LIFT

Low-Input Farming and Territories – Integrating knowledge for improving ecosystem based farming

Research and Innovation action: H2020 – 770747
Call: H2020-SFS-2016-2017
Type of action: Research and Innovation Action (RIA)
Work programme topic: SFS-29-2017
Duration of the project: 01 May 2018 – 30 April 2022

Innovative public and private measures to encourage the adoption of ecological practices and enhance the performance and sustainability of ecological agriculture

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DELIVERABLE D6.3

Workpackage N°6

Due date: M44

Actual delivery date: 17/12/2021

Dissemination level: Public

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 770747

About the LIFT research project

Ecological approaches to farming practices are gaining interest across Europe. As this interest grows there is a pressing need to assess the potential contributions these practices may make, the contexts in which they function and their attractiveness to farmers as potential adopters. In particular, ecological agriculture must be assessed against the aim of promoting the improved performance and sustainability of farms, rural environment, rural societies and economies, together.

The overall goal of LIFT is to identify the potential benefits of the adoption of ecological farming in the European Union (EU) and to understand how socio-economic and policy factors impact the adoption, performance and sustainability of ecological farming at various scales, from the level of the single farm to that of a territory.

To meet this goal, LIFT will assess the determinants of adoption of ecological approaches, and evaluate the performance and overall sustainability of these approaches in comparison to more conventional agriculture across a range of farm systems and geographic scales. LIFT will also develop new private arrangements and policy instruments that could improve the adoption and subsequent performance and sustainability of the rural nexus. For this, LIFT will suggest an innovative framework for multi-scale sustainability assessment aimed at identifying critical paths toward the adoption of ecological approaches to enhance public goods and ecosystem services delivery. This will be achieved through the integration of transdisciplinary scientific knowledge and stakeholder expertise to co-develop innovative decision-support tools.

The project will inform and support EU priorities relating to agriculture and the environment in order to promote the performance and sustainability of the combined rural system. At least 30 case studies will be performed in order to reflect the enormous variety in the socio-economic and bio-physical conditions for agriculture across the EU.

Project consortium

No.	Participant organisation name	Country
1	**INRAE - Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement**	**FR**
2	VetAgro Sup – Institut d'enseignement supérieur et de recherche en alimentation, santé animale, sciences agronomiques et de l'environnement	FR
3	SRUC – Scotland's Rural College	UK
4	Teagasc – Agriculture and Food Development Authority	IE
5	KU Leuven – Katholieke Universiteit Leuven	BE
6	SLU – Sveriges Lantbruksuniversitet	SE
7	UNIBO – Alma Mater Studiorum – Universita di Bologna	IT
8	BOKU – Universitaet fuer Bodenkultur Wien	AT
9	UBO – Rheinische Friedrich-Wilhelms – Universitat Bonn	DE
10	JRC – Joint Research Centre – European Commission	BE
11	IAE-AR – Institute of Agricultural Economics	RO
12	MTA KRTK – Magyar Tudományos Akadémia Közgazdaság – és Regionális Tudományi Kutatóközpont	HU
13	IRWiR PAN – Instytut Rozwoju Wsi i Rolnictwa Polskiej Akademii Nauk	PL
14	DEMETER – Hellinikos Georgikos Organismos – DIMITRA	GR
15	UNIKENT – University of Kent	UK
16	IT – INRAE Transfert S.A.	FR
17	ECOZEPT Deutschland	DE

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List of acronyms and abbreviations

AES: Agri-Environmental Schemes

AEMs: Agri-Environment (- Climate) Measures

ABM: Agent-Based Model

CAP: Common Agricultural Policy

CF: Conventional Farming

CIIB: Cumulative Impact Incentive Bonus

CREP: Conservation Reserve Enhancement Program

CUMA: Coopérative d'Utilisation du Matériel Agricole

DCE: discrete choice experiment

EAFRD: European Agricultural Fund for Rural Development

EAGF: European Agricultural Guarantee Fund

EFA: Ecological focus areas

EU: European Union

FMSE: Fonds national Agricole de Mutualisation du risque Sanitaire et Social

FOP: front-of-pack

GC: Grand Coalition

GHGs: greenhouse gases

LCA: life-cycle assessment

LFA: less favoured area

LI: low-input farming

OF: organic farming

EU: European Union

FADN: Farm Accountancy Data Network

MPR: minimum participation rule

NE: Nash Equilibrium

NRW: North-Rhine-Westphalia

PDO: protected designation of origin

PES: payment for ecosystem services

SALCA-BD: Swiss Agricultural Life Cycle Assessment - Biodiversity

SC: stable coalitions

SMART: Sustainability Monitoring and Assessment Routine

t CO_2e: tonne of CO_2 equivalent

UAA: utilised agricultural area

WTA: willingness to accept

1 Summary

This deliverable (D6.3) of the LIFT project presents the results of a series of investigations around innovative approaches to induce the adoption of ecological approaches. Innovative approaches are defined here as those that have not, or only scarcely, been implemented, including public subsidies based on results (individual or collective) or private financing of ecological approaches via payments for ecosystem services (PES). We use desk research, primary and secondary data to address (i) the role of the current, and future, Common Agricultural Policy (CAP) framework to induce the adoption of ecological approaches and (ii) the potential of innovative measures, such as individual or collective results-based instruments, to induce a more widespread adoption of ecological practices.

Specifically, the following investigations are presented:

- An examination of the extent to which current proposals for the future CAP of the European Union (EU) (2023-2027) promote the adoption of ecological approaches (section 3)
- A synthesis of stakeholders' views on the current and potential future CAP frameworks, gathered during annual stakeholders' workshops in LIFT project's case study areas (section 4)
- A series of studies on the potential for innovative approaches to induce the adoption of ecological practices (section 5)
- A focus on the role of collective-based policy approaches to induce the adoption of ecological approaches, based on modelling approaches and primary data gathered in LIFT project's case-study areas (section 6).

2 Introduction

In the context of the CAP reform, including the Green Deal and the Farm-to-Fork strategies, it is essential to assess the potential for innovative measures, that have never or seldom been implemented, to increase the adoption of ecological practices[1]. Indeed, despite an increasing share of CAP budget dedicated towards environmental measures, farmers' uptake of ecological practices has been slow.

This document presents the results of the research carried out in task 6.3 of the LIFT project, on innovative measures (policies and private arrangements) to encourage the adoption of ecological practices, and enhance farm, farm-group and territorial performance and sustainability of ecological agriculture (in terms of public goods and ecosystem services provision). Work was based on desk research, modelling exercises, experimental approaches and consultations to local stakeholders as regard the best practice in policy instruments and private arrangements that should be adapted to the local contexts.

This document begins by setting the policy scene by providing an analysis of the future CAP agreement (2023-2027), as formally adopted on December, 2nd 2021. **Section 3** examines the extent to which it

[1] Ecological practices are understood in LIFT as low-input practices and/or practices that are environmentally friendly. The originality of LIFT in this view is not to focus on a specific type of ecological approaches, but to cover the whole continuum of farming approaches, from the most conventional to the most ecological, including the widest range of ecological approaches. This comprises the existing nomenclatures such as organic farming, low-input farming, agroecological farming, etc. It also encompasses approaches that are not yet part of a nomenclature, but that can be identified with various criteria such as management practices, on-farm diversification etc. Thus, conventional practices mean non-ecological practices.

may promote the adoption of ecological approaches, given its novel organisation, in particular an increased responsibility at the national level and the new Pillar 1 eco-schemes. The most relevant contribution potential by LIFT concerns an in-depth understanding of acceptability and behavioural aspects facing measure implementation. This will allow a support for a better design of existing policies and a more aware design of new implementation options (such as collective and results-based), which require a more thorough understanding of farmers' and other actors' behaviour. In addition, several existing measures suffer from low participation and unclear effectiveness, which can also be improved based on insights provided by the project.

