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▶ **To cite this version:**

Amalie Bjørnåvold, Maia David, David Bohan, Caroline Gibert, Jean-Marc Rousselle, et al.. Why does France not meet its pesticide reduction targets? Farmers' socio-economic trade-offs when adopting agro-ecological practices. Ecological Economics, 2022, 198, pp.107440. 10.1016/j.ecolecon.2022.107440 . hal-03716593

HAL Id: hal-03716593
https://hal.inrae.fr/hal-03716593

Submitted on 28 Nov 2022

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Why does France not meet its pesticide reduction targets? Farmers' socio-economic trade-offs when adopting agro-ecological practices

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Abstract

Despite substantial policy efforts made by the French government to reduce dependence on pesticides, farming practices are only changing slowly. This paper analyses the socio-economic trade-offs that 110 farmers are currently facing in the transition to agro-ecological practices. A mixed-method approach - a quantitative discrete choice experiment (DCE) and qualitative interviews - was set up to understand these farmers' motivations and perspectives, and how policy can improve to accompany them on the road to low-pesticide agriculture. Results of the DCE indicate that the majority of the farmers in our sample are keen to change practices but are at a loss as to how this can be done, as a number of preferences for this transition came out as inconclusive. Qualitative interviews with a representative sample of the farmers that took part in the DCE complemented this result by illustrating a deep uncertainty for the future and a disconnect felt between authorities and themselves as a group. We argue that this uncertainty contributed to a lack of clear-cut solutions established through the DCE. The in-depth discussions with farmers illustrated the wish for concrete and local policy measures based on farmers' networks and peer support.

Keywords: Agro-ecological practices ; Discrete choice experiment; Qualitative interviews.
JEL Classification: Q12, Q18, Q51, Q57, C35.

Acknowledgments: This work was part of the C-IPM EraNet BioAWARE project. We would like to thank Aser Balima, Thibaut Lameille and Théophile Yumrutas for their support and comments on this work.

1 Introduction

The past decades have seen a surge in studies implicating pesticides in environmental pollution, biodiversity loss and health problems (Wilson and Tisdell, 2001). In an effort to curb these effects and encourage a transition to more sustainable agricultural systems (an agro-ecological transition), there has been an increase in policy measures across France to reduce farmers' dependence on the use of pesticides. Research has shown that reducing pesticide use does not necessarily lead to lower agricultural yields or profits (Lechenet et al., 2017) and reducing pesticides may reduce farmers' costs, improve their health and living environment, and prevent pest resistance (Bourguet and Guillemaud, 2016).

Despite these trends, and rapidly rising consumer demand for organic products, pesticide application remains high, and reduction targets are consistently not met. The French Ecophyto Plan aimed to reduce pesticide use and active ingredients sold by 50 % between 2007 and 2018. Nonetheless, recent figures show that, overall, pesticide use increased in France between 2008 and 2018 (Lapierre et al., 2019; Hossard et al., 2017). Further, the subsequent plan of Ecophyto 2 aims to reduce pesticide use by 50 % between 2018 and 2025, whereas pesticide use has increased between then and now as well (French Ministry of Agriculture, 2020). Several policy instruments have been put in place to reach these goals, such as the creation of networks of local groups of farmers that are provided with technical support to reduce the use of pesticides (known as the DEPHY networks (Cerf et al., 2017)), pesticide reduction certificates, increased communication and information, as well as research and innovation on alternative solutions and integrated pest management, to financial support: 71 million Euros are devoted annually to the Ecophyto plan (French Ministry of Agriculture, 2021).

Why, then, are farmers reluctant to adopt agro-ecological practices and why is the transition so difficult to attain? More specifically, the research question underlying this study is the following: what barriers do the farmers taking part in our study face in the transition to agro-ecological practices in France? We argue that this reluctance to reduce pesticides largely mirrors a resilience of existing socio-technical systems and patterns of behaviour. While analysts suggest that factors such as low taxes on chemicals and high prices for cereals created recent incentives to spray more chemicals to protect harvests (Stokstad, 2018), we suggest that better understanding socio-economic and behavioural factors lies at the heart of improving responses to pesticide reduction policies. Substantive system changes are required in the transition from one socio-technical system to another (Rip and Kemp, 1998; Geels, 2005). Socio-technical changes do not solely involve technological innovation or substitution, but also require complex and interconnected social changes in the overall configuration of culture, habits, work, markets, consumer practices, scientific knowledge and agri-food systems (Geels, 2011; Elzen et al., 2004; van den Bergh and Bruinsma, 2008; Safarzyńska et al., 2012; Bjørnåvold et al., 2020). What matters is not merely the technological innovation itself (and in this case, agro-ecological practices allowing a greater uptake of alternatives to pesticides), but also the social and economic systems in which the existing technology is embedded (Upham et al., 2019).

A mixed-method study was conducted - a discrete choice experiment (DCE) and qualitative interviews - to understand farmers' decision criteria to accompany them on the road to changing their practices. A DCE is a non-market valuation method based on repeated fictional choices made by respondents to elicit their preferences. While literature exists on the need for qualitative approaches in the DCE design phase (Rakotonarivo et al., 2016; Jeanloz et al., 2016), this paper focuses on their value in complementing data acquired from the DCE itself. This approach of

mixing DCEs with qualitative methods (through focus groups, group discussions or interviews for example) has previously been undertaken by e.g., Brouwer et al. (1999), Clark et al. (2000), Powe et al. (2005), Powe (2007), Spash (2007) Araña and León (2009) and Schaafsma et al. (2017), to name a few. DCEs are valuable to estimate preferences in a hypothetical setting. However, when considering such complex socio-technical transitions that may affect entire livelihoods, respondents may need open-ended discussion forums that complement the more rigid DCE format.

Our principal contribution to the literature is the use of two complementary methods to deepen our understanding of some farmers' behavioural patterns on the reluctance of reducing the use of pesticides. First, our DCE explores decision factors - such as the transition time to adopt new agricultural practices - which seeks to incorporate the notion of uncertainty into the DCE model. During this transition time, impact on income, health and environment are uncertain due to unknown effects on sales, costs, yields and development of the soil, while substantial learning and knowledge on novel practices are simultaneously required. We further included attributes taking the inclusion in a network of farmers into account, as well as changes in the organisation of work - that are part of the social factors that may play a role in the transition. To the best of our knowledge, these attributes have not yet been studied in the DCE literature on farmers' behaviour regarding environmentally friendly practices (see among others Birol et al., 2006; Christensen et al., 2011; Blazy et al., 2011; Broch and Vedel, 2012; Villanueva et al., 2015; Peterson et al., 2015; Chèze et al., 2020). Second, we treat semantic data obtained through an open-ended qualitative survey to complement the DCE analysis and let farmers express themselves through an open discussion.

The remainder of the paper is structured as follows. Section 2 presents a conceptual framework of the themes discussed in the literature on the agro-ecological transition and farmers' decision-making processes, followed by section 3 which presents the mixed-method approach applied to the study; firstly detailing the DCE followed by the qualitative method of interviews. Sections 4 and 5 respectively present and discuss the results from both methods. Our conclusions are presented in section 6.

2 Conceptual framework

This paper seeks to contribute to an understanding of how to increase farmers' adoption of agro-ecological practices, with the reduction of pesticides playing an important role in this transition. In bringing this discussion forward, it is important to define what this agro-ecological transition refers to. The term agro-ecology has been used for many decades, and was mainly used in purely scientific domains to begin with, but has evolved to denote ecologically sound agricultural practices - encompassing social and economic dimensions from food sovereignty to the entire food system (Francis et al., 2003). As Wezel et al. (2018, 2020) explore, agro-ecological practices look to novel ways of improving and increasing sustainability in agricultural systems, making use of natural processes and biological interactions, while simultaneously minimising synthetic and toxic external inputs.

Nonetheless, as Plateau et al. (2021) discuss, many studies on agro-ecology limit themselves to farm-level analyses on sustainability (Hubeau et al., 2017), even though the agro-ecological transition should not be separated from its social and economic dimensions (Woodgate and Sevilla Guzmán, 2015; Aubron et al., 2016; Dumont et al., 2016; Kapgen and Roudart, 2020). Studies that *have* previously looked beyond farm-level analyses, and integrate ecological, economic and social dimensions, have, among other topics, looked into the interactions between innovative niches and the dominant socio-technological regime and agri-food systems (Bui et al., 2016; Hermans et al., 2016), the lock-in

mechanisms supporting the incumbent system (Magrini et al., 2016; Vanloqueren and Baret, 2008; De Herde et al., 2019), and the role played by alternative agro-food networks (Chiffoleau et al., 2016; Forssell and Lankoski, 2015). Plateau et al. (2021) themselves study the contradictions internal to the organisations engaged in an agro-ecological transition. Hostiou et al. (2012) examine the reorganisation of tasks and schedules that arise as a result of the agro-ecological transition, and, in turn, the increased complexity and cognitive load in farmers' work. This increase can arise from new required fields of animal observation, as well as new cropping systems, for example. As Coquil et al. (2018) further discuss, techno-centred approaches look to implications of work transformations at an organisational level - to quantify work needs and to assess the associated cognitive load. On the other hand, anthropocentric and social approaches look to the way in these processes and transformations are also socially constructed, given that instruments and peer networks also define professional norms, in addition to considerations of what can be defined as a good and bad agricultural practice (Coquil et al., 2018). These approaches are not mutually exclusive, however: an integrated systemic framework inspired by technical, social and economic approaches is required.

This paper contributes to the literature seeking to integrate these technological, economic and social approaches, when considering farmers' decision-making processes regarding their continued use of pesticides in their transition to agro-ecological practices. As Bakker et al. (2021), Damalas (2021) and Lamichhane et al. (2016) discuss, there is no clear consensus on the principle reasons for farmers' decisions to reduce pesticide use, and to, in turn, reduce their environmental impact. We argue that barriers to decision-making processes that contribute to farmers' reluctance to reduce pesticide use can also be rooted in different forms of perceived uncertainty underlying these transitions. We here find that the definition of uncertainty put forward by Milliken (1987) as "an individual's perceived inability to predict something accurately" is helpful. As Meijer et al. (2007) further highlight, in the case of new technologies, uncertainty will arise not only about the technology itself, but also about the socio-institutional setting in which the emerging technology is embedded. In the case of farmers' uptake of alternative pest control technologies, we find that uncertainty can be divided into four components including perceived i) technological uncertainty, ii) economic uncertainty, iii) social uncertainty, and iv) governmental uncertainty.

Regarding technological uncertainty, barriers to decision-making for the adoption of alternative methods include informational hurdles, such as lack of knowledge on alternatives or biased information coming from industry players with vested interests (Van den Bosch, 1978; Wilson and Tisdell, 2001; Jin et al., 2017; Lamichhane et al., 2016). Another technical uncertainty relates to a reported lack of alternatives to the use of conventional technologies, such as pesticides (Lechenet et al., 2017; Khan and Damalas, 2015).

Referring to economic uncertainty, some related contributions argue that barriers to reduction in pesticide use include economic dependence on conventional methods, related to technological lock-in from past financial investments (Cowan and Gunby, 1996; Wilson and Tisdell, 2001), as well keeping up with market demand and aesthetic expectations of consumers (Skevas and Lansink, 2014). Moreover, Chèze et al. (2020) find that the risk of substantial losses in production as a result of pests reduces farmers' willingness to reduce their pesticide use.

While technological and economic aspects are critical to farmers' decision-making, social and group-mediated behaviour may have just as much an effect on change - as put forward by anthropocentric approaches to understanding the agro-ecological transition. Transitioning to alternative agricultural practices brings large amounts of uncertainty, including social uncertainty. One crucial motivation for group-mediated action is uncertainty reduction (Smith and Louis, 2009). Identifying with relevant reference groups and guiding your behaviour based on what your peers are doing can

reduce uncertainty through knowledge and experience sharing (Smith and Louis, 2009; Cialdini and Goldstein, 2004). In times of uncertainty, norms within a group or community that a farmer belongs to may therefore be more likely to influence their behaviour than anyone else's. As illustrated by Bakker et al. (2021), the intention to reduce pesticide use is strongly determined by whether other farmers also act, and especially peers such as conventional neighbouring farmers and members from study groups, and those that shared similar values and experiences. The importance of peer support in implementing new strategies, and working together with other farmers when decreasing pesticide use, was also found by Brewer and Goodell (2012); Parsa et al. (2014); Stallman and James Jr (2015).

