'existe peut-être pas sur le marché)
2. **Entretien du sol avec couverture** (paillage, couverts végétaux, pelouse sèche, plantes grasses, enherbement spontané / semé)
3. **Technique et approche pour la conduite et/ou la protection des vignes sans aucun phyto** (y compris, phytos autorisés en bio -- soufre et cuivre) // Débouchés pour les vins sans aucun phyto)

❄ **Boule de neige**

II. For technical support and socio-political actors:

Nature, positionnement, rôle de l'acteur + système SST

- Pouvez-vous nous présenter votre activité en tant que (conseillère ; gérant ; chargée de…)
- **Lien avec les vitis du Pilat rhodanien actuellement ? Potentiel, dans le futur ?**
    - Grace à … qu'on a votre contacte. **En lien avec quels autres agri et acteurs du Pilat ? Notamment en ce qui concerne les drones ?**

Situation actuelle observée dans la la protection des cultures en viti, dans la région, ce qui influence actuellement l'utilisation des PPs, et ce qui pourrait aider à diminuer leur taux d'utilisation

- Quels sont d'après vous les **enjeux principaux pour les viticulteurs des côtes du rhône Septentrionales** aujourd'hui ?

Produits phytos

- Quels sont, d'après-vous, **les facteurs qui influencent l'utilisation des PPs**?
    - facteurs techniques, sociaux, organisationnels, économiques, politiques…
- Quels sont les facteurs qui d'après-vous, **actuellement,** contribuent à leur réduction voir leur élimination ?
- Quels sont les facteurs qui **pourraient** contribuer à leur réduction voire leur élimination ?

- **Quelles sont vos stratégies, en tant que (conseillère ; gérant ; chargée de…), pour favoriser la réduction des PPs spécifiquement?**
    - **Avec qui travaillez-vous au sein de ces initiatives ?**

Stratégie de protection des cultures

- **Méthodes prophylactiques pour la protection des vignes que vous observez ? // que vous encouragez ?**

- Quelles stratégies observez-vous pour le **désherbage sur le rang ?**
- Quelles stratégies observez-vous pour assurer:
    - la protection des vignes contre les pression fongiques ?
    - un apport suffisant en eau aux plantes ? (désherbage, couverture du sol, sens des plantations)
        - Stratégies pour faire face à **la concurrence en eau** par les adventices ?
    - la protection des vignes contre les **bioagresseurs** qui posent le plus de problème ?

Baguette magique → comment envisagez-vous l'évolution idéale des vignobles des Côtes du Rhône Septentrionales ? // Rôle du projet, Be Creative ?
Boule de neige, pour le futur du projet ? "Territoire zéro phyto"

For market actors:

<u>Description de votre activité en tant que commerçant.e</u>

- Pouvez-vous nous présenter succinctement votre activité // la structure dans laquelle vous travaillez ?
- Pouvez-vous nous présenter les produits du Pilat rhodanien que vous vendez?

<u>Organisations// Réseaux</u>

- Pouvez-vous nous donner une idée des partenaires de l'amont avec lesquels vous travaillez (producteurs, coopératives, distributeurs, etc.) ?
    - Depuis quand avez-vous acheté des produits de …
    - Dans quelle mesure travaillez-vous avec …
- Quelles démarches faites-vous auprès des agriculteurs pour orienter les pratiques et les qualités des produits que vous vendez ?
    - *Par exemple, les cahiers des charges ?*
    - Quelles demandes leur faites-vous ? / Quelles demandes vous-ont ils fait ?

<u>Mise en marché</u>

- Comment sélectionnez-vous les produits que vous vendez ?
    - Comment percevez-vous les souhaits, les critères gustatifs de vos clients ?
    - Communiquez-vous ces critères aux producteurs desquels vous achetez des fruits / des vins ? Si oui, comment ?