Section 4 draws on the extensive involvement of stakeholders in the workshop organised in the various LIFT case-study areas. It provides a synthesis of stakeholders' views about the current CAP framework and how it could be improved, about complementary approaches to induce the adoption of ecological practices such as privately-funded PES, and about collective-based strategies. Given the heterogeneity in case studies, countries, and types of stakeholders involved, and the inevitable recruitment bias, the insights from this synthesis should be taken with cautious, but nonetheless raise some interesting points, in particular regarding the interactions between Agri-Environmental Schemes (AES), PES, future eco-schemes and consumer-driven price markup.

Section 5 includes different contributions assessing, either ex-ante or ex-post, innovative approaches, in particular in terms of their effect on measure adoption and on environmental improvement. Applications include the Irish Burren hybrid payment scheme, partly results-based; German crop diversification and flower strips AES and a potential Pesticide-free eco-scheme; different input or results-based PES to reduce methane emissions from dairy cows; an increase in pesticide price in France; and an environmental footprint front-of-pack labelling system in Belgium.

Section 6 focuses on collective-based approaches and their potential role in increasing the adoption of ecological practices. After reviewing the literature and in particular identifying examples of implementation of such approaches internationally, it includes an investigation of the barriers and opportunities for the necessary spatially-arranged collective management of terrestrial voles outbreaks; results from a pilot experiment and the LIFT large-scale farmer survey about farmers' views on and responses to collective-based policy approaches such as the agglomeration bonus; a theoretical investigation of the impact of minimum participation rules for pollination management and a discrete-choice experiment on the role of collaborative networks to encourage adoption of ecological practices and the sustainability of ecological agriculture.

Finally, **section 7** draws out the main findings of these studies and provides conclusions for policy and the research community going forward.

3 CAP 2023-2027

This section provides an analysis of key issues in the CAP post 2020, i.e. post-2020 CAP, now usually termed CAP 2023-2027, that can be relevant for the LIFT project in view of exploiting the results to identify improved solutions to promote the adoption of ecological practices.

At the time of writing this deliverable, the new regulations have just been published (Parliament approval on 23/11/2021 and publication on 06/12/2021). As a consequence this section is based on documents available during the preparatory process plus some updates based on a first analysis of the new regulations.

3.1 Post-2020 CAP proposals

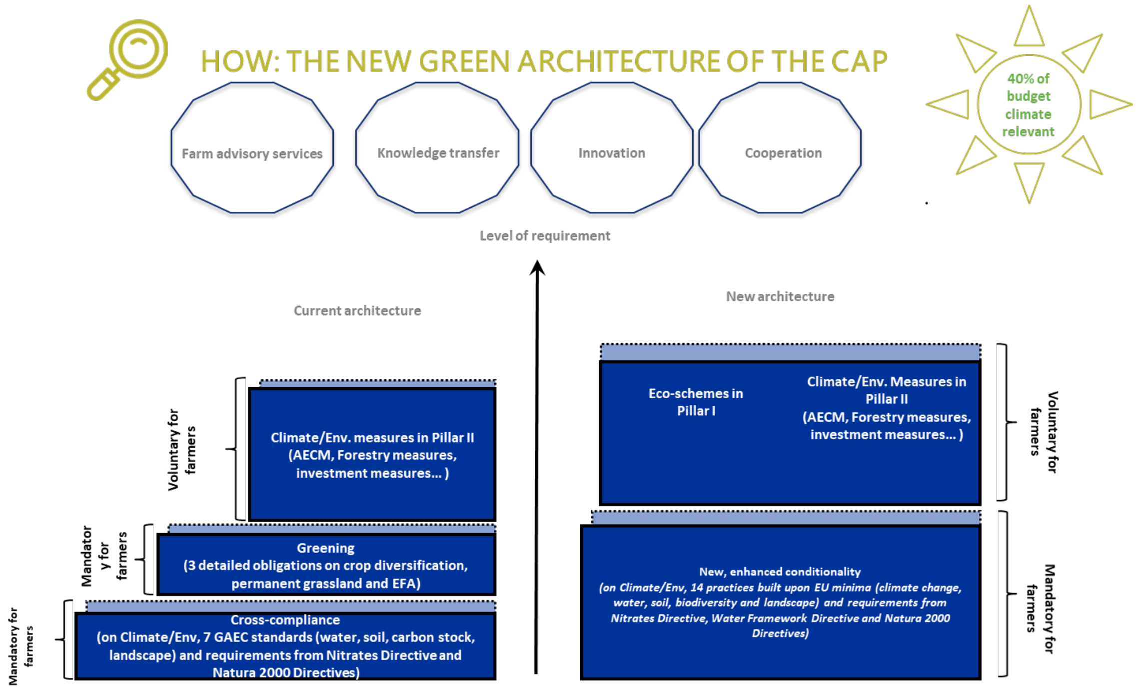
After the release of preliminary documents in 2017, the European Commission published the legislative proposals for the post 2020 CAP in June 2018.

The objectives of the future CAP are:

- to ensure a fair income to farmers;
- to increase competitiveness;
- to rebalance the power in the food chain;
- climate change action;
- environmental care;
- to preserve landscapes and biodiversity;
- to support generational renewal;
- vibrant rural areas; and
- to protect food and health quality.

A comparison of the old and new green architecture of the CAP is provided in Figure 2.1.

Figure 2.1 – Old and new architecture of the CAP



Source: I. Aganetto presentation, Seville, Spain, May 2019.

The basic structure of the CAP is not expected to change dramatically, in particular the organisation into two main pillars. However, in terms of measures, the CAP will bring some important novelties. These include the refocusing of the direct payments towards a basic payment for sustainability; the replacement of the current cross-compliance and greening measures with a new enhanced conditionality scheme; and the provision of voluntary ecological payments in the first pillar.

A critical aspect of the CAP reform is the new delivery model, leaving to strategic plans to devise precise actions for implementation. Strategic plans are expected to cover all CAP measures and to be designed at Member State (MS) level. This implies a larger level of flexibility for MS concerning the design of measures and implementation, while the European Commission will monitor the results on the basis of a list of indicators. This should, in principle, allow for higher efficiency through greater flexibility and better targeting, but will also rely more on decentralised coordination and management capacity.

The main measures of interest are likely the following:

- basic payment for sustainability;
- enhanced conditionality scheme;
- voluntary ecological payments in the first pillar;
- future agri-environment-climatic measures (AEM) in the second pillar.

In practice, several other measures may be relevant as shown by the current second pillar. For example, several projects under the collaborative innovation measure (measure 16) are promoting more sustainable practices. The same applies for value chain-related measures, e.g. producers' organisations. The context of the green architecture as expressed by the European Commission puts emphasis also at the interplay with farm advisory services and knowledge transfer.

The basic payment should in principle be neutral with respect to technological choices; however, as the name links to sustainability, it may be expected that the level and distribution of payments might be connected to enhanced conditionality at least as long as sanctions for non-compliance are related to the basic payment.

Voluntary eco-schemes in the first pillar remain rather difficult to comment at the current stage as they are new and there is not much information about their potential design.