In a similar vein, social uncertainty has in past research been shown to also be related to governmental uncertainty and acceptance for policy. For instance, group norms have been shown to influence farmers' intentions to perform sustainable agricultural practices (Sok et al., 2015; Borges et al., 2016). Still, the effect that group norms have on behaviour depends on the level of identification with the collective (Fielding et al., 2008; Beedell and Rehman, 2000; Franks and McGloin, 2007). For example, the more farmers identify themselves with a sustainably oriented community, the more likely it is that members within the community will experience group pressure to participate in agri-environmental measures (van Dijk et al., 2016). In addition, the more farmers identify with farmers in their communities, the more they are likely to show reactance to a policy aimed at them: as Bonke and Musshoff (2019) point out, reactance refers to a "defiance against measures to limit one's behaviour." If attacks on ways of behaving and working and on identities increase, reactive behaviour becomes a likely outcome (Stoll-Kleemann, 2001).

3 Method

3.1 Discrete Choice Experiment

Discrete choice experiments have been extensively used to model people's choices and identify preferences (Louviere and Hensher, 1982; Louviere and Woodworth, 1983). Each respondent is presented choice cards with several alternatives - defined by various attributes (i.e., fundamental characteristics of the respondent's situation), each associated with a given level - and asked to choose their preferred alternative. The main goal of a DCE is to estimate the weight and sign of each attribute in respondents' decisions from the repeated choices made (Cuervo et al., 2016). One of the attributes is generally monetary, while the others can include either or both environmental and social implications of the issue. If we are to democratise our current policy, modelling preferences of key target groups on issues at stake is critical. This paper seeks to estimate individual components of policies to accelerate agro-ecological transitions. Understanding the trade-offs between policy components are important to ensure a quicker transition, and in this case, DCEs are a method of choice. DCEs are one of the preferred methods to estimate values for changes in many public goods, including environmental services, human health effects, and other outcomes for which (direct or indirect) revealed preference data are not available (Johnston et al., 2017). Hence, they are one of the only available means to estimate non-use values, or use values associated with changes that fall outside the range of observed conditions (Johnston et al., 2017). Moreover, DCEs are well suited to situations where a change is multi-dimensional, and the trade-offs between these dimensions are of interest.

DCEs have until now been used to investigate various aspects of farmers' views on pesticide reduction measures. Birol et al. (2006) investigate the diversification of crop varieties in farm-

ers' home gardens which contributes to understanding the potential role of home gardens in agri-environmental schemes (AES). Christensen et al. (2011) study the trade offs that farmers are willing to make between subsidy size and individual AES requirements and find that most farmers are willing to trade off the size of the subsidy for less restrictive scheme requirements and that the subsidy size depends on the specific scheme requirements. Moreover, Blazy et al. (2011) look to farmers reducing pesticide use by adopting agro-ecological innovations in view of receiving a subsidy, while Kouser and Qaim (2013) quantify the health and environmental benefits associated with cotton in Pakistan – and its associated reduced use of pesticides. They found that farmers themselves value these positive effects at US $79 per acre, of which half is attributed to health and the other half to environmental improvements. Jaeck and Lifran (2014) investigate preferences for using alternative weed control technologies, based on a single payment scheme per hectare and Kuhfuss et al. (2016) study farmers' preferences for joining an AES scheme to reduce pesticide use, also based on a single payment scheme per hectare. Jin et al. (2017) investigate farmers' valuations for health risk changes associated with pesticide use in China and find that female farmers and those that are more educated are more likely to accept a compensation scheme if health risks increase. Danne et al. (2019) illustrate that farmers prefer the use of glyphosate to other alternatives to prevent weed infestation, while also saving work and labour costs, especially on large farms. Chèze et al. (2020) find that the risk of substantial losses in production as a result of pests reduces farmers' willingness to reduce their pesticide use.

In our case, respondents are farmers choosing between three alternatives of agricultural practices. Two alternatives are hypothetical situations implying a change of farming practices and a reduction in pesticide use, while the third one is an opt-out or status quo option, corresponding to the current situation of the farmer (i.e., nothing changes). Including an opt-out is known to attain more realistic results (Lancsar and Louviere, 2006; Kontoleon and Yabe, 2003; Adamowicz and Boxall, 2001), as opposed to 'referendum' type DCEs where respondents choose between two options. We intentionally kept the change in agricultural practice in the two alternatives to the status quo general. With general alternatives, any modification in the farming practices leading to the reduction of pesticides could be envisioned by the farmers taking part. By not explicitly stating the exact nature of this change, we therefore sought to accommodate different types of farms and soil-climate conditions. At the same time, we provided examples of practice changes to farmers to make the decisions more realistic and concrete in the informative material provided to the farmers, which can be found in Appendix A.1. Figure 7.

3.1.1 Choice of the attributes and their levels

The first step in the design of a DCE study is choosing the attributes and their levels. As explained by Chèze et al. (2020), several factors influence farmers' choices in reducing or maintaining pesticide application such as reducing input costs, increasing the sales price, improving their public image, taking part in a network of farmers, improving quality of life and health, obtaining subsidies, routine behaviour, lack of technical knowledge, an aversion to uncertain outcomes, to only name a few. The attributes were chosen based on: i) the literature on farmers' use of pesticides and alternative practices ii) refinements based on pre-tests and two focus groups (one held at SOLAGRO, Toulouse, France and one held at AgroParisTech, Grignon, France) conducted with small groups of farmers to establish the elements of their greatest current and future concern; and, iii) online consultation with farmers who had previously converted to agro-ecological practices via the online OSAE (OSez l'Agro Écologie) platform. The number of attributes was limited to five to minimise the risk of

cognitive load and non-attendance bias. The selected attributes were: i) impact on income; ii) transition time of the change of agricultural practices; iii) impact on health and the environment; iv) impact on work schedule; and, v) potential agricultural support accompanying the change of practice (training, advice, network...). A detailed explanation of the attributes and the choice cards is given in Appendix A.1, as was shown to respondents.

The first attribute is the monetary attribute represented by the impact on income. The associated levels are -10%, 0%, or + 10% of income compared to the current situation, and defined as the total revenue minus the total expenditure. Farmers' incomes are expected to vary - either positively or negatively - upon changing practices due to various reasons related to the impact on yield, spending on pesticides, governmental support, labour costs, investments and output prices of agricultural produce. The output prices of agricultural produce would change as produce that uses little pesticides can be sold at higher prices (i.e., organic products). Investments could include technologies needed to adapt to agro-ecological practices, such as a spike tooth harrow, to give an example. The choice of presenting income as a percentage change in 10% increments, and not precisely budgeted, was chosen after consultation with experts and farmers, and a review of the literature. The limited number of three levels sought to simplify the choice scenario and the cognitive burden imposed on respondents.

The second attribute represents the time taken to transition to new agricultural practices and the time expected to represent a period of uncertainty and adaptation in redefining a new cropping system. During this time, impact on income, health and environment are uncertain due to expected risk and unknown effects on sales, costs, yields and development of the soil, while substantial learning and knowledge on novel practices are simultaneously required. This attribute represents a new and innovative facet that, to the best of our knowledge, has not previously been taken into account in former DCEs conducted with farmers on the reduction of pesticides. Reviews providing an overview of studies investigating farmers' decision-making in general indicate that this concept of 'transition time' has not been taken into account either (Bartkowski and Bartke, 2018). A DCE investigating farmers' willingness to adopt genetically modified oilseed rape did include an attribute entitled 'waiting period'; i.e., the time elapsed between the last year of GM cropping and the first year of non-GM cropping (Breustedt et al., 2008), however, one taking 'Transition time' to new and alternative practices is a novel way to account for uncertainty, and our approach seeks to understand how the attribute and the notion of uncertainty with regard to the redefinition of new cropping systems may affect farmers' choices. The selected levels are 2, 3, and 5 years, corresponding to a rapid transition for less complex changes to an upper average duration expected to transition to agro-ecological practices.[1]

The third attribute includes the impact on health and the environment upon changing agricultural practices. This attribute represents the expected decrease in the amount of pesticide residues found in the human body, food - and therefore impacting both farmers' and consumers' health - as well as the various compartments of the environment. This attribute therefore has both personal and social advantages. When designing this attribute, we considered having two separate attributes, given that the impacts of health and the environment present distinct components (Carvalho, 2017). However, research has shown that they are highly correlated – one necessarily impacts the other (Juraske et al., 2007). Given that the complexity and imposed cognitive burden of DCEs generally also goes hand in hand with the number of attributes and levels chosen (Caussade et al., 2005; Hensher et al., 2015), we finally agreed to stick to one attribute combining the impacts of pesticides

[1]For example, three years are necessary to produce enough carabids in direct drilling with cover crops in France (10.1016/j.agee.2017.02.014).

on health and the environment, in conjunction with discussions with farmers and experts. In a previous study, this attribute had not been significant on average (Chèze et al., 2020), but we chose to include it to corroborate or challenge this prior result. The levels selected for a decrease in pesticide residues were -20%, -50% and -95%. These levels were chosen to correspond to different levels of application of agro-ecological practices. The highest reduction of -95% approximates the amount needed to transition to organic farming practices, where the use of any pesticide is virtually prohibited, with some exceptions (in case there is an emergency pest attack, chemical pesticides may be authorised).

The fourth attribute corresponds to the change in the organisation of work - or work schedule - expected to accompany a change in agricultural practices. Specifically, this refers to the change in the distribution of time directed to the farming practices, with different options where workload would: i) become more condensed (with increasing alternating work peaks/rest times); ii) become more spread out, evenly, over time; or, iii) be unchanged. In consultations with farmers, the attribute of a potential change in work schedule frequently came out as an important aspect of concern with regard to changing practices. As also discussed by Vidogbéna et al. (2015), the change in the distribution of work can greatly impact farmers' preferences. We chose to stick to the attribute of 'work schedule', as opposed to workload, as we found that in the literature there is currently no consensus as to whether the use of pesticides increases or decreases farmers' workload (Lechenet et al., 2014; Paudel et al., 2020), while there is literature that highlights the modification of the organisation of work over time that the change in practices ensues (Daghagh Yazd et al., 2019). Given that we did not want to take a stance on this point, we chose to focus on the distribution of work as opposed to the workload in this fourth attribute.

The final attribute looks at farmers' preferences for support in transitioning to low-pesticide agriculture and for inclusion in a network. Support was assumed to be optional and free and to be in addition to any current support. Types of support were: i) follow-up by an advisor; ii) membership within a peer network for an exchange of practices, knowledge and experience with neighbouring farmers; iii) target local training on new technologies and practices; and, iv) none of the aforementioned measures.

Table 1: Attributes and levels
SQ: level in the status quo (also possible in the other options); only SQ: level only in the status quo option

Attribute	**Attribute Levels**
Impact on income	-10 %; 0 % (SQ); +10 %
Transition time	2; 3; 5 years; no transition (only SQ)
Impact on health and the environment	-20%; -50%; -95% residues; no reduction (only SQ)
Work schedule	Condensed; Spread out; Unchanged (SQ)
Optional and free agricultural support	Advisor; Network; Training; None (SQ)

3.1.2 Experimental design of the DCE

With five attributes and three to four levels for each attribute, there are too many attribute-level combinations to present all of them to the respondents. NGene, a software tool created explicitly for the design of DCEs, was used to select the sub-set of these combinations that procures maximal information (see experimental design techniques in Louviere et al., 2000; Street et al., 2005). We used an efficient Bayesian D-optimal design which have consistently been shown to be statistically superior to orthogonal designs (Rose et al., 2008). In comparison to orthogonal designs, they take preliminary information about the target group's preferences into account to maximise the information collected (Metrics, 2012). Efficient designs also allow for the attainment of lower standard errors in estimating the model for smaller respondent groups, which are characteristic of farmer DCEs. According to Greiner (2016), using a D-efficient experimental design, as we do, requires a much smaller sample size than a random orthogonal design. The design created 12 different choice cards, which were blocked into two groups of 6 choice cards to which respondents were randomly assigned (see one of the choice cards in Figure 1). Thus, each participant answered six choice cards to limit the cognitive burden (Hensher et al., 2015). The NGene code used for the experimental design is available from the authors upon request.



Figure 1: Example of a choice card translated from French

3.1.3 Questionnaire

The questionnaire was distributed between January and May 2019. It was sent to over 2000 French farmers - both conventional and organic - practicing various farming activities (see Appendix A.2, Figure 15). A significant proportion of the DCE distribution to farmers was done via the French

agricultural network of SOLAGRO - which distributed the survey to farmers throughout France. Further contacts were attained through organisations providing agricultural training such as *CertiPhyto* (training on the use of pesticides which is mandatory for French farmers) and through meetings with agricultural stakeholders and networks, which allowed the authors to approach farmers. A Facebook page was also created with a link to the questionnaire that was only posted in private groups for farmers residing in France. The questionnaire's distribution was mostly by electronic means, except a dozen responses that were attained through in-person contact with farmers (using a hard-copy transcript of the electronic questionnaire).