<u>Perspective sur les influences sur l'utilisation des produits phytos de synthèse</u>

- Selon vous, quel est le rôle des commercant.es en ce qui concerne l'utilisation des intrants chimiques en agriculture ?
- D'après vous, est-ce qu'il y a la place sur le marché *pour plus de fruits bio ? pour plus de vin bio ?*
- Comment décrivez-vous la demande actuelle pour les produits bios et locaux (frais/transformés), et comment a-t-elle évolué (sur les 5-10 dernières années) ?
- Quels avantages et quels inconvénients, pour vous, y a-t-il dans la vente des fruits bios/produits transformés bios? *(transport des produits, des fournisseurs, de stockage etc).*
- Souhaitez-vous augmenter la vente de produits bios/locaux, et si oui, quelles en sont les raisons ?
- Avez-vous fait et/ou planifiez vous de faire des démarches pour encourager la demande ? Si oui, pouvez-vous nous les décrire ?

B. Questionnaire for consumers “From field to plate” (*Du champ à l’assiette)*

Questionnaire : Du champ à l’assiette ☼ *Projet de recherche ‘Be Creative’ dans le Pilat*

1. **Où faites-vous vos courses ?**
   Cochez une ou plusieurs réponse(s) :
   - ☐ Supermarchés grandes surfaces (ex : Carrefour, InterMarché, E. Leclerc…)
   - ☐ Au marché
   - ☐ Vente directe, à la ferme
   - ☐ Magasin de producteur
   - ☐ Magasin bio, indépendant (ex : Panier du Pilat)
   - ☐ Magasin bio, chaîne (ex : BioCoop, Naturalia…)
   - Autre(s) : _____

2. **Êtes-vous client.e des fermes locales ou des magasins de producteurs?**
   Cochez une seule réponse :
   - ☐ Non
   - ☐ Oui, une ou deux fois par an
   - ☐ Oui, une ou deux fois par mois
   - ☐ Oui, une ou deux fois par semaine

3. **Achetez-vous des produits issus de l’agriculture biologique ?**
   Cochez une seule réponse :
   - ☐ Non
   - ☐ Oui, une ou deux fois par an
   - ☐ Oui, une ou deux fois par mois
   - ☐ Oui, une ou deux fois par semaine
   - ☐ Oui, uniquement

4. **Quels produits privilégiez-vous en termes d’agriculture bio ?**
   Cochez une ou plusieurs réponse(s) :
   - ☐ Produits laitiers
   - ☐ Viande
   - ☐ Légumes
   - ☐ Fruits
   - ☐ Céréales
   - ☐ Vin
   - Autre(s) : _____

5. *Si vous buvez du vin* : **Boire du vin bio, est-ce une priorité pour vous ?**
   - ☐ Non
   - ☐ Moyennement
   - ☐ Oui

6. **Manger des fruits bio, est-ce une priorité pour vous ?**
   - □ Non
   - □ Moyennement
   - □ Oui

7. **Faites-vous quelque chose pour réduire l'utilisation des pesticides ?**
   - □ Oui
   - □ Non

Si oui, décrivez : _____

8. **Pensez-vous que les consommateurs ont un rôle à jouer dans la diminution de l'utilisation des pesticides ?**
   - □ Non
   - □ Moyennement
   - □ Oui
   - □ Pas sûr

Décrivez : _____

9. **D'après vous, qui a le pouvoir de faire évoluer les pratiques agricoles?**
   Notez 1-8 par ordre d'importance (1 le plus de pouvoir, 8 le moins de pouvoir)
   - _____ Les agriculteurs
   - _____ Les supermarchés, grossistes, distributeurs
   - _____ Les consommateurs
   - _____ Les fournisseurs de matériaux et/ou intrants
   - _____ Les Chambres d'Agriculture
   - _____ Les associations
   - _____ Le gouvernement
   - _____ Les politiques locales (ex : Communautés de communes, Parcs)

   Autre(s) : _____

Merci ! ☺

C. Complete list of interviews and participatory observations, for the domains of activity: production and technology and support (1/3).