There is no much evidence of major changes in the design of AEMs, except for the emphasis on considering using collective or results-based implementation solutions. This is indeed a new topic if considered on a broad scale, though several examples already exist.

The concept of green architecture, similar to the previous programming period, emphasises the need to work across different measures, considering the design and working of the whole policy mix.

In addition, the interaction of different branches of policy, especially agriculture and environmental, but also climate, innovation and bioeconomy, will need to be given more emphasis than in the past.

The reform proposes a change in the role of the different actors, at least on two grounds:

1. First, it moves higher design and target-setting responsibilities at the country level, while the European Commission retains a higher role in checking that the target objective are achieved;
2. Second, by requiring one strategic plan per country, the reform pushes for redistribution of role on a multilevel scale, in particular for countries that used to rely on regional rural development plans with a very decentralised decision-making process.

The combination of these features will likely have the following effects:

- there is a higher flexibility in design, that most likely will end up in a further heterogeneity and variety of schemes implementation at local level;
- a higher number of administrative bodies and stakeholders could be involved in the design process, while a wider variety of actors may be involved in implementation; as a result, the role of evidence supporting the design stage will be likely increased;
- there will be the need for a higher effort in measuring results and attaching them to incentives (payments) and evaluation process.

3.2 New CAP 2023-2027 regulations

The new CAP regulations related to the CAP 2023-2027 are the following:

- REGULATION (EU) 2021/2115 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 2 December 2021 establishing rules on support for strategic plans to be drawn up by Member States under the CAP (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013.

- REGULATION (EU) 2021/2116 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 2 December 2021 on the financing, management and monitoring of the CAP and repealing Regulation (EU) No 1306/2013.
- REGULATION (EU) 2021/2117 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 2 December 2021 amending Regulations (EU) No 1308/2013 establishing a common organisation of the markets in agricultural products, (EU) No 1151/2012 on quality schemes for agricultural products and foodstuffs, (EU) No 251/2014 on the definition, description, presentation, labelling and the protection of geographical indications of aromatised wine products and (EU) No 228/2013 laying down specific measures for agriculture in the outermost regions of the Union.

Regulation 2021/2115 is the one setting out the main provisions. From a first analysis the main points are worth highlighting.

The new conditionality is regulated in Chapter 1, article 12 and following. Topics addressed by conditionality include:

a) the climate and the environment, including water, soil and biodiversity of ecosystems;

b) public health and plant health;

c) animal welfare.

Eco-schemes are confirmed in chapter 2, article 31.4. Each eco-scheme shall in principle cover at least two of the following areas:

a) climate change mitigation, including reduction of greenhouse gases (GHG) from agricultural practices, as well as maintenance of existing carbon stores and enhancement of carbon sequestration;

b) climate change adaptation, including actions to improve resilience of food production systems and animal and plant diversity for stronger resistance to diseases and climate change;

c) protection or improvement of water quality and reduction of pressure on water resources;

d) prevention of soil degradation, soil restoration, improvement of soil fertility and of nutrient management and soil biota;

e) protection of biodiversity, conservation or restoration of habitats or species, including maintenance and creation of landscape features or non-productive areas;

f) actions for a sustainable and reduced use of pesticides, in particular pesticides that present a risk for human health or environment;

g) actions to enhance animal welfare or combat antimicrobial resistance.

Payments shall be granted as either:

a) payments additional to the basic income support set out in Subsection 2; or

b) payments compensating active farmers or groups of active farmers for all or part of the additional costs incurred and income foregone as a result of the commitments made which shall be calculated in accordance with Article 82 and taking into account the targets for eco-schemes; those payments may also cover transaction costs.

Chapter 3 – Types of intervention for certain crops, envisages specific support for activities related to specific crops in connection to common market organisation that include several measures related to the environment, such as organic farming.

This may be of high interest in the context of strategic plans, in order to ensure coordination between environmental issues and value chain strategies.

Chapter 4 – Types of intervention for rural development confirms the relevance of environmental topics, under item (a) environmental, climate-related and other management commitments. Article 79 (5) explicitly set out that "Member States may promote and support collective schemes and result-based payment schemes to encourage farmers or other beneficiaries to deliver a significant enhancement of the quality of the environment at a larger scale or in a measurable way." This corroborates the potential need of support in deciding whether to design results-based and collective measures, as well as supporting appropriate design.

The interconnection among the measures above in light of the need to avoid double funding is a clear issue for attention. The preliminary analysis also confirms the focus set by the project on agglomeration bonuses and other forms of collective solutions, as well as on private arrangements and results-based actions. An investigation of policy (measure) mixes in the framework of CAP Strategic plans will be key to ensure relevance and contextualisation of the policy-relevant results.

4 Stakeholders' views on current and potential future CAP frameworks

This section presents a synthesis of discussions held during stakeholders' workshops (See Table 4.1) organised in different LIFT case-study areas on the topic of "innovative" approaches to ecological farming. Given the heterogeneity in case studies, countries, and types of stakeholders involved, and the inevitable recruitment bias, and lack of exhaustivity, the insights from this synthesis should be taken with cautious, but nonetheless raise some interesting points.

Any discussion aimed at assessing the potential role of PES hinges on the difficulty to distinguish PES from quasi-PES (to which AEMs pertains). Hence, some of the points discussed as facilitating, or on the contrary impeding, the adoption of ecological approaches applies to both public AEMs as well as privately financed PES.

Table 4.1: Stakeholders' workshops feeding in the synthesis

Workshop topic	Case study areas involved (number of participants)
What place for PES as lever of action for the adoption of ecological farming?	France: Brittany (5), France: Sarthe (8), Italy: Ravenna (5)
What are the determinants of participation in PES?	France Sarthe (2), Greece: Lasithi (19), Ireland (6), Italy: Ravenna (11), Poland: Lubeskie (13), Poland: Podlaskie (15), Romania: Cluj (4), Romania: Suceava (6), UK: High Weald (4), UK: North Kent (4)
What role for collective-based approaches?	France: Sarthe (4), Sweden (7)

Source: Krupin and Zawalińska (2019, 2020, 2021)

This synthesis is organised into three parts, that encompass most of what has been reported from the different stakeholders' workshops listed in Table 4.1. The first section discusses the pros and cons of the current public policy framework put forward by participating stakeholders. The second section is dedicated to PES (and in some instances quasi-PES), their role and their necessary features to successfully attract farmers' participation. Finally, section 3 focuses on collective-based approaches.

4.1 Assessment of current CAP framework

The beneficial effects of the current CAP framework that have been pointed out by stakeholders include: financial benefits, the dissemination of ecological farming practices with targeted ecological benefits (e.g. support for alfafa), spatial expansion of the adoption of ecological practices, increased awareness on the interest for ecological practices within the farming community.

However, participants have also expressed concerns or dissatisfaction over the following points.

Regarding policy-design, some stakeholders pointed out that the ***compensation of foregone profits only*** is not very encouraging to adopt. Furthermore, some stakeholders highlighted the focus of current policy packages on ***large farms*** as a negative feature. Indeed, some participants regretted that the subsidy levels were decreasing with the ecological intensity of the practices, except for the compensatory allowance for natural handicaps. Setup and investment subsidies focus on large enough farms, leaving small surfaces, with potential high ecological impacts, aside. By the same token, some stakeholders noted that as long as payments are hectare-based, rather than workforce-based, there will be a "***race for increasing area***" incentive, whilst, from experience, stakeholders think that there is an optimal farm size for a given ecological practice. In this regard, section 5.4 of this deliverable addresses the impact on the competition for farm land, between conventional, low input and organic farmers, of an increase in pesticides' price.