There was a known risk to disseminating surveys electronically, including the potential for sampling bias, as those who choose to respond may have different preferences to those that choose to ignore it. Further, there may often be complexity attached to DCEs, and this complexity cannot be clarified to the respondent when the survey is disseminated electronically. Our survey instrument included the choice sets and other questions regarding respondents' work, farming practices, income, attitudes, and socio-demographic characteristics of the participants. Other sampling biases, such as particular groups being more interested than others, would be controlled for in the data analysis. In particular, distributing the survey through Facebook also opened up to potential biases, as the sample is then drawn from a population without regard to who that sample may be excluding. Nonetheless, given Facebook's large user base, it has in recent years become a popular tool in survey research as it enables swift and low-cost recruitment (Ramo and Prochaska, 2012; Zhang et al., 2020; Schneider and Harknett, 2019; Kalimeri et al., 2019; Grow et al., 2020). Given its large user-base, it also opens up the possibility of reaching traditionally hard-to-reach population groups (Schneider and Harknett, 2019). As discussed, farmers are part of those difficult-to-reach groups. In a study with 980 French farmers, 86 % stated that they were active on the internet on a daily basis, with 68 % of those active on social media, and Facebook was the most popular social media tool (Agricole, 2021). Based on these elements, we decided to supplement our sample with farmers recruited through Facebook.

The questionnaire was developed on the survey platform LimeSurvey and designed to last about 15-20 minutes.[2] The respondents were initially presented with an introduction to the organising actors – the French National Research Institute for Agriculture, Food and the Environment (INRAE) - emphasising the work of the institute and the respondents' likely role in influencing public decision-making through their participation. This latter statement is important to improve the consequentiality of the study, that is the fact that respondents believe there is a nonzero probability that their answers actually influence decisions, which should increase incentives to answer truthfully (Johnston et al., 2017). The objectives of the study were then outlined, while the anonymity of respondents was ensured. The respondents were given a series of questions on their farming activities. Their perception regarding the use of plant protection products was also queried, along with their perception of pesticide impacts on the environment and health, preferences for work schedule, support measures and time of transition. Following this initial section, respondents were shown two videos explaining the issue, how to answer a choice card, the attributes and their levels[3], and the task at hand. A further statement that aimed to improve the survey's consequentiality was included at the end of the second video. This statement indicated that the respondents could be offered the opportunity to participate in a pilot programme to reduce pesticide use following the survey and

[2]The exact questionnaire that was sent to farmers (in French) is available following this link: https://catisae2.toulouse.inra.fr/limesurvey-206/index.php/325585?lang=fr

[3]As mentioned before, slides were also used to explain in detail the choice cards and the meaning of each attribute (see Appendix A.1).

that their answers would influence this programme. This statement sought to incentivise farmers to take part in the DCE with the assurance that their responses would have a consequential impact on public policy.

Then came the six choice cards. As shown in the example in Figure 1, small informational icons were present in each choice card, providing - when clicked upon - a reminder of the attributes' definition and of how to complete the choice card. The order of the choice cards was randomised to prevent bias caused by either order or survey fatigue.

An additional question was asked to respondents selecting the status quo level in all the six choices to identify potential protest answers. Comprehension questions (degree of understanding and satisfaction), an open-ended question on the other factors that may influence their decisions and socio-demographic questions (income, age, education, gender, other sources of revenues, etc.) were also included after the choice cards. Socio-demographic answers are essential to better interpret the farmers' responses as they allow for interactions to be included in the econometric modelling.

3.2 Qualitative interviews

Open-ended interviews were conducted with a representative sample of the farmers who completed the DCE. All the farmers who provided their contact details at the end of the DCE questionnaire were contacted by email and 18 participated in an interview. The interviews were conducted from August to October 2019 over the telephone, given the France-wide distribution of the farmers. They lasted from 30 minutes to 1 hour and a half. The interviews' objective was to understand farmers' preferences for agro-ecological practices (as was the case for the DCE), and complement the responses extracted from the choice cards by posing follow-up questions about these responses. The qualitative interviews allowed researchers to obtain information that was not accessible in a closed-form, formal questionnaire, such as the DCE. Participants were aware of the research goals (and that they would be asked to provide further information on the choices made), the research institution organising the survey, as well as the researchers' characteristics (name, job position, research interest). The interviewer did not know any of the participants prior to the study and there were no repeat interviews. All interviews were audio-recorded and transcribed *ad verbatim* in the language in which interviews were conducted: French. These transcripts were then translated into English for semantic data analysis.

3.2.1 Interview set-up

Before the interview process began, an interview guide was developed based on comprehension questions, reasons for answers and views related to agricultural practices and policy changes. This interview guide can be found in the Appendix. The process and method of conducting the interviews followed an iterative process and informal structure. The interviews' main purpose was to delve further into the results of the DCE by allowing the farmers to speak freely and express their views on the topics at stake. Moreover, in-between interviews, the authors regularly discussed the semantic issued from the narratives in the interviews to identify the main themes emerging from the farmers' responses. This identification of semantic and themes would later form the basis of the codes for data analysis (Chambliss and Schutt, 2018).

3.2.2 Data analysis of the qualitative survey

Data management and analysis were performed using the qualitative data software package NVivo. The transcripts were read and thematically coded by the authors to organise a pattern of convergence and divergence in the narratives of the responses of the farmers interviewed (Creswell and Poth, 2016; Patton, 2014). The qualitative content analysis thus included familiarisation with the data through slow reading, followed by a combination of deductive and inductive construction of codes classified into main categories and subcategories, depending on the main themes highlighted by the farmers, while remaining open to new main categories emerging from the semantic data. Coding discordance was discussed and re-coded as necessary. During the analysis, interviewees' statements were assigned to the themes to establish differences in the perspectives of the farmers involved. This process made it possible to identify relations as well as emerging patterns and ideas. If a statement was relevant for multiple topics or sub-topics, it was possible to assign the response multiple times.

We followed contemporary guidance in qualitative research methods when conducting the in-depth interviews. While a large number of articles, book chapters and books recommend anywhere from 5 to 50 participants as adequate (Morse, 2000; Charmaz, 2006; Baker and Edwards, 2012), while Boddy (2016) considers a sample size "over 30 too unwieldy to administer and analyse," debates often respond that "it depends" (Baker and Edwards, 2012). Nonetheless, the general consensus is that new interviews should be conducted until data saturation is reached when "further interviews yield little new knowledge, until the law of diminishing returns applies" (Kvale, 1994). The concept of data saturation, which is the point at which no new information or themes are observed in the data from the completion of additional interviews or cases is a useful concept in terms of discussing sample size in qualitative research (Kvale, 1994). Data saturation was therefore considered to have been reached when no additional codes or novel data points were identified. In our case, this point was reached after 18 interviews, representing 16% of the DCE sample. As a comparison, Guest et al. (2006) found - in their example - that data saturation starts to become evident at six in-depth interviews and definitely evident at 12 in-depth interviews.

4 Results

4.1 Discrete Choice Experiment

4.1.1 Descriptive statistics

121 complete answers were received, and eleven of these were removed due to a lack of comprehension or protest answers. Tests were completed in order to clean up and understand the data sample (see Figure 2 for a summary of these tests). To examine the robustness of the results, respondents were sequentially removed based on their motivation or a lack of understanding. Such removals could be identified based on responses to the post-experimental questions. Concentration was also tested, evaluating an expectation of consistently opting for one alternative (on the left, either all six times or five out of six times) and short duration spent watching the explanatory video or completing the questionnaire. The authors also controlled for quality of the sample by doing background checks on those that had provided their email addresses (57 out of 121 farmers), as well as questions relating to farming activity and farm size, by making sure that the full sample were truly farmers. We found that 3 out of the 121 that took part were not currently farmers, and were therefore removed from the sample.

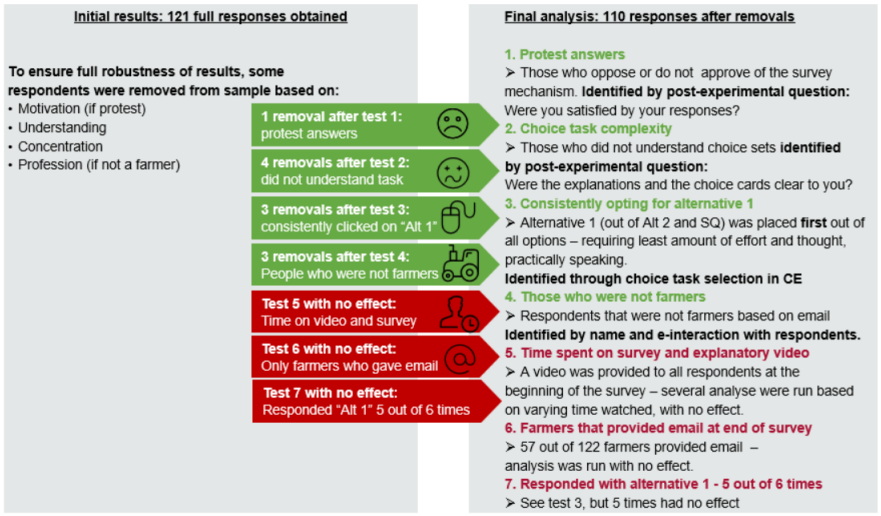


Figure 2: Final number of respondents to the DCE after sample removals

In the end, 110 full responses, and data from 5.5 % of farmers who received the questionnaire by email could be analysed. A major issue of online surveys is the participation rate, as response rates are generally very poor, as compared to in-person data collection (Nayak and Narayan, 2019). The small sample size is also an especially common limitation for groups that are more difficult to reach compared to the general population, such as farmers when discussing controversial topics like pesticides. This is clear from the many published DCEs conducted with farmers with similarly low sample sizes: to name a few: 90 French farmers in Chèze et al. (2020), 134 Swedish farmers in Franzén et al. (2016), 104 Australian farmers in Greiner (2016), 128 German farmers in Schulz et al. (2014), 104 French farmers in Jaeck and Lifran (2014), 49 U.S. farmers in Hudson and Lusk (2004). Nonetheless, there certainly exist DCEs conducted with farmers with higher sample sizes, such as Christensen et al. (2011) with 444 responses and Blazy et al. (2011) with 607 responses, to name only a couple. With this limitation to our study in mind, for future studies conducted with farmers, time and resources need to be well adjusted to mitigate the risk of low response rates.

While the survey was designed and distributed according to best practices on state-of-the-art DCE methodological considerations (Johnston et al., 2017), there may also have been a rejection of the study by farmers at the outset, leading to a non-response bias. Of the farmers that started the survey, 25.6 % of these completed it, with a great majority of the dropouts occurring at the very start of the survey. The survey was distributed at a time when topics surrounding the reduction of pesticides was a particularly sensitive topic (Kudsk and Mathiassen, 2020), with farmers' demonstrations surrounding agro-environmental and economic policy reaching a particular peak in 2019 in France, which may also have contributed to the low response rate, and rejection by certain farmers. Notwithstanding this limitation, as discussed previously, the design used in this DCE is a D-efficient experimental design, which, as discussed by Greiner (2016), requires smaller sample sizes than random orthogonal designs, as illustrated by Rose et al. (2008) and Bliemer and Rose (2011). Furthermore, the time taken to complete the survey may have discouraged some farmers, leading to drop-offs. The average time taken to complete the survey was 15.9 minutes. Given this

limitation of a small sample size, our results are not generalisable to all French farmers, but are still valuable given the little existing research on French farmers' reluctance to reduce pesticide use, and difficulty in reaching large samples at once.

Figures in the Appendix summarise the sample's main characteristics. Figure 15 depicts the sample distribution on age, level of education, type of culture and number of employees on the farm. Table 2 indicates the proportion of farmers in the sample that i) have revenues from outside the farm, ii) are organic, iii) have already reduced their use of pesticides, iv) use alternative practices to pesticides, v) frequently attend training and vi) have neighbours who have reduced their use of pesticides.