Domain of activity	Exp	S-D	Production (22 interviews, 2 OP) Actors involved in agricultural production	Exp	S-D	Technology and support (13 interviews, 5 OP) Actors involved in: (i) development and dissemination of knowledge (ii) provision of inputs, equipment and services (iii) conservation, selection, evaluation and dissemination of genetic resources
Exploratory interviews (Exp) and semi-directive interviews (S-D) **51 total**	3 6 3	5 4	• with 16 fruit producers • with 10 wine producers • with 11 farmers of other productions (livestock, grains, eggs, medicinal plants) • Producers' cooperatives (*Coop des Balcons, Sicoly, SARL Vergers Lyonnais, AOP winegrowers' unions: Côte-Rôtie, Condrieu, St-Joseph; Winegrowers' union of Chavanay)*	1 1 1	3 1 3 3	• Agricultural advisors and technicians (*Chamber of ag. Isère, Loire, Rhône and Savoie*) • Actors and organizations offering training and events (*ARDAB, ADDEAR*) • Coordinators of farmers' collective , ex.GIEE/DEPHY/30 000 (*ATCR, Oxyane, Maison Cholat, Chamber of ag Ardèche*) • Suppliers of agricultural equipment and inputs (*NaturaGriff, Sothextho, Oxyane*)
	12	**9**		**3**	**10**	
Participant observation **25 total**	• Weeding / hoeing session in the vines at *Domaine des Amphores* • Bi-weekly volunteering on organic vegetable and fruit farm (*Le potager d'Olivier*) • Attendance and group-interview at Economic and environemntal interest group (GIEE) PILATS farmers collective on soil health, with 7 grain growers and livestock keepers			• (3) Half-day events and field-days with ARDAB : - *Orchards low in chemical inputs*, presentation of results of Groupe 30 000, visit of orchards and new processing facility (*EARL des Pommières)* - Tractor and equipment demo for orchard weed management (*EARL Benitier des Oiseaux)* - Field meeting on apple tree care and protection with technician from Chamber of ag. Savoie (*EARL des Eminées)* • *Café-Agro* and co-design workshop on promoting diversified orchards (*Gothéron*, experimental site of INRA) • Networking meeting and workshop for coordiantors of farmers' collective working on pesticide use (*DRAAF AURA, Quali-EAuRA, Chambe of ag. Drôme, Ardèche, Isère ; Oxyane, Maison Cholat)*		
	2			**5**		

C. Complete list of interviews and participatory observations, for the domains of activity: civil-society and socio-political (2/3).

Domain of activity	Exp	S-D	Civil-society (2 interviews, 7 OP) Actors involved in the communication, valorization and consumption of agricultural products	Exp	S-D	Socio-politique (9 interviews, 4 OP) Actors involved in the elaboration and implementation of public policies and standards that affect agricultural production (regulation, financing, certification) and food
Exploratory interviews (Exp) and semi-directive interviews (S-D) **51 total**	1 1		• (8) Members of a local non-profit that promotes organic food (*Vent de bio)* • Director of association for the promotion of organic agriculture (*ARDAB)*	1 2	4 2	• Territorial resource management specialists (*inter-municipalities of Pilat Rhodanien, Vienne-Condrieu, Loire-sur-Rhône; Strategic Fruit Committee; DRAAF AURA; ARRAA*) • Activists (*Secrets Toxiques ; Génération Futures*) • Non-profits and associations (*Coordinateur Quali-EAuRA ; President of FNAB*)
	2	-		**3**	**6**	
Participant observation **25 total**	• Participatory theater piece on passing down farms to the next generation (*ADDEAR 42)* • (2) Participatory workshops on citizen concerns with *EXAECO* collective intelligence agency, for the inhabitants of Pélussin • Salon *Primevère Alter-écologie,* ecological industries fair • Film screening of *Goliath,* docu-drama on pesticide lobbies, followed by public discussion and apero • 2nd annual Nature Festival, *Fête de la Nature* in Pélussin: preparation meetings and facilitation of a stand amongst *Terre de Liens, Colibris, Vayrana, Robin des bois, Mairie de Pélussin, Vent de Bio, ADDEAR)* • General assembly of *ADDEAR 42,* peasant agriculture non-profit			• *Interfel* conference, *How to reconcile citizen expectations and challenges in the fresh fruit and vegetable industry* • Meeting with members of the Strategic Fruit Committee, for their industry plan 2023-2026 (*DRAAF, Région AURA)* • Meeting organized by Parc du Pilat with diverse agricultural actors in the territory, on agro-environmental measures • *Café Parc*, meeting with 50+ territorial stakeholders on the revision of the Charter of the Parc du Pilat		
	7			**4**		