Also, stakeholders raised concern over the fact that ***adoption pioneers***, those on the frontline, taking the risks of implementing a new practice, are out of reach of current policy packages. Indeed, when policy changes are introduced to take into account the new practices, pioneers are no longer eligible for support.

Regarding policy implementation, participants pointed out the ***lack of stability*** of certain measures as a barrier for their adoption. In particular, the irregular opening of the scheme was considered a barrier to the further adoption of organic dairying in Ireland, even if the level of payment was assessed as good, due to lack of forward planning. Also, faced with doubts expressed by consumers about the effectiveness of certain ecological practices, stakeholders expressed the need to develop ***benchmarking*** for policy-driven practices, i.e., to have a thorough assessment of how a given practice improves the environment in comparison to conventional and other practices.

4.2 Role and features of PES

Throughout the discussions on PES, their ***relation with other types of incentives*** -– AEMs, future Pillar 1 eco-schemes - was extensively discussed, in particular how the piling up of measures might deter/encourage participation by farmers. The uncertainty surrounding how the eco-schemes will be applied make it difficult to draw any definite conclusion, but they appear as useful to maintain ecological practices while AEMs may be useful for transitioning from one system to the other. Section 5.2 of this deliverable addresses this issue, examining how farmers may adopt a potential "Pesticide-free" eco-scheme on top of existing AEMs, and how this may affect their environmental performance. Besides, PESs appear as filling in gaps in the current policy landscape. There was a consensus on the idea that PES should be more focused on results rather than means (even if some rare AEMs are based on results monitoring), which raises the question of the type of environmental service that can actually be monitored in terms of results (case of water quality, for instance).

In direct relation, the question of ***who should pay for environmental improvements*** (Government, consumers, direct beneficiaries of the ecosystem service), hence ecological practice adoption, was extensively discussed. The idea of disentangling the price of agricultural product into production-relating costs (to be paid by the consumer), and environmental benefits provided by the farmer (to be paid by the consumer, possibly, but also others), was raised and debated. This would allow ecologically-produced products to develop outside niche markets. Indeed, the willingness to pay of consumers for ecological farming practices may not be high enough to ensure the sustainability of these practices for every production. In this respect, section 5.5 of this deliverable analyses the role of ecological footprint labels in consumers' choices and highlights the trade-offs made by consumers between different types of information more or less related to the ecological nature of vegetable production. Then, the example of school canteens was discussed: there is a psychological price threshold above which parents are not ready to pay for their children's lunch, impeding the development of local supply for institutional catering. Such a system of decoupling production/service provision in the final product price would also allow the intervention of private actors, other than the direct consumers.

For environmental issues that have a typical local feature (such as water quality), the question of distance from the ecosystem service provider and the ecosystem service consumer was raised – why would a consumer of e.g. Loué chicken (produced in Sarthe region) residing anywhere else in France pay for improved water quality in Sarthe?

With regards actual PES, ***the nature of the ecosystem service*** appears to be important in the willingness of farmers to participate in and in the proposals for innovative PES in the area. Hedgerow maintenance is a good candidate for PES, in particular because it is a visible feature of the landscape, so that the result of the PES is easy to monitor and show; due to its linear nature, it is not appropriate for area-based payments, hence it is not well covered by current AEMs. Biodiversity-focused PES are also appreciated. Water quality is also a common topic for PES, with a targeted approach on catchment areas. Some stakeholders thought that PES are likely to be effective (or to emerge) only in specific location with highly concentrated environmental values, e.g. water quality for water facilities company. It is probable that they cannot be used generally.

The extent to which farmers are influenced by the opinions of others in their community was also identified as a factor affecting willingness to enter a PES scheme, especially in the early stages of the scheme. Many farmers may be reluctant to enter such a scheme if it sets them at odds with the rest of the farming community. Workshop participants agreed that the pioneering farmers, who first joins a novel scheme, are likely to be those who are least affected by ***peer pressure***. Alternatively, some stakeholders expressed the view that willingness to participate in a PES scheme is complicated by stakeholder concerns over how farmer performance would be judged, and what farmers would need to demonstrate in order to qualify for payments.

Regarding ***results-based approaches***, some farmers expressed reluctancy to engage in a such schemes, because of fears around the many factors that could affect ecosystem service provision that are beyond their control. They also expressed a scepticism about the ability of assessors to accurately measure improvements to ecosystem service provision due to farm management. Farmers' participation may therefore be more likely if such a scheme focuses on farmer actions, and not outcomes. The analysis of the Burren program (section 5.1), where a hybrid payment scheme was implemented based on a measure of individual results, highlights the important role of advisors, and of the whole monitoring process, to ensure the success of such a scheme.

Other stakeholders expressed interest in PES due to the decreased ***level of bureaucracy*** connected with the process of application for funds (including the number and frequency of controls) with PES. This point is also addressed in the Burren program case (section 5.1), since a lot of effort has been put to decrease farmers' administrative workload. Solving how to balance the total transaction costs of implementing a scheme, and how to share these costs between the farmers, the advisors, and the other stakeholders involved, would be a key feature of success of policy approaches to induce the adoption of ecological practices.

A concern raised in multiple case-studies is on the ***additionality*** of PES, and more precisely on what is defined as the status quo. Some stakeholders agreed on the idea to pay only for actions (or results) above the status quo, while others maintained the view that in some instance, maintaining the status quo in itself should be rewarded. The example of hedge maintenance was discussed at this point; in the context of general hedge clearance on farmland, maintaining hedges should be, according to some stakeholders, rewarded – those farmers who have cleared their hedges are going to get subsidies to put them back, while those who have maintained them will get nothing. By the same token, there was agreement in a case-study area that if farmers were to be paid based on observed improvements in ecosystem service provision, this would disadvantage farmers who had already worked hard to enhance the environment prior to the introduction of the scheme. Participants agreed that such a scheme would be more enthusiastically received if payments were made according to the current level of ecosystem service provision.

4.3 Interest for collective approaches

Participating stakeholders explained that from a farmer's perspective, collaborating is not a new way of managing farms' resources, but engagement in such collaborations is not feasible if the ***environmental benefits are not clear***. Also, participants declared that they observed peer-effect types of mechanisms for remunerative practices – however, a sufficient sectoral development is necessary to accompany these. The relevancy of collective-based approaches was especially discussed by stakeholders in the case of water management (both quantity and quality, depending on the case study areas); landscape management and more generally cultural heritage protection; collective implementations of ecological focus areas (EFA), buffer zones for erosion management, and finally grassland management.

The question of the ***size of the territory*** on which to apply such collective-based approaches was discussed. It has to be big enough not to discourage innovation, but not too small so that the environmental impact can be observed and linked to the adoption of the practice. It must also contain sufficient potential adopters.

The question of the ***participation threshold*** to activate a potential collective bonus, was discussed in relation with farm size. In areas where farms are large, the number of farms willing to participate do not need to be large. For areas where farms are smaller, the number of farms participating in the measure need to be larger. Furthermore, the number of participants should be "optimal" depending on the project. Good collaboration and variety of skills among the participants is of great importance.