While there is a diversity of farming systems in the sample, the great majority (72.56 %) are field crops farmers who use fungicides, insecticides and herbicides. Followed by this are mixed crop and livestock farmers (22.54 %), and a very low number of vineyards and market gardening farmers (both representing 1.96 % of the sample). About 6.4% of the sample are organic farmers. Organic farmers were included in the sample as their preferences could provide valuable insights into the way farmers in general should be accompanied in the transition to agro-ecological practices, as they have already gone through these processes. Furthermore, studies have shown that the insecticides organic farmers are authorised to use may have negative impact on pollination and pollinators, and certain organic farmers are seeking to transition to agro-ecological practices even further (AgenceBio, 2021).[4]

Around half of the farmers taking part have additional external sources of revenue. Out of all respondents, 79% have already reduced pesticide use (although the average reduction amount of our sample was a 30 % reduction throughout their professional careers) , and 89% have used alternative practices to pesticides. Upon questioning the impact of pesticides on the environment and health, many believe them to have a 'moderate' effect on both (50 %). Given that recent figures show, as mentioned above, that pesticide use has increased in later years (Lapierre et al., 2019; Hossard et al., 2017), this high number of farmers stating that they had already reduced pesticides may indicate that farmers that took part in this study are some of the more motivated and green front-runners of French farmers. However, we also need to acknowledge that these figures also depend on the way that pesticides are measured (whether in kilogrammes, litres, through activation and other indicators), which means we need to interpret these figures with caution. Changes can and will also be linked to farm and crop type changes, as well as weather conditions. Nonetheless, even if this selection bias may exist in our sample, the obstacles to reducing pesticides may then be *even* stronger in the overall population of farmers that have not taken steps to reduce pesticides, as compared to those that have already done so. The results obtained from this group therefore remain relevant, and perhaps even more so, to farmers in general that have not yet started to reduce the use of pesticides.

The largest proportion of respondents were in the age group 40 - 49 (31.3 %), followed by age groups 30-39 and 50-59 (both at 26.3 % respectively), then 18-29 at (10.1 %) and lastly those over 60 (6 %). In terms of education, most of the farmers that took part had completed Bachelor's level degrees (47.06 %), followed by a high school diploma (22.55 %), a Master's degree or higher (14.71 %) and vocational training (11.76 %). The lowest proportion had not completed any formal secondary education (1.96 %). Most of the respondents worked as sole employees on their farm (55.35 %), some with one to two employees (31.68 %), and a minority worked with three or more employees (12.97 %).

[4]A robustness check has been performed to verify that these respondents have not skewed the data. Results remained similar which shows this is not the case.

Table 2 compares the descriptive characteristics of our DCE sample with the average French farmer, based on information from AgenceBio (2021), Graph'Agri (2020) and Chèze et al. (2020). Our sample is rather representative of the population in terms of age and the proportion of respondents with high school diplomas. However, similar to the sample of Chèze et al. (2020), farmers with higher education diplomas are over-represented - which is typical for online surveys. Nonetheless, statistics show that the level of French farmers' education has drastically increased over the generations (as is the case for all professions in France). In 2016, 50 % of farmers had a bachelor's degree or higher. For farmers under 40, 85 % of farmers have a level of education at least equal to the bachelor's degree. It is important to mention that subsidies for farmers are conditional on a minimum level of education, and these subsidies increase depending on the level of education a farmer may have. One of the results is that French farmers now have among the highest levels of education in the European Union (Graph'Agri, 2020). In our sample, the mean size of farms is significantly larger than it is for the country as a whole, even though data shows that farms in France are consistently growing - i.e., in 2016 the average farm in France was 63 hectares large, which is 7 hectares more than in 2010 and 20 more than in 2000.

As mentioned above, our results are therefore not entirely directly applicable to the entire population of French farmers. Nonetheless, an imperfect sample is better than no sample, and we believe that insight from the farmers that did take part are still valuable input to the policy discussion.

Table 2: Comparison between survey sample and French farmers in general

	Our sample	French farmers
Mean age	40-49	50.6
Farm size (hectares)	179	63
Proportion with a high school diploma	13.72 %	21 %
Proportion with a higher education diploma	84.32 %	50 %
Farmers with an outside revenue	58 %	51 %
Organic farmers	6.36 %	8.3 %
Farmers that have already reduced pesticide use	79.09 %	13 %
Farmers that frequently attend training (>every 2 years)	52.83 %	53 %
Farmers that have neighbours that already reduced pesticides	44.34 %	n/a
Farmers that use alternative practices	89.09%	n/a

4.1.2 Econometric analysis

Attributes for impact on income, impact on health and the environment, and transition time were treated as quantitative continuous variables. Optional support and work schedule were modelled as qualitative categorical variables. The levels of the categories for the additional optional support were "advisor", "network", "training" and "none", with base level being "none" via a dummy encoding. The levels were "more condensed", "more spread out" and "unchanged" for the work schedule, with base level being "unchanged", also via a dummy encoding. Econometric analysis was performed using Stata.

The conditional logit model (McFadden, 1973) was first run on our results, which is considered the workhorse model of discrete choice experiments. The conditional logit model is based on three

assumptions: (1) independence of irrelevant alternatives (IIA): the probability ratio of individuals choosing between two alternatives does not depend on the presence or absence of any other alternative within the set of alternatives included within the model ; (2) that error terms are independent and identically distributed across observations; and (3) no preference heterogeneity (i.e. identical preferences across respondents) (Hensher et al., 2015). We ran the Hausman-test of the IIA assumption (Hausman and McFadden, 1984) on our conditional logit model, and our results confirmed that the IIA assumption could be rejected in our model ($p < 0.01$).

That the IIA assumption could be rejected suggests that the random parameters logit model is preferable to the conditional logit model given that it relaxes the IIA assumption. The assumption of homogeneity is also relaxed in random parameters logit models as it enables capturing unobserved preference heterogeneity by allowing the preference parameter to vary across participants, in addition to the traditional assumption of having no correlation between the random parameters (Train, 2009). Latent class models, on the other hand, are used to uncover possible different preference patterns among assumed respondent segments and also extends the conditional logit model. Segment membership, which is unknown to the analyst, is characterised by unobserved (latent) variables which can be related to a set of discrete observed measures such as general attitudes and perceptions, as well as socio-economic characteristics of the individuals (Amaya-Amaya et al., 2008). Based on the log likelihood values, we can also safely reject the conditional logit model in favour of either the random parameters logit model or latent class model. To compare the model fit of the random parameters logit model and the latent class model the comparison on a likelihood ratio test is not appropriate as they are not nested. AIC and BIC values illustrated that the latent class model had the best model fit, and we therefore present the latent class model below. Results of the main random parameters logit model are presented in the Appendix.

In the latent class model, determining the optimal number of classes (segments) is key as it is not predetermined. Generally, the literature sees that somewhere between two and five classes should suffice (Amaya-Amaya et al., 2008), and that the best segment retention criteria is a variation of the Akaike's information criteria (AIC) with a per-parameter penalty factor of 3 (Bozdogan, 1993; Andrews and Currim, 2003).[5] Nonetheless, it is recommended that several criteria are compared (including the Bayesian information criteria (BIC) and the Consistent Akaike information criteria (CAIC)). The results of the attempted number of classes and associated information criteria are presented in Table 3. They clearly indicate that the best model fit lies in the model with two classes.

Respondents in class 1 represent 76 % of respondents in the sample and are more likely to frequently attend training and be a mixed crop and livestock farmer than those in class 2. Results for class 1 revealed a significant, strong and negative value for the constant, indicating that there was a preference of this class to exit the status quo, i.e., to change their farming practices. They also show a significant preference to reduce impact on health and environment by reducing the use of pesticides.

Respondents in class 2 are the remaining 24 % of respondents in the sample. They show a highly significant dis-utility to reduce the impact on health and the environment through the reduction in the use of pesticides - in other words they do not want to change to alternative practices. This is confirmed by the insignificant coefficient associated to the constant, indicating these farmers do not show a preference to exit the status quo and modify their farming practices. Farmers in class

[5]This information criteria is defined as AIC3 = 2LL – 3K where LL is the estimated log-likelihood of the model and K is the number of estimated parameters. As long as decreases on AIC3 are observed, adding segments (classes) is beneficial.

2 value positively a spread out work schedule compared to a condensed one. Interaction effects in this class showed that, somewhat counter-intuitively, the more frequently a farmer in this class attended training the higher the dis-utility for a higher income. Moreover, the older farmers, as well as field crops and mixed crops and livestock farmers, were more likely than the average to have a significant utility for reducing the impact on health and the environment through the reduction in the use of pesticides.

Table 3: Model statistics for two to five segments (classes) of the latent class model

	Log-Likelihood	Parameters	BIC	CAIC	AIC	AIC3
2 classes	-555.0241	25	1227.56	1252.56	1160.0482	1185.0482
3 classes	-541.46	41	1275.64	1316.64	1164.92	1205.92
4 classes	-527.4194	57	1322.766	1379.766	1168.8388	1225.8388
5 classes	-515.0482	73	1373.231	1446.231	1176.0964	1249.0964

Table 4: Latent Class Model

	Class 1 (std. err)	**Class 2** (std. err)
Income	-0.025 (0.028)	0.062 (0.052)
Constant	-1.40*** (0.366)	0.791 (1.01)
Transition time	-0.006 (0.051)	-0.019 (0.162)
Health and environment	0.018* (0.018)	-0.047*** (0.015)
Condensed work schedule	0.063 (0.274)	1.062 (0.608)
Spread out work schedule	0.236 (0.267)	1.06* (0.548)
Advisor	0.263 (0.205)	-0.758 (0.682)
Training	0.175 (0.191)	-0.295 (0.544)
Network	0.039 (0.190)	-0.338 (0.523)
Subject effects		
Age*Health and Environment	-0.001 (0.001)	0.005** (0.003)
Training Frequency*Income	0.003 (0.007)	-0.043** (0.021)
Field crops*Health and Environment	-0.012 (0.008)	0.049*** (0.008)
Mixed crop and livestock*Health and Environment	-0.014* (0.008)	0.051** (0.022)
Class share	0.759	0.241
Log-likelihood	-561.53516	
AIC	1195.07	
BIC	1392.91	
N	1800	

Asterisks denote statistical significance at the *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ level.

The remaining attributes were not significant despite all attributes and levels being described as relevant and important in both focus groups and pre-tests. These insights required further testing, given that they did not conform with the information acquired in the pre-experimental stage, and in-depth discussions were required with the farmers to understand why the attributes 'Transition time', 'Work schedule' and 'Free and optional agricultural support' were disregarded and therefore inconclusive.

4.2 Qualitative interviews

4.2.1 Descriptive statistics

The 18 farmers that took part in the qualitative interviews were representative of those that took part in the DCE with a slight over-representation of farmers frequently attending training (Table 5). Based on our comparison, we can assume that the results from the qualitative interviews provide indications for all the participants who took part in the DCE. Further graphs that support this assumption can be found in Appendix A.3. The sample that took part in the interviews therefore hold the same limitations as those for the DCE: a selection bias could exist and a number of respondents in the sample had already reduced pesticides, with large farms and high levels of education.

Table 5: Descriptive statistics of qualitative interviews' sample compared to DCE sample

	DCE sample	Qual sample
Mean annual income	€18,566	€17,067
Size of farm (ha)	179 ha	190 ha
Farmers that have already reduced pesticide use	79.09 %	86.67 %
Farmers who have already used alternative practices	89.09 %	86.67 %
Farmers with neighbours that already reduced pesticides	44.34 %	40 %
Farmers that frequently attend training (>every 2 years)	52.83 %	86.67 %

4.2.2 Results

The qualitative results and open-ended discussions showed that farmers are facing unprecedented challenges in how they undergo their professional activities. Given the nature of the changes at stake - to farmers' everyday lives - it was clear that the farmers that took part in the interviews appreciated an open forum and personal interaction to discuss their concerns. The interviewers let the farmers express themselves freely but also discussed topics covered by all the attributes to deepen the understanding on the apparent rejection of the farmers of certain attributes in the DCE. These topics included income, transition time, impact on health and the environment, work schedule, and optional and free agricultural support. The responses from the farmers indicated that there was no simple answer to these questions, requiring further discussion in a more open format than the DCE.