C. Complete list of interviews and participatory observations, for the domains of activity: market and Be Creative Pilat (3/3).

Domain of activity	Exp	S-D	Market (5 interviews) Actors involved in packaging, transport, processing, marketing, distribution of products	Be Creative Pilat (3 interviews, 2 OP) Actors involved in running the Be Creative research project in the Pilat Rhodanien, during the WP1 phase and/or throughout
Exploratory interviews (Exp) and semi-directive interviews (S-D) 51 total	1 1	2 1	• Cooperative directors (*Coop des Balcons du Mont Pilat, SARL Vergers Lyonnais*) • Vendor of local products (*Gastronovrak)* • Manager of wholesale marketplace (*Marché de gros Lyon-Cor*bas)	• Landscape tour and reading with agriculture evaluation officer at Parc du Pilat • (2) Meetings to capture data on arboriculture and viticulture in the Pilat Rhoranien with agroecology offider at Parc du Pilat • Weekly meetings and/or work sessions with ISARA supervisors and agroecology officer at Parc du Pilat
	2	**3**		
Participant observation 25 total	• Saturday and Sunday weekly markets in Pélussin • Organic on-farm producers' market (*Ferme des Clarines*) • Monthly meeting with organizers of local organic food fair *(Vent de Bio)* • 8th annual Organic Winemakers Festival of the AURA region • 93rd annual Wine market of *Ampuis* • Salon *Sirha Green*, for responsible food service, catering, and food business profes*sionals*			• (2) Monthly team meetings with all employees at the Pilat Natural Regional Park
			6	**2**

D. Existing practices, technologies and activities in the Pilat Rhodanien or nearby territories with potential for reducing chemical input use.

In bold are the key existing technologies (KET) which we investigated further in the semi-directive phase.

Categories	Arboriculture	Viticulture	Multi-sector
Commercialization	• **Approaches for value-added processing and sales** (including Sales of "ugly" fruit) • Mobile processing workshops	• "Zero-pesticide" wine brands (ex. *Oé vins*) • Oénotourism	• Environmental quality labels (ex. organic, biodynamic, HVE)
Collaboration	• Investments made for new orchard plantations by processing companies (ex. baby food, *Blédina*) • "Agroecological" contract specifications with supermarkets (ex. *Carrefour*) • Collective processing centers	• Collective certification for *HVE* label via *InterRhône* • Organic Winemakers' Festival • Local winegrowers' unions	• Coordinated farmer collectives to reduce chemical input use (ex. *Groupe 30,000, DEPHY, GIEE)* • Studies and coordination for the protection of potable water quality
Regulation	• "Bee safe" products • Laws limiting or restricting treatments during flowering and pollination periods	• Re-authorizing spraying via airway for the use of drones	• Zero-pesticide municipal charters
Climatic			• Weather stations (individual or collective, ex. *Weenat*) • Decision-aid tools (ex. *RimPro*)
Technical, agronomic	• **Conservation biological control** • Mechanical tools for orchard soil tillage (ex. *Intercep)* • Knocking branches with batons to fell insects • **Varietal selection, resistant varieties** • Protective anti-insect predator nets (ex. *AltoCarpo)* • Prophylactic measures (ex. collecting and removing leaves after harvest season)	• Prophylactic measures (ex. trellising, aeration, non-mutilative pruning, removal of problematic vegetation) • **Access to tools for mechanical tillage of hillsides** (ex. *Intercep*, horse-traction, treuil, or not on the market) • Spraying via drones • **Soil maintenance with ground cover** (mulching, vegetative cover, spontaneous or sown grass, green manure) • Biodynamic certification, practices and preparations	• Methods of biocontrol (ex. sexual confusion, virus introduction) • Vegetative ground cover and/or mulching • Organic authorized plant protection products (ex. copper/sulfur based; neem oil; kaolin clay) • Natural plant preparations (ex. nettle, comfrey, horsetail slurries and compost teas)
Restructuration	• **Diversification of varieties and/or species within the orchard** • Small parcels of orchard within new, diversified farms	• Replanting vines for mechanical work • New grape varieties (ex. resistant to fungal outbreaks) • Vitiforestry	• Grazing animals (ex. chickens in orchards, sheep in vineyards) • Developing agroecological infrastructures (ex. hedgerows, marshes)