The relevance for ***farmers' participation*** in collective-based AEMs was also related with the: i) structural characteristics of the farms, and ii) farmers' goals. Some examples are the landscape; owners vs. tenants; farming for living vs. farming for hobby; full time farming vs. part time farming; living on the farm vs. having land as additional occupation/income source.

Finally, it should be noted that for the authorities the whole concept of collective-based AEMs appears to be an ***administrative challenge***, and they see the application possibilities as very limited.

Analyses presented in section 6 address several of these points.

5 Innovative strategies to induce the adoption of ecological practices

5.1 The Burren Programme: a results-based AES (Ireland)

The Burren LIFE project was established in Ireland in 2004 in order to improve the Burren's future in farming (Williams *et al*., 2009). The main objective of the Burren LIFE project was to protect the Burren's natural heritage and develop a sustainable agricultural management. The project focused on conservation through farming as the Burren offers such a diverse range of flora and fauna (Parr *et al*., 2010).

The objective of the study was to undertake a descriptive review of the Burren Programme to disaggregate the components of scheme design into individual components in order to learn lessons to facilitate, water quality improvement, biodiversity enhancement and agro-ecological approaches. The research undertaken includes a comprehensive review of published (and grey) literature combined with farmer survey questionnaires and qualitative interviews with programme advisers, programme management and biodiversity experts. The surveys were designed to generate feedback from farmers on the programme in relation to farmers' attitude change towards the environment since joining the programme. To assess the transaction costs for farmers participating in the programme, the surveys also examined the time and money that farmers contribute to the programme on an annual basis. Qualitative interviews were designed to get detailed information on how these schemes are designed. They were targeted at those involved in design such as advisers and managers of the programme.

The cost of running a scheme by an agency can be broken down into two categories, the running of the scheme (administration and operating), and the payments allocated to participating farmers (Mettepenningen *et al*., 2009). When discussing the costs of running an AES, we use the term transaction costs. These transaction costs are incurred by both the government/agency administering an AES and by farmers participating in an AES.

The Burren Programme has a hybrid payment structure; annual payments are made to farmers to undertake actions and as payment for environmental impact. A base amount is paid based on the condition of the site. The better the condition of the site, the higher the payment received i.e. under/overgrazing results in low (or no) base payment (see Table 5.1 for an example of payment rates). The level of funding provided by the Burren Programme depends on how environmentally beneficial an 'action' may be. An action which will have a larger benefit for the environment than for the farms' productivity will receive larger funding (usually 75%). However, an action chosen with little environmental benefits but more beneficial for farm productivity may only receive 25% funding. This acts as an incentive for farmers to opt for the actions that are more environmentally friendly. Secondly, there is a 'payment for results'. Here, the farmer and adviser devise a plan which suggests farm management actions to achieve the best results. Using a score advisers monitor the level of management and allocate each field a score based on indicators which vary from the presence of certain species, to the level of litter and soil erosion. These scores are checked and finalised by the management team. According to the Programme Manager, while monitoring is the largest transaction cost of the programme, it is necessary for quality control and ensures the participants remain compliant. Studies on the cost of running AES in the UK also reached the conclusion that monitoring is a main contributor to high costs (Pretty *et al*., 2000). However, the cost of this monitoring is rewarded by the clear results in environmental improvement which can easily be identified in the Burren Programme.

Table 5.1: Scores and payment rates for management of Burren lowland grasslands

Per ha payment (Euros)	Score 10	Score 9	Score 8	Score 7	Score 6	Score 5
0-10 ha	315	240	192	168	144	120
>10 ha	158	120	96	84	72	60

As well as providing a high level of monitoring, the Burren Programme also provides a high level of technical support, which is important for maintaining a high standard of knowledge and awareness among participants, which in itself supports the monitoring process. In addition to technical support, there is ongoing communication with both advisers and farmers. The management team claims that the high level of technical support and communication is one of the significant differences between The Burren Programme and other AES such as GLAS (Green Low carbon Agri-environment Scheme). This communication work is vital in building personal relationship between farmers and those involved in managing the programme, building trust in the programme and the management team.

In short, this case study shows that the improvement in environmental health reflected in increasing biodiversity scores in the Burren Programme over time, is testament to the success of the results-based approach. It was suggested by the ecologists interviewed as part of the Burren case study that AES actions need to be more evidence-based. Without evidence of improvement, the outcome of compliance monitoring can be misleading when it is not followed up the necessary impact monitoring. A high rate of compliance does not reflect the status of biodiversity or environmental health (Gibbons *et al*., 2011). Results-based payments are considered to be a more cost-efficient option due to their 'no result no reward' system, although more studies are needed to determine exactly how much more efficient they are (Burton and Schwarz, 2013). By offering more funding for actions that have a higher environmental impact, this automatically encourages the farmer to choose the action which is more beneficial for the environment. By integrating these environmentally beneficial actions, farmers increase their environmental awareness (Michel-Guillou and Moser, 2006). This strategy, combined with the financial reward provided for desirable environmental outcomes, acts as an effective incentive for farmers to pay more attention to environmental and ecological factors (Schroeder *et al*., 2013).

5.2 Assessing the impact of AES and one potential eco-scheme on biodiversity: A modelling approach (Germany)

As recently confirmed by the European Environment Agency (2019), agricultural intensification is considered the main driver of biodiversity loss in Europe. One of the aims of the CAP therefore is to better reconcile European agricultural production and the environment, including biodiversity. Opt-in AEMs incentivise farmers to implement environmentally friendly farming practices beyond compulsory policy instruments such as under the nitrate and water framework directives (Europäischer Rechnungshof, 2011; European Commission, 2017). This paper investigates impacts on on-farm biodiversity of two AEMs offered by the German state of North-Rhine-Westphalia (NRW), namely crop diversification and flower strips, and additionally of the production of crops without the application of chemical-synthetic pesticides, as a currently discussed so-called eco-scheme under the first pillar of the new CAP (LWK NS, 2021).

The effect of AEMs and of the potential eco-scheme on biodiversity is assessed employing the model FarmDyn as a highly detailed bio-economic farm-scale model which builds on mixed-integer programming. The model allows the simulation of economic optimal farm management and investment decisions considering technical as well as financial and work-time constraints (Britz *et al.*, 2021). A complete model documentation is available online (Britz *et al.*, 2018). Table 5.2 gives an overview of the implementation of these measures in FarmDyn.

Table 5.2: AEMs in FarmDyn

AEM	Current policy	Premium	Regulations
Crop Diversification	Yes	90 € / ha	Min. 5 different main crops per year (crop shares: 10 % - 30 %) Min. 10 % legumes Max. 66 % cereals
Flower Strips	Yes	1200€ / ha	Max. 10 % flower strips
PesticideFree	No	100 € / ha	Summer barley and silage maize without chemical-synthetic pesticide application

Source: Deutscher Bundestag (2021), LWK NRW (2021a), LWK NRW (2021b).