The methodological implications highlight the advantage of complementing the rather rigid format of the DCE when approaching topics that may be of a controversial nature, and for certain expert groups, such as farmers. This may have led to the initial rejection of farmers to take part in a closed-form survey and disregard of several attributes in the DCE. The findings of the qualitative interviews were key to understand farmers' motivations. What came through in the discussions, as through the DCE, was that most farmers were keen to make a change, but were at a loss as to how this could be done. From these discussions and data analysis, the main results could be sub-categorised into four major themes as listed below:

- technological uncertainty
- economic uncertainty

- social uncertainty
- governmental uncertainty

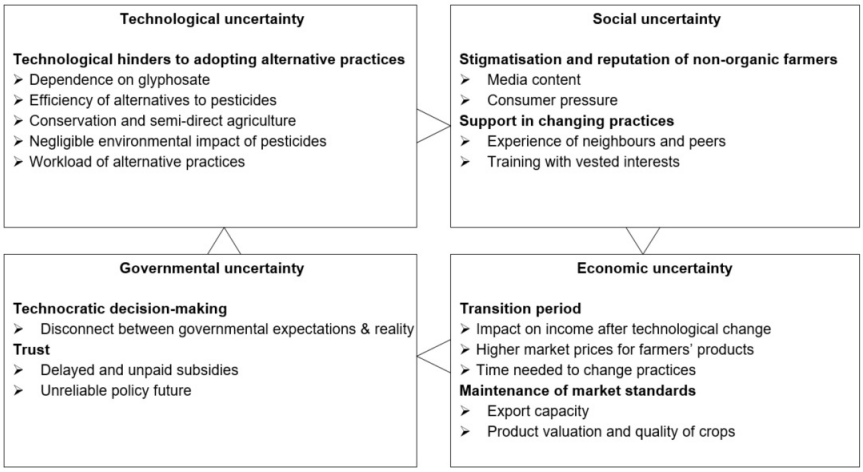


Figure 3: Summary of main themes emanating from qualitative interviews

These themes - that are all interconnected - are summarised in Figure 3. Figures 4 and 5 show visual representations of word frequencies ('word clouds') derived from all interview transcripts, firstly on the general topic (Figure 4) and, secondly, divided into the four main categories (Figure 5). The more often a word appeared in the transcripts, the larger the word appears in the word cloud generated. While word clouds are useful to gain an overview of the main issues being discussed in the interviews, limitations exist to using these tools for analysis, however. Words are retrieved out of context as the technique omits the semantics of the words, and the phrases they comprise. Qualitative content analysis thus also included, with Nvivo, familiarisation with the data through slow reading, deductive and inductive construction of codes, phrases and quotations classified into main categories and subcategories.



Figure 4: Visual representation of word frequency derived from interview transcripts

A frequency table (Table 6) was developed and used to provide descriptive information on the interviews, to guide our descriptive language in the analysis below, referring to the share of farmers



1. Technological uncertainty

2. Economic uncertainty

3. Social uncertainty

4. Governmental uncertainty

Figure 5: Visual representation of word frequency within four main themes

interviewed that vocalised a given issue: >50% was considered "Most"; 30–49% "Many"; 10–29% "Some"; <10% "Few" in the interviews, once the data had been classified into each category. A table of representative quotations for each category and sub-category can be found in Appendix A.4. The bold lines indicate the categories that were drawn from the sample's responses. The sub-categories are listed below the categories.

Technological uncertainty

All farmers made clear that they felt they were being pushed into changing practices, despite a lack of clear and realistic alternatives being available to them. Most farmers pointed out that glyphosate dependence was synonymous with this hindrance; that for instance, "if glyphosate is banned, there is nothing I can do", while another stated that "the main problem, as is the case for all my colleagues, is glyphosate dependence". Glyphosate, one of the world's most widely used active substances in plant protection products, has, in recent years, become a subject of controversy over its safety and impact on the environment. Despite these controversies, the EU has renewed its approval of the substance until 2022, even though several member states, including France, call for its ban. The future of glyphosate is highly uncertain. With this in mind, some farmers vocalised their opposition to the ban, maintaining that there are no viable alternatives for the chemical. A quick transition to farming without the use of glyphosate is for many farmers too costly and challenging. Farmers working in conservation agriculture particularly highlighted this, whose method is based on non-tillage - causing dependencies on herbicides such as glyphosate. As one farmer clarified: "I want to stick to conservation agriculture using plant covers, but that can only be done with glyphosate." Many of the farmers interviewed stated that alternatives to pesticides were just not efficient enough and that "there is no alternative that will maintain the current level of production."

While many farmers did raise concerns about the impact of pesticides on the environment, with

Table 6: Frequency of codes organised by themes, categories and sub-categories

Theme 1. Technological uncertainty		
Category and sub-categories	**No. of respondents**	**% of respondents**
Technological hinders	**18**	**100 %**
Dependence on glyphosate	10	55.55 %
Efficiency of alternatives to pesticides	8	44.44 %
Uncertain environmental impact of pesticides	8	44.44 %
Workload of alternative practices	7	38.88 %
Conservation and non-tillage agriculture	5	27.77 %
Theme 2. Economic uncertainty		
Categories and sub-categories	**No. of respondents**	**% of respondents**
Transition period	**16**	**88.88 %**
Impact on income after technological change	14	77.77 %
Time needed to change practices	5	27.77 %
Higher market prices for their products	3	16.66 %
Maintenance of market standards	**9**	**50 %**
Product valuation and quality of crops	5	27.77 %
Export capacity	4	22.22 %
Theme 3. Social uncertainty		
Categories and sub-categories	**No. of respondents**	**% of respondents**
Stigmatisation of non-organic farmers	**15**	**83.33 %**
Media content	8	44.44 %
Consumer pressure	7	38.88 %
Support in changing practices	**14**	**77.77 %**
Experience of neighbours and peers	12	66.66 %
Training with vested interests	4	22.22 %
Theme 3. Governmental uncertainty		
Categories and sub-categories	**No. of respondents**	**% of respondents**
Technocratic decision-making	**12**	**66.66 %**
Disconnect between expectations and reality	12	66.66 %
Trust	**15**	**83.33 %**
Delayed/unpaid subsidies	10	55.55 %
Unreliable policy future	5	27.77 %

one stating that he wanted to stop exposing himself "to improve the quality of [his] life," many others felt that by using the right equipment and respecting good practices, changing practices was not necessary as they were already able to "minimise impact" by doing this. A further factor that added to apprehension was the additional workload and time needed to adjust: many interviewees mentioned this. This was especially true for those that had already made changes to their pesticide application routines: as one farmer mentioned, "since I switched to mechanical weeding, my workload has significantly increased. Chemical weeding used to take me 2 days, but now it takes me at least 15 days a year." Stress on day-to-day lives was also highlighted as a transition "involves more monitoring and more observation." At the same time, another underlined the "lack of knowledge and [the] experience required" to make a change. While some acknowledged that these technological uncertainties presented new opportunities, the hurdle they have to cross - from learning new practices to investment in new technologies - seemed insurmountable to most farmers due to the attendant risk of not ensuring a smooth transition.

Economic uncertainty

While income was noted as a major factor influencing decision-making, it was most of all a lack of certainty and predictability on income that elicited an aversion to switching to alternative practices. Incorporated into this uncertainty was the expected transition period and income instability during this period, a concern raised among most farmers interviewed. One questioned the interviewers: "How am I going to make a living during this transition period when it is expected that we will be making less money [during this time]? It has to be possible to maintain the farmer's income during the transition period." Another highlighted that "if I have to invest in a big tractor and other machines [to make a transition], I will not have any income left." One pointed out that "if farmers are profitable in the system they are currently operating in, they will not change." A few noted the wish for improved valuation of their products: "my main concern is that the efforts made are not valued at the level of the product. I don't want any subsidies or help. I want a remunerative price to make a living from my job." Furthermore, some felt that too much time was needed to change practices, as it is expected that the transition period "lasts at least 5 years." Moreover, most farmers were concerned about maintaining market standards and the quality of their crops. One such concern was raised by some interviewees related to the expected export capacity, with a fear that there would be an "unfair competition with international products" and that if glyphosate were to be banned, they would "no longer be competitive." Some also pointed to a fear of maintaining yield and productivity, with one claiming that "I have the best yield in my area, so I do not need to change practices." This statement corresponds with the findings of Pedersen et al. (2012): that some farmers are more focused on optimising yield and pay less attention to expenditures and crop prices.

While most interviewees confirmed that farmers were open and willing to change practices, the economic uncertainty and unpredictability involved were of central importance to decision-making. As discussed above, several of the farmers highlighted the precariousness of their situation: from low incomes, to high costs of transitioning to alternative practices and difficulties maintaining competitiveness. This context likely contributes to farmers' perception that regulatory bodies constrain their ability to execute their role as producers effectively, as they put pressure on what farmers feel is an already strained line of work. As agriculture has increasingly become the focus of much environmental scrutiny, farmers may feel that their productive and profit-earning capacity is at risk in complying and reaching new standards (Burke and Running, 2019), on top of the precariousness of the agricultural profession that already exists.

Social uncertainty

In terms of social uncertainty, farmers that took part in the interviews felt intense pressure "from the government and consumers, but especially from the media." Most of the farmers interviewed felt stigmatised for not being organic. In turn, they felt a lack of understanding between farmers and non-farmers (out-group), leading to what felt like an attack on their identities. In almost all interviews, what came across was the intense social pressure they felt against their profession as farmers, and particularly from the media: “I’m worried on a daily basis that I’ll be attacked in the media” as one farmer said. One mentioned that whenever he goes out with his protective gear on, “I feel like everyone is watching me.” This sense of stigma has, in turn, led to them being defensive of their profession, with some arguing that “people on social media should stop taking themselves for agronomists.” Moreover, “the pressure comes from people who do not know what they are talking about – with the internet making things worse,” as one noted. On the other hand, collaboration and cooperation between farmers is strong. Something that came across among most of the respondents was the wish for face-to-face interaction in finding solutions to changing practices, as exemplified by statements such as “the first advisor I listen to is my neighbour, and innovative peers: it is what is done in the fields that is proof of what works,” to "when I changed practices, I did it together with friends and neighbours", and "you have to directly see what works for farmers." Furthermore, some of the farmers spoken to highlighted the need for regulatory bodies to converse personally with farmers to achieve results: "It is by talking to farmers that we can find solutions," while simultaneously “promoting greater visibility for those who are more efficient.” Some further highlighted that particular training types had vested interests, stating that, for instance, “authorities should go directly to farmers that want to progress instead of going to chambers of agriculture or cooperatives, as these are often only looking to sell products even when treatment is not necessary.” A consistent theme that emerged from the interviews was that policymakers, support-measures and consultants should have direct contact with farmers if results are to be achieved.

In times of uncertainty, norms within a group or community that a farmer belongs to may be more likely to influence behaviour than anyone else’s. Identifying with reference groups and guiding behaviours based on what peers are doing can reduce uncertainty through knowledge and experience sharing (Smith et al., 2008). Furthermore, a main motivator for success is achieved in group contexts by positive in-group evaluations relative to other relevant out-groups, which suggests making examples of successful farmers in a given farming community could contribute to positive behaviour change. We, therefore, confirm the findings of Fielding et al. (2008); Bakker et al. (2021) that maintain that concrete recommendations emanating from other farmers may be more readily accepted than recommendations from others, such as governmental advisors. As has previously been illustrated by Sutherland et al. (2012), most of the farmers interviewed in our study underlined that they would be more inclined to change practices with the support of peers, through face-to-face interaction based on the sharing of experiences, rather than via external training by travelling technicians. This is a critical point for the future organisation of governmental support measures.

Governmental uncertainty

Finally, discussions with interviewees demonstrated what felt like a large disconnect between farmers and the government. As such, farmers interviewed saw that policies were out of touch with the agricultural reality and that incentives were not targeted appropriately at specific farmer groups. Policy is considered to be decided from Paris by ’technocrats’ (in the sense of an office worker who does not know much about farming): "the government is out of touch with reality. (...) We need specific policies for each region". Another pointed out that "the government is completely

disconnected from the reality of farmers because it is led by technocrats, not by people who know what farmers know: the government needs to listen to farmers," and "I have nothing against the government, but they do not know how to deal with people and professions different to them." In addition to an apparent disconnect between farmers and the government, a lack of trust was also highlighted in most interviews, with trust needing to be regained if policy targets are to be reached. This lack of trust often stemmed, from most farmers interviewed, from delayed and unpaid subsidies to those who had made shifts to a more sustainable agricultural system. One farmer underlined that "the government is lagging behind. I only received the payments and subsidies for 2017 today (two years later),", while another stated: "I am skeptical of any support from the government" in general for instance. This lack of trust also emanated from an unreliable policy future with some feeling that "the future of my farm is very unclear" for example. Therefore, what was highlighted was that communication between both groups should be encouraged, which could close the gap between what farmers consider the 'out-group', on the outside, and the 'in-group' of fellow farmers. A central argument that the farmers wanted to communicate to the authors was that they wanted to be listened to by the government, especially given that they felt that there is no current workable alternative to their farming practices. Many felt that their efforts to date had not been valued and that the government needed to "better support" alternative practices.