E. Consent sheet and project description for participants

Fiche de consentement pour participer au projet de recherche Be Creative

À propos du projet

Vous êtes invité à participer à la première phase d'un **projet de recherche nommé Be-Creative** initié début 2021 et qui durera 6 ans. Le projet prend place sur 10 territoires français, notre étude se focalisant sur le Pilat rhodanien. L'objet principal du projet est de **comprendre ce qui influence l'utilisation ou non des intrants chimiques.** L'objectif final est de **trouver des solutions et d'accompagner les acteurs du territoire pour réduire l'utilisation des intrants chimiques, tout en favorisant la performance des exploitations et des filières**. L'étude à laquelle vous participez (février 2022 à août 2022) sera effectuée par les co-chercheuses, Anna Hirson-Sagalyn et Lucy Zwigard, étudiantes à NMBU (l'université norvégienne des sciences de la vie) sous la tutelle d'Hélène Brives et Florian Celette, enseignants chercheurs à l'Isara Lyon, et en partenariat avec le PNR (Parc naturel régional) du Pilat.

Avantages de la participation

Vous avez été identifié(e) comme participant(e) sur la base de vos connaissances concernant les systèmes agricoles et/ou alimentaires du Pilat. En participant à cette recherche, **vous contribuez à une meilleure compréhension de l'état actuel et de l'évolution de différentes filières en vue de la diminution de l'utilisation des intrants chimiques** dans le Pilat rhodanien.

Ce que nous ferons des informations collectées

Les informations recueillies seront utilisées pour rédiger et soutenir un **mémoire de master en anglais** qui sera disponible sur l'archive en accès libre *Brage* (nmbu.brage.unit.no). Les **données** seront **anonymisées avant d'être publiées. Un rapport pour le PNR du Pilat sera également produit.** Si vous consentez à l'utilisation des données récoltées lors de nos entretiens, **votre identité sera visible aux chercheurs de Be Creative et à l'équipe de PNR du Pilat collaborant au projet.** Les notes d'entretiens, éventuelles photographies et enregistrements, continueront d'être stockées pendant cinq ans jusqu'à la fin de la période de recherche sur un serveur sécurisé. Anonymisées, les données pourront être utilisées en vue de futurs publications du projet Be Creative.

Votre participation : un choix libre

Il n'y aura aucune conséquence négative si vous décidez de ne pas participer ou de vous retirer à tout moment avant la publication du mémoire. Nous nous engageons à répondre à toute questions concernant la confidentialité et l'anonymat, qu'elles soient exprimées avant, pendant, ou après l'entretien. Veuillez vous assurer de le faire avant la soumission du mémoire, en août 2022.

Vos droits

Tant que vous pouvez être identifié dans les données recueillies, vous avez le droit :

- d'accéder aux données personnelles qui sont traitées à votre sujet
- de demander l'effacement de vos données personnelles
- de demander que les données personnelles incorrectes vous concernant soient corrigées
- de recevoir une copie de vos données personnelles et
- d'envoyer une plainte à l'autorité norvégienne de protection des données (NSD) concernant le traitement de vos données. NSD peut être joint par courriel : personverntjenester@nsd.no ou par téléphone : +47 55 58 21 17.