Our study uses three biodiversity assessment methods: the *Paracchini-Britz* method (Paracchini and Britz, 2010), the Sustainability Monitoring and Assessment Routine (*SMART*) by the Research Institute of Organic (FiBL) (Schader *et al.*, 2016) and the Swiss Agricultural Life Cycle Assessment - Biodiversity (*SALCA-BD*) developed by Agroscope (Jeanneret *et al.*, 2009; 2014). Their selection reflects that, first, they can be calculated based on the model's output, second, that they are applicable to different farm types in Germany and third, that they allow an aggregation into an index or score. The *Paracchini-Britz* method as the simplest one assesses biodiversity using solely three different indices: a Modified-Shannon-Index, a N-Fertilisation-Index and a Ruminant-Index. Generally, this method assumes that diverse crop rotations in combination with low management intensities are best for biodiversity on arable lands. It requires relatively little detail on farm management. The *SMART* method is a comprehensive sustainability assessment method including biodiversity that is divided into three dimensions - Ecosystem Diversity, Genetic Diversity and Species Diversity and covers 72 sub-indicators of which 22 are implemented in FarmDyn (Schader *et al*., 2016). *SALCA-BD* is a highly detailed biodiversity assessment method that examines the impact of agricultural activities and management decisions on eleven indicator species groups (Jeanneret *et al*., 2009; 2014). It requires quite detailed information on individual field operations. Scores of the three assessment methods are standardised in FarmDyn to take on values between 0 and 1.

The contribution of AEMs to improve on-farm biodiversity according to the three methods is evaluated by calculating biodiversity scores for nine representative farms, with and without the opportunity to participate in AEM. These sample farms (three arable farms, three dairy farms, two beef farms and one pig farm) are selected based on the farm typology by Kuhn and Schäfer (2018) and the Farm Structure Survey of 2016 (Statistisches Bundesamt, n.d.). For each soil climate region (Roßberg *et al*., 2007) of NRW one sample farm is chosen, typically the most important one according to their farmland share, such that the production program and farm size of the nine selected farms jointly cover the most important farm types in NRW by specialisation, size and stocking density. First, each farm is calibrated to the observed production program based on Britz (2021), excluding potential AEMs, but considering the greening obligation. Here, the EFA is fulfilled by cultivating catch crops or idling land, as the most frequently observed option (Table 5.2). Data on landscape elements eligible for EFA are not available such that we might overestimate catch crop and idling areas and cannot quantify the contribution of existing hedgerows etc. The calibration step provides the benchmark for our two counterfactuals. The first one offers each sample farm the possibility to participate additionally in the two existing AEMs detailed above.

In a second scenario, the impact of the voluntary eco-scheme *PesticideFree* is assessed with silage maize and summer barley being eligible as currently discussed. Solely sample farm Dairy 3 cultivates both crops and is accordingly selected for the evaluation of this eco-scheme. In a third model run, this farm has the opportunity to participate in the eco-scheme in addition to the two AEMs and produce silage maize and summer barley without chemical-synthetic pesticides, assuming the uptake of mechanical weed control and yield losses of 15% (Kritstensena and Ramussen, 2002). Whether and to which extent the farms take up the voluntary measures depends on potential profit gains. Other behavioural aspects, such as intrinsic motivation or risk are not considered in the quantitative analyse.

Production Programme

The production programs of the sample farms and their changes by the potential implementation of AEMs and, in case of sample farm Dairy 3, of the eco-scheme can be seen in Table 5.2. Except for one, all sample farms with arable land implement the AEM *flower strips* up to the maximum eligible share of 10.00 % on their arable land. The implementation of flower strips requires a reduction in the acreage of main crops, which is achieved by a decreased cultivation of economically less attractive crops. Five of nine sample farms further adjust their crop shares such as to meet the requirements of the AEM *crop diversification*. Further, flower strips become more attractive as a Greening measure through joint implementation as AEM. As a consequent, five sample farms growing catch crops in the baseline scenario reduce catch crop production in favour of flower strips when participating in AEMs.

With the possibility to further participate in the eco-scheme *PesticideFree*, Dairy 3 farm starts producing silage maize without pesticide use. This is associated with reduced input costs for pesticides, but a slight increase in labour requirements. Increasing machinery requirements for mechanical weeding are offset by a decrease in machinery use for pesticide applications. Adjustments in grassland management and wheat production reflect changes in monthly labour requirements and compensate for the decreased harvest of silage maize for feeding. In contrast to silage maize, the production of summer barley does not change. Here, the offered premium combined with cost saving from skipping chemical pesticide spraying cannot compensate for increasing labour requirements and machinery costs as well as decreasing revenues due to the assumed yield drop.

Biodiversity Scores

Figure 5.1 gives an overview of the biodiversity scores at the benchmark and their changes through the implementation of the AES and the eco-scheme. On five of the nine sample farms, all three assessment tools show increased biodiversity score due to the implementation of AEMs. This reflects mostly that *flower strips* are beneficial for biodiversity compared to the (intensive) crops they partly replace. Some moderate improvements of biodiversity scores by the AEM *crop diversification* are due to a more diversified and even distribution of the crops.

For three farms (Arable 3, Dairy 1 and Dairy 2), the assessment tools do not agree on the direction of change. According to *SALCA-BD,* the implementation of AES is beneficial for biodiversity on all farms. In contrast, *SMART* shows a decline on one farm while the results Paracchini and Britz (2010) indicate slightly negative effects on three farms. Thereby, the decline *Paracchini-Britz* is due to the partly strong decrease in catch crop production, resulting in more unevenly distributed crop shares.

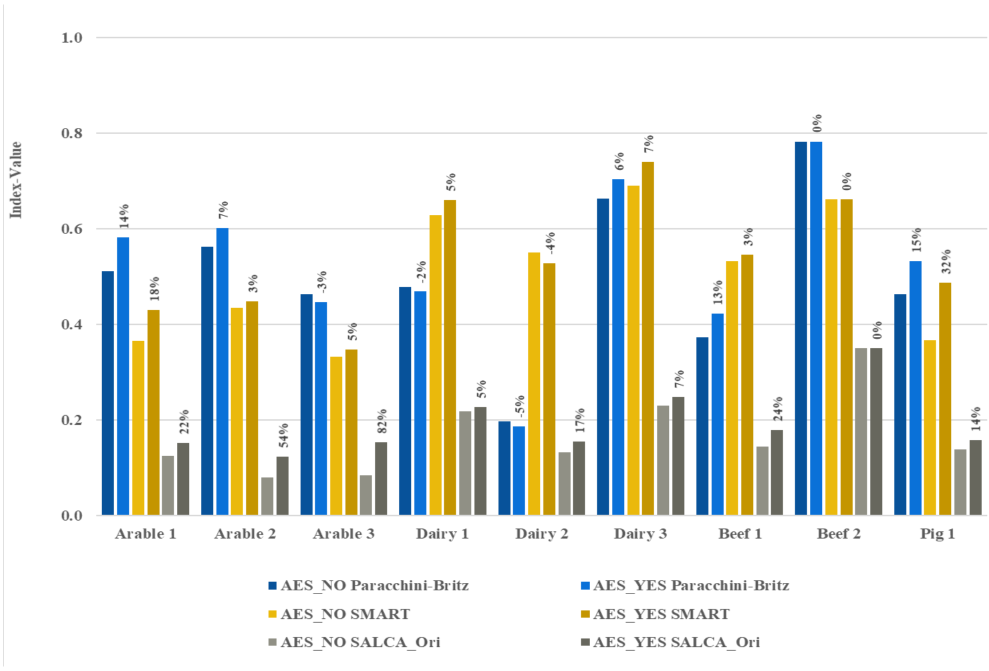
Sample farm Beef 2 cultivates grassland only and does thus not implement AEMs included in the study. Here, the production program and biodiversity remain unaffected. Due to the extensive production, Beef 2 farm, however, achieves the highest biodiversity score. Generally, farms with grassland achieve a higher level of biodiversity according to *SMART* and *SALCA-BD*. This reflects mainly that permanent grasslands tend to be more beneficial for biodiversity than arable cropping. For example, *SMART* sets pesticide and fertiliser application into relation to the total land of the sample farm, grassland partly exhibiting lower application rates. As both AEMs refer to arable land, improvements of the biodiversity score depend strongly on the farms' arable land shares.