The interviews illustrate that social pressure from within farmer communities is often more likely to influence behaviour than pressure coming from outside pushes. Many reasons can be attributed to this. Past research has shown that when authorities or communities are trusted less (Tanis and Postmes, 2005), there will be less acceptance to engage in recommendations provided by that authority (Mackie et al., 2000). In addition to this, past research has shown that there may be a greater resistance to criticism that stems from out-group members (Hornsey and Esposo, 2009). Farmers in our study made clear that they yearned to be better listened to as they felt policies were out-of-touch with reality and that they, as a profession, were not taken seriously. It was clear that they felt their opinions and experience as farmers were unfairly undervalued and discredited in how the future of farming was planned. A way to bridge this gap in trust would be to integrate farmers' perspectives in policy approaches. Concrete possibilities to bridge the gap between farmers' perspectives and policy could include more field visits by policymakers, experts and agricultural advisors to farms to discuss individual cases and alternatives for change. On the other hand, farmers could be invited to seminars and training organised by authoritative research institutions and governmental organisations. Similarly, training could be organised for policymakers on the technical aspects related to agriculture, organised in collaboration with farmers.

5 Discussion

Even though we cannot generalise our findings to all farmers in France, we can draw some conclusions based on the group of farmers that we did reach - which includes farmers with a higher proportion of higher education diploma, which have already reduced pesticides to a certain extent and have larger farms than the average French farmer. Bringing the results together, both the quantitative and qualitative results illustrate that most farmers in our sample wish to change practices but are at odds as to how this could be done. The results of the latent class model illustrated that the majority of the farmers that took part (75.9 %) wished to change practices (through a preference for an exit from the status quo) and showed a preference for reducing impact on health and the environment through a reduced use of pesticides, but disregarded the remaining attributes presented to them - including income, transition time, and optional and free agricultural support.

The remaining farmers in our sample (24.1 %) that took part in the discrete choice experiment showed a significant preference for *not* reducing impact on health and environment through the reduction of pesticides.

Based on the results of the qualitative interviews which illustrated a deep uncertainty for the future for technological, economic, social and governmental reasons, it is clear that there is no one-size-fits-all solution to encouraging and accelerating the transition to agro-ecological practices. We argue that the interviews provided us with some indications as to why the attributes of income, transition time and preference for optional and free agricultural support were not significant: the majority of the farmers that we discussed these topics with could not realistically foresee how this pesticide-free future would look like due to these inherent uncertainties. Moreover, the political scrutiny currently aimed at the agricultural sector may have elicited resistance among the farmers as evidenced by very high drop-off rates at the start of the survey as soon as the farmers became aware of the topic they would be questioned about - due to the controversial pesticide issue which divides opinion, for example between communities such as farmers, ecologists and authorities.

While the use of inputs like pesticides and fertilisers is always a controversial issue for most conventional farmers - given that farmers generally feel they use the necessary amount of inputs - the survey was distributed at a time when the topic of pesticide reduction was a particularly sensitive topic in France for several reasons. Since the mid to late 2010s, discussions with farmers surrounding the reduction of pesticides has generally been compounded by *agribashing* in France. van der Ploeg (2020) defines agribashing as the "simultaneous referral and deligitimisation of all critiques of the current organisation of farming [...]." An example of what farmers refer to as agribashing was a documentary released in 2018 on French national channel *France 2* entitled "Pesticides : notre santé en danger" - translated to "Pesticides: our health in danger" which caused protests by many French farmers (Chèze et al., 2020).

There exists a deepening socio-political divide between French farmers and non-farmers. As evidenced in a recent survey entitled the Farmers' Confidence Barometer distributed by Copa-Cogeca with 2,500 farmers in Italy, Hungary, France and Germany, 75 % of French farmers stated that their farming practices had been criticised, while 48 % suggested that the number of critical comments had dramatically increased in 2019 in comparison to previous years. Germany came second with 59 % of farmers believing that their practices had been criticised, while in Hungary (38 %) and Italy (12 %) criticism in public discourse proved to have less of an impact. As Copa-Cogeca is a European lobby group for farmers' interests, they have a certain interest in providing such numbers, but we can nonetheless take note of French farmers surveyed being the most affected by feelings of outside criticism in comparison to the three other countries studied.

As van der Ploeg (2020) discusses, around the time of the distribution of our survey - during the summer of 2019 - a round of demonstrations directed against free trade agreements such as Mercosur and CETA took place - notably in France - with heavy participation from farmers. The opponents of these trade agreements argued that they would undermine European social and environmental regulations by allowing agricultural imports from outside the EU, causing a potential hit to farmers' livelihoods. These demonstrations were followed by demonstrations against agribashing, environmental constraints[6] and low prices in October and November 2019 led by the official, farmers' union FNSEA (Fédération Nationale des Syndicats d'Exploitants Agricoles: National Federation of Farmers' Unions). The FNSEA presented agribashing as a generalised problem: bringing

[6]Several French mayors declared municipalities to be 'pesticide free zones'. This caused considerable discontent among farmers, while also bringing farmers' organisations together in a unified coalition. The discussed ban on glyphosate also played an important role in these demonstrations.

together attacks by animal welfare activists, governmental environmental policies, unwillingness of consumers to pay fair and remunerating prices, the climate crisis, and so on, into one category that refers to 'others' and which helps to avoid the needed debate on the crisis within agriculture. The avoidance of such a debate partly stems from the FNSEA itself being deeply involved in the production, processing and distribution of food themselves (van der Ploeg, 2020).

We argue that when presented with the controversial topic of pesticides, that presents an unprecedented change to their professional lives and ways of work, filled with uncertainty, farmers in our sample could not accept a one-size-fits-all response. Our experience thus illustrates how farmers' narratives - including local and individual components- could not be fully tackled - in this particular case - through a rigid and closed-form approach as the DCE. We believe this experience can be of benefit to DCE researchers investigating similar controversial topics in the future. Nonetheless, the in-depth discussions further provided indications that uncertainty and an apparent disconnect between farmers and outside pushes were central, and allows us to draw the conclusion that improved communication between authorities and farmers is key if we are to accelerate the transition to agro-ecological practices. The interviews further highlighted how farmers draw upon social relations and local knowledge in their reactions and resistance to contemporary agro-ecological policy, and the importance of in-group influence, peer experience and social identification with other farmers. Also, the farmers despised feeling incriminated by the general population, media pressure and felt a strong disconnect with the government. As mentioned by Smith and Louis (2009), uncertainties accentuate in-group influence. Moreover, the distrust felt by farmers regarding the French government (due, among other factors, to delayed payments) amplifies the rejection of out-group influence.

This uncertainty might have participated to farmers' rejection of the choices presented in the DCE. Farmers may have considered it too unrealistic to make choices on their professional future due to the uncertainty with regard to technological change - they do not see how they can make a change without the pesticides they are currently using, nor do they see how they can maintain their income. Further, the problem felt by many farmers is that current approaches tend to exclude the expert knowledge of farmers in the way that the future of farming is being planned out through policy. As highlighted by Burke and Running (2019) in their discussions with farmers on pro-environmental behaviour, farmers often painted a picture of "us versus them," with the "them" portrayed as "well-meaning but silly city folks without intimate knowledge of the natural environment." In this sense, the farmers argue that agricultural policies and recommendations have little understanding of the technological difficulty of implementing the policies (Fielding et al., 2008). If farmers view that regulatory agencies compete with their interests, and threaten their credibility by not considering their expert knowledge, they will be less inclined to adopt the proposed technological change. Given that the DCE was presented to them where a transition to farming with reduced pesticides was assumed, farmers who do not know how this is possible may have rejected the choices presented to them.

This paper has contributed to the literature within the field of agro-ecological transitions that takes both social and economic dimensions into account when considering farmers' decisions to adopt agro-ecological practices (Woodgate and Sevilla Guzmán, 2015; Aubron et al., 2016; Dumont et al., 2016; Kapgen and Roudart, 2020; Plateau et al., 2021). In so doing, we corroborate findings of scholars looking into similar themes that we divide into four particular domains - including technological, economic, social and governmental uncertainty. Regarding these four domains, our results indicate a technological uncertainty related to the alternatives to conventionally used technologies such as pesticides, that has previously been found in studies by Lechenet et al. (2017)

and Khan and Damalas (2015). As further elaborated upon in the interviews, regarding economic uncertainty, we found that the investments required to take up new practices, and those already made, caused some farmers to be risk-averse about changing practices - which illustrates a certain technological lock-in from past financial investments (Cowan and Gunby, 1996; Wilson and Tisdell, 2001). Quality of products (and in turn consumer expectations, as was found by Skevas and Lansink (2014)) also contributed to a particular economic uncertainty felt by farmers interviewed. As was illustrated by Bakker et al. (2021), the intention to reduce pesticide use is strongly determined by whether other farmers also act, and especially peers such as conventional neighbouring farmers and members from study groups, and those that shared similar values and experiences. The importance of peer support in implementing new strategies, and working together with other farmers when decreasing pesticide use, was also found by Brewer and Goodell (2012); Parsa et al. (2014); Stallman and James Jr (2015), and the farmers we interviewed made a strong case for these findings as well. Our work complements these results in highlighting how, in particular in our case among the French farmers that took part, there is a strong disconnect between authorities and themselves as a group of farmers. We argue that this governmental uncertainty brings farmers together and further increases the importance of peer support and policy that take agricultural networks into consideration.

6 Conclusion

This paper has analysed the socio-economic trade-offs that French farmers are currently facing in the transition to agro-ecological practices. Despite substantial policy efforts, it is increasingly clear that the marked rise in the adoption of agro-ecological practices necessary to achieve sustainable agricultural systems is not happening fast enough. The respondents who took part in the study included farmers residing in France, and our aim was to capture an overview of some farmers facing these changes and challenges. Given that our sample was not representative of all farmers throughout France, our policy recommendations are based on the findings from the farmers in our sample. They provide avenues for solutions and actions but need to be corroborated by further research.

The quantitative results showed that most farmers that took part are keen to change the current state of affairs (i.e. the coefficient associated, in the model, to a change from the status quo was highly significant for a majority of respondents), while a minority did not wish to change practices through a reduced use of pesticides. However, the early drop-off rates were high and farmers that did take part disregarded many of the remaining attributes presented to them. We argue that farmers appear at a loss as to how to achieve transition in a one-size-fits-all rigid approach such as the DCE.

The qualitative interviews complemented the results of the DCE by illustrating that, from our analysis, farmers were keen to openly discuss their personal experiences on the topic of pesticide reduction. They revealed the importance of peer and network support in reducing pesticide use. The farmers that took part repeatedly mentioned the central importance of feedback from other farmers' experience, which indicates the crucial role of in-group influence. Also, the farmers feel incriminated by the general population and experience media pressure and a strong disconnect with the government, which is amplified by several factors. First, the strong uncertainties that have been reported by farmers regarding technological change, the economy, society and the government. Second, the distrust felt by farmers regarding the French government (due, among other factors, to delayed payments) amplifies the rejection of governmental and policy influence. In sum, the

interviews highlighted how farmers draw upon social relations and local knowledge in their reactions and resistance to contemporary agro-ecological policy. It is this precise form of resistance that binds together the otherwise rather heterogeneous group of farmers. The problem felt by many farmers is that current approaches tend to exclude their expert knowledge, which forms an essential element in the identity of farmers. Our results further highlighted the importance of in-group influence, peer experience, and how social identification with other farmers affects willingness to change practices.

The use of DCEs might have been partly rejected in our case as i) farmers are professionals and thus experts on their everyday work topics, making them less inclined to accept abstract and simplified approaches made by researchers and people that are not fully immersed within their groups through DCEs - to mimic their decision process ii) the agro-ecological transition is characterized by strong uncertainties for farmers and iii) the pesticide issue is controversial and strongly divides opinion between communities such as farmers and non-farmers. This paper thus highlights the importance of qualitative approaches to complement the more closed-ended DCE format on controversial topics inducing strong uncertainties and impacting livelihoods and respondents' identities.

Overall, both the quantitative and qualitative results illustrate that farmers wish to change practices but are at odds as to how this could be done. Several policy recommendations arise from our findings.

First, perceptions of peers may influence behaviour more efficiently than outside pushes, which is key to take note of when planning strategy and policy. We corroborate the findings of Bakker et al. (2021) which was based on Dutch farmers, on the importance of collective action - in the sense that future pesticide reduction strategies should rely on social interaction and shared experience. French farmers in our sample look to successful examples of how to decrease pesticide use, either through exchange with peer farmers or knowledge provisioning on alternative pest control methods. Specifically, within-group comparison standards between farmers could potentially be made use of to encourage behavioural change and to attain more targeted approaches. One crucial motivation for group-mediated action is uncertainty reduction. Identifying with relevant reference groups and guiding your behaviour based on what your peers are doing can reduce uncertainty through knowledge and experience sharing (Smith and Louis, 2009; Cialdini and Goldstein, 2004). In times of uncertainty, norms within a group that a farmer belongs to may therefore be more likely to influence their behaviour than anyone else's. The importance of peer support in implementing new strategies, and working together with other farmers when decreasing pesticide use, was also found by Brewer and Goodell (2012); Parsa et al. (2014) and Stallman and James Jr (2015).