Si vous avez des questions n'hésitez pas à nous contacter.

Stagiaires

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Formulaire de consentement

J'ai reçu et compris les informations ci-dessus. J'ai eu la possibilité de poser mes questions.

Je donne mon consentement (veuillez cocher les cases correspondantes) :

- ☐ À participer à un **entretien** et/ou un groupe de discussion
- ☐ À être pris en **photographie**
- ☐ À ce que les données récoltées soient **anonymisées et traitées comme décrit ci-dessus**
- ☐ À ce que les informations que je fourni soient **conservées et utilisées au sein du projet Be Creative**

Nom : _____ **Signature :** _____ **Date :** ____/____/ 2022

Adresse mail : _____

F. Treatment frequency indicators by viticultural bassin in France.

IFT moyen par type de traitement et par bassin viticole

Bassin viticole	IFT Fongicide	IFT Insecticide - acaricide	IFT Herbicide	IFT Total	dont IFT Hors herbicide	dont IFT Biocontrôle
Alsace	13,7	0,8	0,4	14,9	14,5	3,0
Beaujolais	16,4	0,8	1,4	18,7	17,2	2,2
Bordelais	14,3	2,2	0,7	17,2	16,5	2,2
Bouches-du-Rhône	7,7	1,2	0,4	9,3	8,9	1,8
Bourgogne	18,0	0,6	0,8	19,3	18,6	2,6
Bugey-Savoie	16,3	1,1	0,7	18,1	17,4	3,1
Cahors	12,7	2,2	0,7	15,8	15,0	2,8
Champagne	21,5	0,9	1,1	23,5	22,3	3,5
Charentes	14,6	2,6	0,7	18,0	17,3	0,9
Cher	16,3	0,7	0,6	17,6	17,0	4,5
Corse	11,2	2,3	0,3	13,9	13,6	1,5
Côtes-du-Rhône Nord	12,4	0,5	0,6	13,6	13,0	3,0
Côtes-du-Rhône Sud	11,2	1,1	0,5	12,7	12,2	2,1
Dordogne	12,3	2,3	0,6	15,2	14,6	2,0
Gaillac	12,7	2,3	0,7	15,7	15,0	2,4
Gers	15,4	2,5	1,0	18,9	17,9	2,1
Languedoc hors Pyrénées-Orientales	10,6	2,6	0,8	14,0	13,2	1,2
Lot-et-Garonne	12,3	2,2	1,3	15,9	14,6	1,7
Provence (Var-Vaucluse)	9,0	1,0	0,4	10,3	10,0	1,8
Pyrénées-Orientales	7,1	2,9	0,5	10,4	9,9	1,4
Val de Loire	13,0	1,2	0,8	15,0	14,2	2,1
Ensemble	**12,7**	**1,9**	**0,7**	**15,3**	**14,6**	**1,8**

Source : *SSP - Agreste*, survey on plant protection practices in wine production, 2016. (Agreste et al., 2020)

G. Key organizations structuring the *AOCs* and their role in the socio-technical regime

AOC structures exist across all of the major wine producing regions of France[30]. Their ubiquitousness and overarching governance by the *INAO* (National Institute for Origin and Quality) may imply that certain regime dynamics and lock-ins found in the Pilat Rhodanien and related to *AOC* governance scale-out and apply to production systems on a broader geographical level. The *AOC* auditing process is carried out by third party organizations under the national authority of *INAO*.

A number of organizations are involved in structuring and supporting the *AOCs* found in the Pilat Rhodanien. *InterRhône* is a prominent institution involved in the coordination, promotion, and development of all *AOCs* of the *AURA* region. Its employees develop and implement communication strategies such as publicity campaigns targeted to specific markets, consumers and distributors, in France and abroad. *InterRhône* promotes *AURA AOCs* through workshops, wine tastings and trainings, participation in wine fairs, and developing oeno-tourism. The organization also conducts wine research. It is broadly funded by the *AURA* region, and was governed for two terms in a row by the owner of *Domaine Chapoutier,* one of the largest domains in the Pilat Rhodanien, several domains across Europe and one in Australia. The owner of another prominent domain, *Guigal,* was on the administration board of *InterRhône* at the time of our research.