With the implementation of eco-scheme *PesticideFree*, the biodiversity scores of sample farm Dairy 3 further increase according to the *Paracchini-Britz* and the *SMART* methods (Figure 5.2). The increase is not only due to the decrease in pesticide applications, but also due to the uptake of idling. *SALCA-BD* reacts less sensitive to these changes in the production program. Here, the biodiversity score increases only marginally.

Both AEMs as well as the currently discussed eco-scheme *PesticideFree* have the potential to improve on-farm biodiversity on the majority of the farms according to all assessment methods. However, the strength of the effect as well as the initial score differ, especially when comparing different farm types. Our results indicate that changes in crop rotations due to the adoption of AEMs might in some cases also lead to a decline in biodiversity. Here, the results of the three assessment methods, however, contradict, and no clear conclusion can be derived. Differences in the results of *Paracchini-Britz*, *SMART* and *SALCA-BD* are caused by different focus of the assessment methods, shedding light on different aspects on how farm management affects biodiversity.

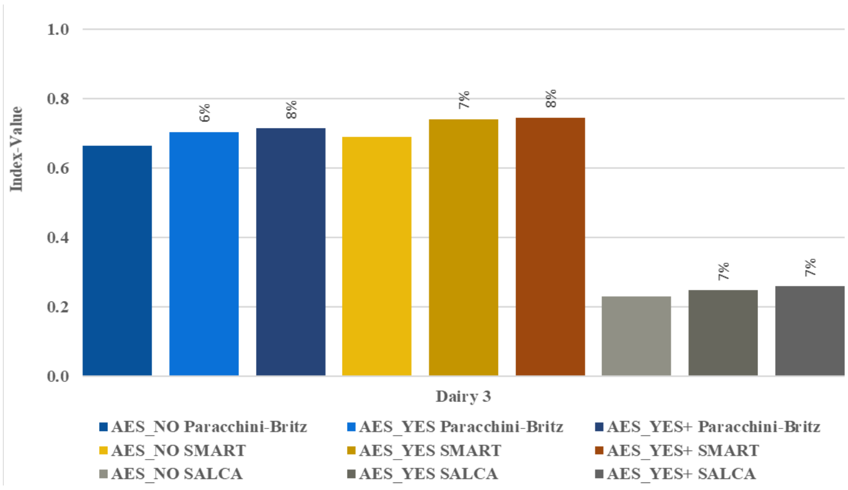
This study contributes to the growing efforts to implement biodiversity indicators in economic modelling approaches (Janssen and van Ittersum, 2007; Reidsma *et al.*, 2018). By linking the optimisation of farmers resource management decisions to various performance indicators, bioeconomic farm-scale models represent a valuable tool to (ex-ante) assess socio-economic and environmental effects of policies on farms (Britz *et al.*, 2021; Janssen and van Ittersum, 2007). Thereby, the analysis assumes a rational, fully informed farmer and the results entail best-practice behaviour. Further factors, such as behavioural and social aspects clearly impact the decision of farmers to participate in AEMs and other environmentally friendly measures (Lastro-Bravo *et al.*, 2015). Nevertheless, economic factors were found to play a key role on farmers' willingness to participate, the AEMs premiums being an important source of income to farmers (Lastro-Bravo *et al.*, 2015).

Figure 5.1: Effect of AES on biodiversity of nine sample farms



Source: Own illustration based on the simulation results.

Figure 5.2: Effect of AES and eco-scheme PesticideFree on biodiversity of sample farm Dairy 3



Source: Own illustration based on the simulation results.

Table 5.3: Production programs of the sample farms

	Arable 1		Arable 2		Arable 3		Dairy 1		Dairy 2		Dairy 3			Beef 1		Beef 2		Pig 1	
AES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	YES +	NO	YES	NO	YES	NO	YES
Arable Land	**57**		**100**		**78**		**35**		**49**			**38**		**31**				**109**	
Wheat	23.5	17.1	36.5	30.0	43.9	42.4	11.0	6.7			10.7	10.3	9.3					39.8	32.7
Barley	13.2	12.0	11.9	10.0							7.7	5.1	5.1	2.3	4.5			30.7	27.3
Barley, NoPesticide																			
Rye									1.2	1.6				1.1	3.1				
Triticale	3.5	5.7							4.3	2.6	1.2	3.8	3.8	8.8	7.9			8.0	10.9
Rapeseed	11.9	10.8			6.6	4.9												17.6	14.1
Grain Maize	2.9	5.7	24.5	23.7	3.9	0.6													
Silage Maize							17.1	17.8	34.2	32.2	13.2	11.2		17.1	9.3				
Silage Maize, NoPesticide													11.4						
Potatoes			13.9	15.0															
Sugar Beets			12.9	11.3	23.6	22.3												7.4	10.9
Field Grass							6.9	7.0	9.3	10.5	3.4	3.8	3.8	1.7	3.1				
Catch Crops	2.9	5.7	16.1	10.0	13.0		5.8	0.1	8.2			3.8	3.8	5.0	3.1				10.9
Flower Strips		5.7		10.0		7.8		3.5		2.0		3.8	3.8		3.1				10.9
Idle	2.0		0.2								1.9		0.8	0.1				5.5	2.2
Grassland							**55**		**34**			**50**		**18**		**50**			
Grazing Only							21.3	20.6	18.1	17.7	11.3	11.3	11.3	7.3	7.9	3.2	3.2		
3 Cuts + Grazing							15.1	16.0	12.5	12.2	7.4	7.4	7.7	4.8	5.3	1.9	1.9		
4 Cuts + Grazing									3.4	4.1				5.9	4.8	6.7	6.7		
Idle Gras							18.6	18.4			31.3	31.3	31.0			38.3	38.3		
Animals										**Cows**					**Bulls**			**Fatteners**	
							87	88	123	120	45	45	45	118	129	48	48	2636	2689

Note: Production program of the sample farms without AESs (NO), with AES (YES) and with both, AES and eco-scheme PesticideFree (YES+)

Source: Own calculations based on the simulation.

5.3 Comparison of payment schemes to reduce methane emissions of dairy cows (France)

In France, 17.4% of GHGs are of agricultural origin. Cattle farming is the main contributor (60.4%) and methane from enteric fermentation of ruminants alone accounts for half of the GHGs emitted by dairy farms. Variations in methane emissions are related to herd management and production practices (Dall-Orsoletta *et al.*, 2019). The most optimised systems are often the most environmentally efficient (Henrikson *et al.*, 2011). On the one hand, increasing the level of animal production reduces methane emissions when expressed per kg of milk. The main cause is the lower share of maintenance requirements in total requirements (Doreau *et al.*, 2017). On the other hand, optimised feed rations increase feed conversion efficiency, resulting in higher productivity and reduced losses, especially in the form of methane. The nature of the diet of dairy cows can thus modify the characteristics of the milk produced, but also the quantities of methane emitted. Several studies have shown that supplementation with omega-3 fatty acids can reduce methane emissions from dairy cows (Martin *et al.*, 2008, Nguyen *et al.*, 2012). Omega-3 rich milk can be produced from grazed grass, or by incorporating flax-based feeds into the ration, which is not widely adopted by farmers because it greatly increases the cost of feed expenses.