Second, bridges between farmers and policymakers should be encouraged. A deepened knowledge of the field by policymakers and immersion within the group of farmers, their livelihood and identity would be most welcome. Former experience as a farmer for certain policymakers and/or increased face-to-face contact, locally, with farmers would be useful. Regulatory bodies that seek to encourage a transition to agro-ecological practices may therefore attain better results by recognising, valuing and shining a light on farmers' expert and local knowledge in policy development. Communication needs to be improved between authorities and farmers - going both ways - due to this major disconnect felt between the two groups. Overall, the research made evident that farmers were keen to discuss solutions to overcoming the transition openly, and both the DCE and the qualitative interviews made clear a wish for targeted, community-focused and personal policy measures to ease the transition.

Third, the extremely strong uncertainty felt by farmers in several fields needs to be reduced. Regarding technological uncertainty, research should be pursued on agro-ecological technological alternatives to pesticides and farmers should be regularly informed on the obtained improvements.

Several interviewed farmers did actually mention their wish to be informed on research advances on this topic. On economic uncertainty, as mentioned in Chèze et al. (2020), cheap and good quality insurance could be offered to farmers to reduce their income variability. Regarding social uncertainty, the general population should be sensitised - with the help of the media - on farmers' work, lives and concerns to reduce the stigma felt by the agricultural profession. As for governmental uncertainty, public authorities should certainly correct the problem of unpaid subsidies to farmers, simplify administrative procedures and implement reliable agri-environmental schemes to regain farmers' trust.

Our analysis presents several limitations. The relatively small sample size and lack of representativeness does not allow us to generalise to all French farmers. The farmers that did take part were over-represented by those that had larger farms and had higher education, the latter which is a common finding in online surveys with farmers, but means that our results should be interpreted with caution and cannot be generalised to the average French farmer. In addition to this, our sample included a majority of farmers that had already taken steps to reduce their use of pesticides. Nonetheless, the obstacles to reducing pesticides may then be even stronger in the overall population of farmers that have not taken steps to reduce pesticides. The results obtained from our sample may therefore remain relevant, and perhaps even more so, to farmers in general that have not yet started their transition to reduce the use of pesticides. Lastly, the open-ended interviews were partly subject to the authors' interpretation, although the information used for the semantic treatment was as neutral as possible as only the exact transcripts of the interviews were used. Further research should be done to corroborate our findings.

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A Appendix

A.1 Descriptive sheets of attributes presented to respondents

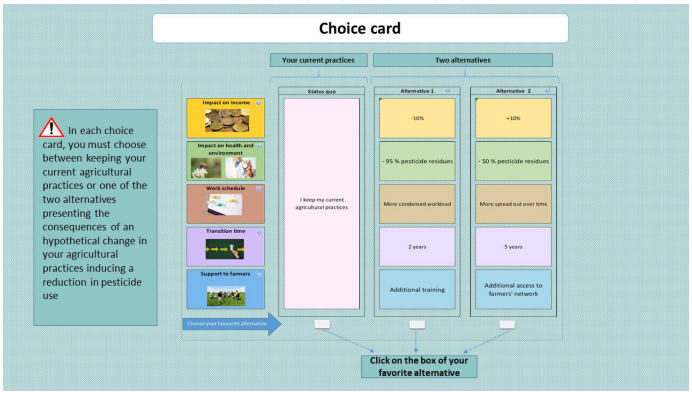


Figure 6: Presentation of a choice card

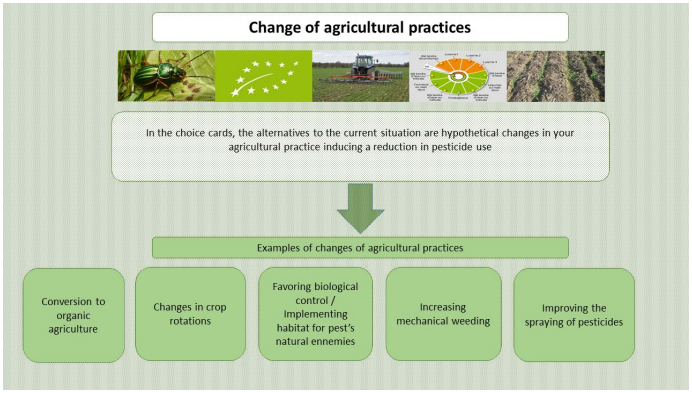


Figure 7: Examples of changes of agricultural practices

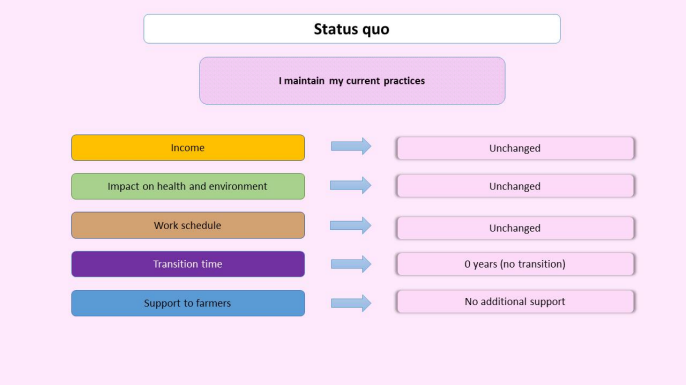


Figure 8: Presentation of the status quo



Figure 9: Presentation of what remains unchanged in all alternatives

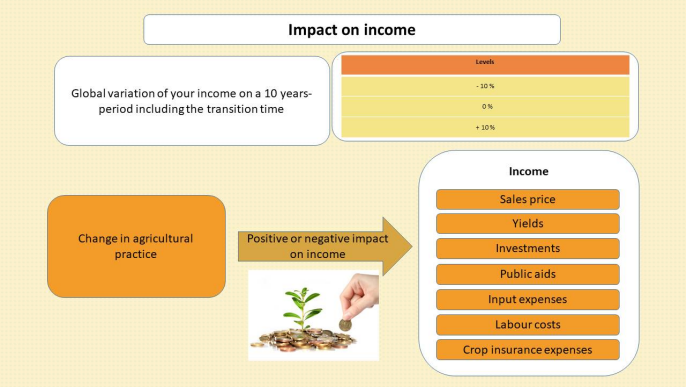


Figure 10: Income attribute

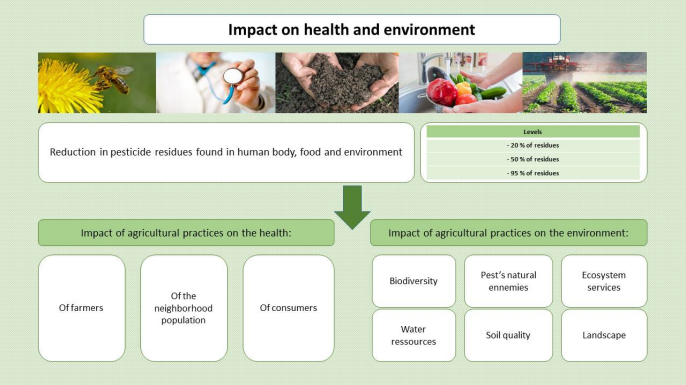


Figure 11: Impact on health and environment attribute

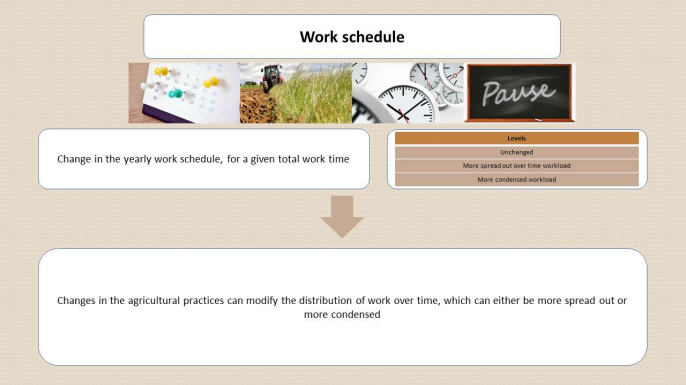


Figure 12: Work schedule attribute

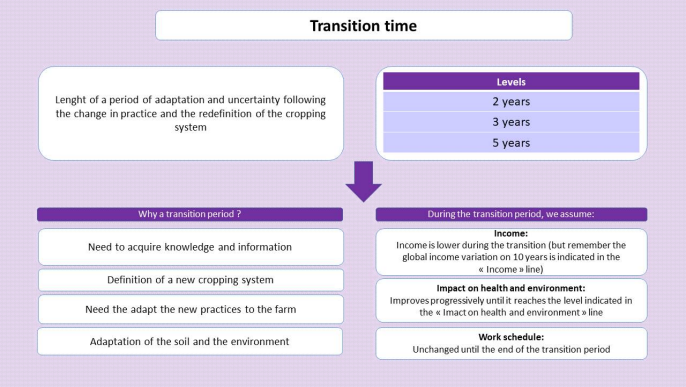


Figure 13: Transition time attribute

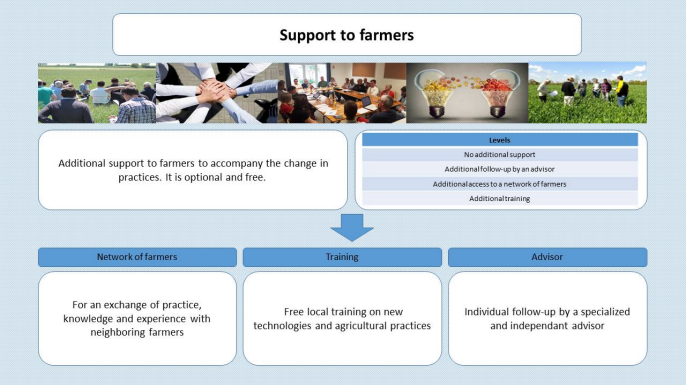


Figure 14: Support to farmers attribute

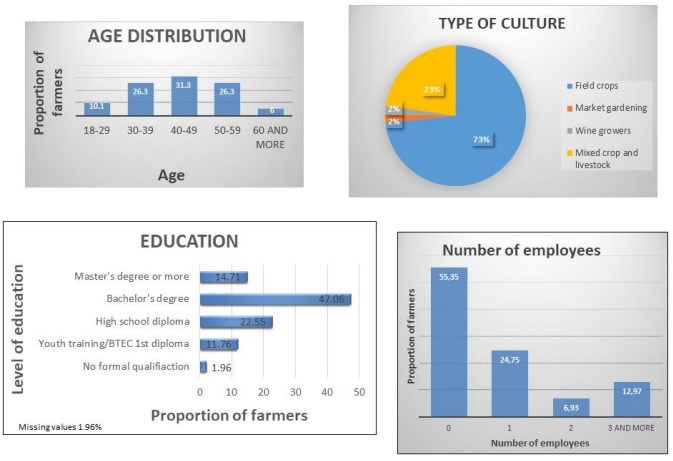


Figure 15: Descriptive statistics of the DCE sample

A.2 Results of the Random Parameter Logit

Table 7: RPL model estimates (n=110) using 1000 Halton draws.

		Coefficients	Standard Errors	p-Values
Main effects model				
Non-random parameter				
Impact on income	Mean	-0.014*	0.008	0.092
Random parameters				
Constant	Mean	-1.328***	0.445	0.003
	St. dev.	-2.663***	0.409	0.000
Transition time	Mean	-0.027	0.054	0.620
	St. dev.	0.144	0.138	0.296
Health and environment	Mean	0.002	0.002	0.372
	St. dev.	-0.008**	0.003	0.017
Condensed work schedule	Mean	0.150	0.248	0.547
	St. dev.	0.346	0.457	0.448
Spread Out work schedule	Mean	0.374	0.242	0.123
	St. dev.	-0.493	0.374	0.188
Advisor	Mean	0.161	0.196	0.412
	St. dev.	0.265	0.497	0.593
Network	Mean	0.072	0.177	0.683
	St. dev.	0.025	0.368	0.945
Training	Mean	0.169	0.190	0.375
	St. dev.	0.008	0.344	0.980
Interaction effects				
Age*Constant	Mean	-1.784*	0.946	0.059
Age*Advisor	Mean	-0.803*	0.450	0.079
Low Educ*Constant	Mean	3.112**	1.376	0.024
Large farm*Transition	Mean	-0.0007*	0.0004	0.068
Prefer Network support*Constant	Mean	-1.848**	0.935	0.048
Prefer Training support*Constant	Mean	-2.480**	0.842	0.008
Training*Constant	Mean	-2.480***	0.842	0.003
Organic Farmer*Health + Env Impact	Mean	-0.026 *	0.015	0.083
Organic Farmer*Advisor	Mean	2.061*	1.067	0.053
Organic Farmer*Training	Mean	2.003*	1.134	0.078
Organic Farmer*Workload - Spread Out	Mean	-3.434**	1.744	0.049
Training Frequency*Health + Env Impact	Mean	0.005**	0.002	0.033
Training Frequency*Constant	Mean	-1.150**	0.430	0.008
Pesticides Env Impact - Belief*Constant	Mean	-1.041*	0.562	0.064
Pesticides Health Impact - Belief*Health + Env Impact	Mean	-0.008 **	0.003	0.024
Pesticides Env Impact - Belief*Const	Mean	-1.041 *	0.562	0.064
Revenue Decrease - Belief*Constant	Mean	1.668*	0.894	0.062
Revenue Increase - Belief*Training	Mean	0.954**	0.403	0.018
Arable Farmer*Advisor	Mean	-1.052 **	0.471	0.026
Arable Farmer*Training	Mean	-0.812*	0.452	0.073
MixedCropandLivestock Farmer*Advisor	Mean	0.821*	0.489	0.093
MixedCropandLivestock Farmer*Network	Mean	0.778*	0.436	0.075
N				660
Log likelihood				-615.47508

Asterisks denote statistical significance at the *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ level.