The Wine Sector Committee (*Comité de Filière Vins*) and AURA Wine Committee (*Comité Vins AUR*A) come together to define and implement the Regional Wine Sector Plan (*Plan Regional Filière Vin*)[31]. In 2018-2021, the plan involved funding for up to 40-50% of the investment in farming equipment (for mechanical work, spraying of inputs, and protection from climate events), *HVE* certification, communication and oenotourisme, with a total envelope of 3,4 million euros (La Région Auvergne-Rhône-Alpes, 2018). This plan, we were told, helps orient politics and decision-making at a national level. Some local winemakers were closely involved in its steering committee.

Another important organization to highlight for its role in structuring the *AOCs* is the French Federation for Export of Wines and Spirits (FEVS, *Fédération des exportateurs de Vins & Spiritueux*). FEVS is a trade organization that is active in trade negotiations related to French wine and spirits. Its missions include helping producers understand regulatory requirements, and intervening with relevant authorities to assert economic priorities and defend clients' interests (FEVS, 2022).

The *Syndicat Agricole et Viticole de Chavanay* is a local and historic winegrower's union which is not specifically associated with *AOC* labels. This union holds a prominent role in determining wine grower's practices and culture, particularly in the southern half of the Pilat Rhodanien. According to a wine

[30] 60% of the surface of grapevines in France was used to produce wine classified as *AOP* in a national survey (*Agreste* et al*.,* 2020).

[31] The Wine Sector Committee is composed of representatives from the Regional Chamber of Agriculture, unions, interprofessional organizations, regional technicians, and producer organizations; and the AURA Wine Committee brings together all organizations involved in the AURA region wine sector.

producer and ex-president of the *Chavanay* union, the goal is to defend the interests of wine makers, notably in terms of real estate and land tenure. Some of the members' deliberations have to do with a fair distribution of land for the next generation of winemakers. They also organize the annual *Chavanay* wine market (in existence since 1924) and other local events, all of which add to the reputation of the vineyards. According to the actor mentioned above, "*These are local activities; above us there are the* appellations*,* Condrieu, St-Joseph, *and their unions, which defend the geographic indication labels*'' [52]. Expressed in this way, this actor draws a hierarchical link between the local *Chavanay* winegrowers' union and the *AOC* unions "above", controlled externally by a national authority and multiple regional institutions.

Oxyane is an agricultural cooperative and agri-food group that works in 10 departments throughout the *AURA* region, formed by the merger of two previous cooperative structures, the *Dauphinoise* and *Terre D'alliances.* The coop runs an outlet for agricultural equipment located in *Ampuis* in the north of the Pilat Rhodanien, whose employees were consulted by almost all of the winemakers interviewed, plus numerous others in the entire study zone. The cooperative offers a wide range of services for multiple kinds of specialized agricultural productions, through their technicians and extension services. The cooperative reaches producers on a sizable 15,000 ha of orchards, 17,000 ha of vineyards, 2,200 hectares of vegetable crops, 80 ha of tobacco, and 20 ha of lemon balm; and the cooperative runs 88 grain collection silos. One long-standing and experienced commercial technician at the Ampuis location seemed particularly influential with regards to farmers' choice-making, rather pivotal in their capacity to experiment, his advice and expertise being valued and respected. His engagement towards the reduction of chemical inputs and knack for newer, sometimes obscure yet promising technologies make him a likely important asset for the reduction of chemical inputs.