A.3 Comparative descriptive statistics of the DCE and the qualitative survey

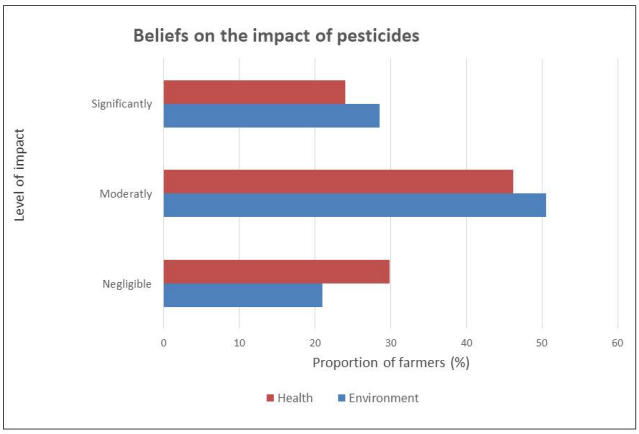


Figure 16: Beliefs on the impact of pesticides

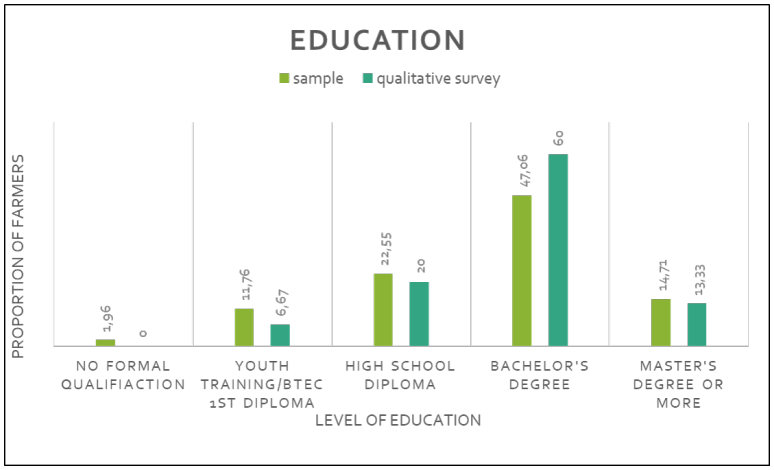


Figure 17: Level of education of respondents in DCE versus respondents in qualitative interviews



Figure 18: Age of respondents in DCE versus respondents in qualitative interviews

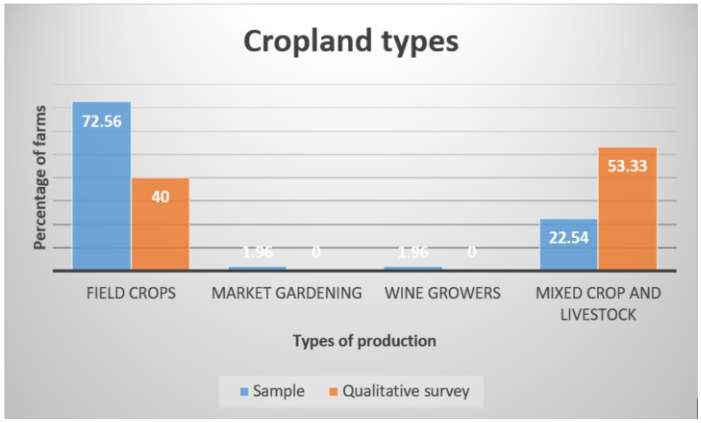


Figure 19: Crop types of respondents in DCE versus respondents in qualitative interviews

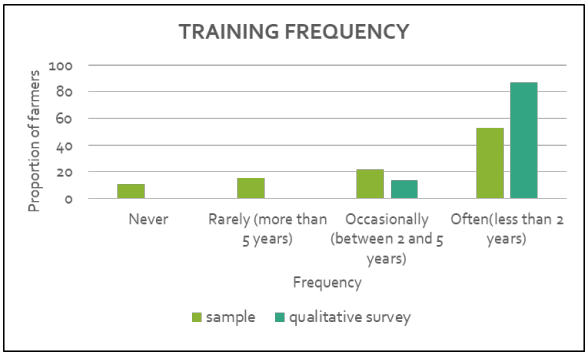


Figure 20: Frequency of traning attendance of farmers in DCE versus respondents in qualitative interviews

A.4 Interview guide and representative quotations - qualitative interviews

Note: These questions were a guide for the interviewer to encourage further discussion when necessary but the respondents were encouraged to express themselves freely through an open-ended discussion and could address any topic they found relevant. **Re-introduction to the study**

- Was the survey and the tasks presented to you clear? Could you describe how you felt about the explanatory videos, the questions, and the choice cards that you received?

Topic under study

- The topic of the survey, as mentioned, was on your preferences for agricultural practices and the use of pesticides. Is the topic of change in practices and the use of pesticides a topic that interests you and that concerns you and your farming activities on a regular basis?

Responses in the DCE

- You stated that you think the reduction in the use of pesticides will increase/decrease your revenue, why do you think this is?
- You stated that you were certain/uncertain whether the reduction in the use of pesticides would impact your costs and salary. What makes you certain/uncertain?
- You responded that you think the use of pesticides impacts your health and the environment to a negligible extent/somewhat/to a high extent – do you think this consideration impacts your choice in agricultural practices?
- Do you think the impact on revenue makes it less/more likely that you change practices?

Further discussion on topics addressed in DCE

- Can you tell us about government support for agricultural and alternative practices in France?
- What do you think the government could do to support the farming sector in the transition to alternative practices?
- Are there any measures of support that you would prefer in this transition to alternative practices that could help, such as e.g., training, an advisor, to be part of a network?
- Would an increase in governmental support make you more likely to change practices?
- You stated that you have reduced your pesticide use by ... % / are an organic farmer. How did this reduction impact your day-to-day work and life?
- Does the organisation of your work schedule – whether it will be more condensed or more spread out impact your choice in agricultural practices?

- If you could be sure that your income would increase, after a period of transition of a number of years, would you be more likely to use alternative practices?

Outside views

- Can you tell us about consumer and governmental demand for alternative practices?
- How do you feel about the local/organic food movement?
- Do you think French consumers are aware or care about this movement?

The future of their farms

- What changes do you predict farming in France will see over the next 15 years?
- How have advances in technology such as, machinery, or chemicals, affected your farm or competition with your farm?
- What are your plans for the future of your farm?

Table 8: Table of representative quotations from major themes

Theme 1. Technological uncertainty
Technological hinders to adopting alternative practices:
Dependence on glyphosate
"The main problem, as is the case for all my colleagues, is glyphosate dependence."
"If glyphosate is banned, there is nothing I can do."
"The government has decided to get rid of glyphosate despite farmers saying there is no alternative."
"I want to stick to conservation agriculture by using plant covers. But that can only be done with glyphosate, so I am dependent on it."
"The ban of the use of glyphosate is a disaster because we [as French farmers] will no longer be competitive."
Efficiency of alternatives to pesticides
"Even with increased subsidies, I cannot reduce my use of pesticides any more than I already have. I see no other solution."
"There is no alternative to pesticides that will maintain the current level of production."
Conservation and direct seeding agriculture
"It is not clear how direct seeding farmers can get by without the use of herbicides."
Uncertain environmental impact of pesticides
"I protect myself and respect good practices and in so doing, I minimise the [negative] impact of pesticides - whether that impact is on biodiversity loss or the ecological balance."
"Even with the right equipment, I sometimes notice negative health effects from the pesticides I use."
"I was exposed to pesticides when I was very young, so I want to stop exposing myself to them now so that I can improve the quality of my life."
Workload of alternative practices
"Since I switched to mechanical weeding, my workload has increased significantly. Chemical weeding used to take me 2 days, but now it takes me at least 15 days a year."
"Alternative farming practices are good, but it just takes longer: using a harrow takes longer than using pesticides."
"[Transition] has increased my workload because it involves more monitoring and more observation."
"For me the problem lack of knowledge and experience required. After five years, it is much easier than after the first year."
Theme 2. Economic uncertainty
Transition period:
Impact on income after technological change
"How am I going to make a living when it is expected that we will be making less money during this transition period ? It has to be possible to maintain the farmer's income during the transition period."
"Earning somewhere between 7 and 800 euros per month I cannot afford to reduce my income just to change practices."
"If I have to invest in a big tractor and other machines, I have no income left. A 10% drop in income is inconceivable as I have not been paid for 1.5 years. My balance sheets are in the red."
"I cannot lose money 3 years in a row. Change [to alternative practices] must be valued."
"If farmers are profitable in the system they are currently operating in, they will not change."
Higher market prices for their products
"My main concern is that the efforts made are not valued at the level of their product. I don't want any subsidy or help. I want a remunerative price to make a living from my job."
"An increase in subsidies will not help people to change practices. I prefer price incentives rather than subsidies."
Time needed to change practices
"The time it takes to transition [to alternative practices] is a hinder."
"How am I going to make a living during this transition period when it is expected that we will be making less money"
"We are in a sector where you need transition periods of at least 5 years."
"The time expected to transition to new practices is too quick."
Maintenance of market standards:
Export capacity
"We have more environmental and regulatory constraints than any other country. If glyphosate is banned, we can no longer compete."
"There is an unfair competition with international products."
Product valuation and quality of crops
"To maintain commercial norms, I am forced to use fungicides. Without this I might lose 50 % of my yield and 50 % of the sales price on top of that.
"Consumers do not want to pay [high prices] for their food."
"I have the best yield in my area so I don't need to change practices."
Theme 3. Social uncertainty
Stigmatisation of non-organic farmers:
Media content
"I'm worried on a daily basis that I'll be attacked in the media."
"There is daily pressure – from the government, consumers, and especially the media."
"I have seen societal pressure increase."
Consumer pressure

"Whenever I go out with my pesticide protective gear on I feel like everyone is watching me."
"Societal pressure has increased."

Support in changing practices:

Experience of neighbours and peers

"The first advisor I listen to is my neighbour and innovative peers: it is what is done in the field that is proof of what works."
"It is by talking to farmers that we can find solutions."
"When I changed practices, I did it together with friends and neighbours."
"You have to directly see what works for farmers"."

Training with vested interests

"Agricultural chambers are incompetent. They are only looking to sell their products even when treatment is not necessary. The problem is that training is often provided by them. I don't trust anyone."
"I would prefer scientific support, but not a technical advisor because the latter have commercial training: I would rather partner with scientists."

Theme 4. Governmental uncertainty

Technocratic decision-making:

Disconnect between expectations and reality

"The government is out of touch with reality. Everything is decided in Paris. We need specific policies for each region."
"I have nothing against the government, but they do not know how to deal with people and professions different to them."
"The government is completely disconnected from the reality of farmers because it is led by technocrats, not by people who know what farmers know. The government needs to listen to farmers."
"I would like authorities to come and meet me and listen to me. The government should go directly to farmers that want to progress instead of going to chambers of agriculture or cooperatives."
"There is a gap between what the government wants, what farmers want and what can actually be done."

Trust:

Delayed/unpaid subsidies

"The government is lagging behind. For example, I only received the payments and subsidies that were meant for 2017 today (two years later)."
"I am skeptical of any support from the government."

Unreliable policy future

"I am quite pessimistic about the future of agriculture."
"The future for my farm is very uncertain."