Our interview with this long-time employee from Oxyane revealed interesting information about the official authorization of products to be sprayed by airway via helicopters in the early 2000s, before their use was banned. At a given point in time, it was solely synthetic chemical fungicides that were taken up administratively by their product suppliers for market authorization (*autorisation de mise sur le marché, AMM*), rendering them legal to spray via helicopter. The product suppliers with organic products did not file for *AMM,* forcing many winemakers who previously used organic fungicides to use synthetic ones instead. The interviewee confirmed the economic question at play: that the companies selling synthetic inputs saw an opportunity in the market authorization of their products, and had greater means than the companies selling organic-authorized products to undertake in the administrative process.

A non-exhaustive list of structures and actors which also partook in the regime may include oenology and winemaking training programs, technical institutes and experimental stations, chemical and natural input fabricators and distributors, wine distributors (wholesale, hospitality, retail) and wine experts. We came into lesser contact with these kinds of actors during our research, partially due to their less transparent and/or non-local roles related to chemical input use in the territory. It would be interesting to interview these actors in further research to understand their role in unlocking the rigid production standards that producers face on the prestigious hillsides of the Pilat Rhodanien.

H. Socio-technical niche dynamics in viticulture of the Pilat Rhodanien

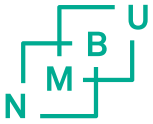
We encountered actors whose activities may be considered "niche dynamics": they generated or supported novel approaches to production and differed in their principles and configurations from the dominant ways of operating (Anderson et al., 2019; Geels and Schot, 2007). These actors expressed a different relationship to wine grapes, stemming from their outlooks on production, the practices and the forms of knowledge that they employed, and/or the social networks in which they partook. We also spoke with consumers and wine retailers who take part in the niche dynamics through their orientation to consumption and sales of wine produced in the "niche" context. We acknowledge that our sample size was limited, and that our observations were limited to the data that we collected over only four months of fieldwork. The below descriptions are thus preliminary, and further research should be conducted to confirm and expand on the findings.

The winemakers in the socio-technical niche that we propose supplemented their vine protection practices with prophylactic measures (Results II.C and III.B), potentially to greater degrees than observed amongst the other winemakers interviewed. These practices reflect their special interest in both preventing problems and supporting their vines' intrinsic ability to survive with minimal to no intervention on their part. Their plant protection strategy lied in building the long-term health of their vineyard. This contrasted with the other farmers who did not emphasize such considerations, but rather spoke of repeating "conventional" practices, using a smaller diversity of techniques to prevent fungal outbreaks, and even fewer techniques with regards to building the water and nutrient holding capacity of their soil.

Wine makers respected and drew information from academic work and generally paid attention to neighbors' practices. However, the observations they made on their parcels were the primary means used to determine appropriate practices. This was prioritized over any recommendations, even if their chosen practices were not well-known or respected. These wine producers said that their approach was neither prominent nor commonly taught in schools, and not easily summarized into a set of specific techniques or recipes, given the importance of site-specific considerations.

One of the wine producers that we interviewed was amongst the founders and main organizers of the Organic Winemakers Festival, and another participated as an exhibitor. This market gathered 32 domains, one third of whom were situated in northern *Côtes-du-Rhône*, the rest from other territories around the *AURA* region. Almost half of the domains were certified with a biodynamic label. In online biographies of the domains, farmers often mention agroecology, peasantry, working with native yeasts, not adding sulfites, with a few mentioning that their family vineyard had always been organic. This festival seemed to be an important yearly event for like-minded wine-makers and passionate consumers to meet and mingle.

We identified two market actors who were involved in the promotion of these wines (either produced at domains directly involved in the niche dynamics, or produced on vineyards in the Rhône Valley which we perceived to hold complementary "niche" approaches to wine grape production). These actors included the up-and-coming wine brand *Oé vins*, who do extensive communications around the sustainable and "zero-pesticide" practices of the farmers who supply their wine, and who market their bottles as wine that goes "beyond organic". Another interesting actor was the creative, anti-food waste catering company, *La Fabuleuse Cantine,* who sold biodynamic wine from the Pilat Rhodanien at the acclaimed *St-Étienne* design center during the design fair in Spring 2022.



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