The objective of this section is to simulate different PES schemes to reduce methane emissions per kg of milk by encouraging farmers to modify the feed ration of dairy cows, and to evaluate their mitigation potential per ton of CO2 equivalent slaughtered. The contributions of this work are multiple.

On the one hand, we compare three payment schemes, which differ according to the funding sources. The first scheme concerns the implementation of a premium per hectare of reinforced grassland, in the continuity of existing AEM, the AEM grassland. This aid is therefore targeted on a practice, that of increasing the quantity of mown or grazed grass in the animals' feed ration. In the second scheme, aid is paid to farmers who use concentrates rich in omega-3, such as flax, in their animal feed. As in the first scheme, this scheme is targeted at the practice of increasing the amount of flax in the animals' feed ration. Finally, in the third scheme, aid is granted directly to farmers in proportion to a reduction in methane emissions. The first scheme is supposed to be financed by public aid, unlike the third scheme, which is financed by private agents who are more sensitive to paying for a targeted reduction in pollution. This last scheme is close to an existing program in France, the “Eco-methane” program. Each farmer participating in this program must provide monthly milk analysis. Thanks to the milk analysis and the quality of its fatty acids, the methane savings of each dairy farm compared to a more conventional agriculture are calculated using a scientific methodology recognised in 2011 by the French Ministry of Ecology and in 2012 by the United Nations (UNFCCC, 2016). The farms are then paid by an association authorised to collect donations from companies, communities or individuals.

Second, we model animal feeding decisions using a microeconomic model defined at the farm level. Standard microeconomic models of agricultural production choices are more adapted to field crop production. Some papers have nevertheless applied these standard models to livestock data, but generally the contribution of these papers was not specifically related to livestock, or in any case, their objective was probably not to adapt these production choice models. However, the role of livestock is predominant in the debates on the impact of agriculture on the environment. The need to evaluate environmental policies also justifies the need to adapt microeconomic models to take into account the specificities of livestock production, which may have a direct role on the impact of a given policy. The issue of climate change often involves ruminants, and mainly cattle. Methane from cattle enteric fermentation alone represents half of the GHGs emitted by dairy farms. Levers exist to reduce these methane emissions, for example by modifying the composition of the feed ration or optimising the management of herd renewal. To assess the impact of environmental policies, it is therefore essential to understand the technical relationships that exist in these farms, and to adapt our microeconomic models.

Finally, our approach uses zootechnical knowledge to extract maximum information from the observed data, which are generated by these known technical relationships, but tainted by the behaviour of farmers, their heterogeneity and measurement error. Concretely, the zootechnical knowledge (i) allows us to directly estimate the milk production technology, which is a deterministic relationship with little randomness, as long as we have the available variables; the implicit prices of the different feed sources are then derived from the profit optimisation program of the farmers; (ii) provide us with additional information to control for unobserved heterogeneity and provide a solution to the problem of endogeneity of the variables; (iii) allow us to verify and validate our results thanks to the parameters that have a zootechnical interpretation.

We estimate a milk yield function by distinguishing between three types of forage (corn forage, grass silage and grass pasture) and concentrates, and by assuming optimisation by the farmer between these different feed sources according to prices. The manipulation of the implicit prices from our optimised model then allows us to simulate the different schemes. To evaluate the potential of these different schemes, methane emissions are calculated from an existing technical relationship (Sauvant *et al*. 2011) between different feed sources and milk productivity. The different systems tested modify these production choices, favouring one or another diet, and directly impact methane emissions per kg of milk.

Local accountancy data similar to Farm Accountancy Data Network (FADN) data are used to calculate methane emissions per kg of milk and to estimate the milk production function of farms in Ille-et-Vilaine (a sub-region in Brittany region in France). For the calculation of methane emissions, there are two sources of uncertainty: the shares of fresh and preserved grass, and the fatty acid composition of concentrates. We propose assumptions for calculating average methane emissions per kg of milk per farm based on information available in the FADN database. Regarding the estimation of the milk production function per cow, the available data do not allow us to explicitly control for farm heterogeneity, such as land quality, equipment accuracy, and herd management, which directly impact the energy quality of the forages provided and the energy requirements of the cows. By using an adapted statistical method, the additional information from zootechnical knowledge allow us to control for this unobserved heterogeneity, which is a potential source of endogeneity.

Once all the model parameters have been estimated, we simulate the different payment schemes. The scenarios are compared according to their potential to reduce GHG emissions, in terms of €/tonne of CO2 equivalent (t CO2e), differentiating the cost for the farmers and the cost for the schemes' funding provider. The grass premium is inexpensive, but its effectiveness in reducing methane emissions per litre of milk is limited. It allows to reach a maximum reduction of about 16 t CO2e per farm, which corresponds to a decrease of about 7% of total CH4, for a cost of less than 150€/t CO2e. The option of subsidising flax-based concentrates is interesting to achieve large CH4 emission reduction, although quite costly, and the price of the flax-based concentrate is higher than the price of the standard concentrate. If flax-based concentrate is 25% more expensive than standard concentrate, then the cost of a 20% reduction in methane emissions is €4,500/t CO2e. The strategy of directly financing a decrease in CH4 emissions per litre of milk is never the most interesting strategy in terms of cost per t CO2e, whether for small or large decreases in emissions. To maximise yield, a joint increase in concentrate and forage is required. However, to reduce methane, one must either increase grass (scenario 1) or concentrate (scenario 2). A joint increase in both (scenario 3) does not optimise CH4 reduction.

5.4 An agent-based model approach of the transition towards agro-ecological farming systems (France)

Rather than studying how conventional farms may be incentivised to change their practices towards more agro-ecological ones, the approach proposed here analyses how different types of regulations may enhance the access to land for farms which already implement desirable practices. This may consist in favouring both the enlargement or the settlement of a specific category of farms. By analogy with land use change studies, the first approach (practice conversion) could be qualified as seeking the development of agro-ecological practices "at the intensive margin", while the approach proposed here (land market access) could be qualified as operating "at the extensive margin".

To do so, we developed an agent-based model (ABM) where farms with specific production technologies compete on the farmland market to get access to production plots. In its basic principles, the proposed model builds on Letort *et al*. (2017) but has been adapted on many aspects to the particular issues addressed here. The proposed model represents an *in silico* experiment in the sense that it is applied to a fictional production region with a simulated population of farms which produce a fictitious agricultural good. Nonetheless, it aims at being realistic because the size of plots, the initial distribution of farms, the specified production technologies, etc., are calibrated so as to mimic production conditions which could exist in real life situations. The proposed ABM should therefore allow to derive general conclusions as regards the respective effectiveness and efficiency of the modelled policies.

In our ABM, farm agents are randomly located in the simulated production area and compete among each other in order to rent in agricultural plots so as to maximise their operating size given their production technology. Apart from their location, farm agents are characterised by the age of their operator and the production function which defines their production technology. On the one hand, operator ages are randomly drawn from a distribution which mimics that of French farmers in 2010. On the other hand, three stylistic production technologies are considered, namely conventional farming (CF), low-input farming (LI), and organic farming (OF), which all use two variable inputs (pesticides and fertilisers) and one fixed input (salaried work force) in addition to land. On each plot, the generic production function is quadratic and specified following Carpentier and Letort (2014) as:

$$y = \beta\bar{y} - \frac{1}{2}(\bar{\mathbf{x}} - \mathbf{x})'\mathbf{\Gamma}^{-1}(\bar{\mathbf{x}} - \mathbf{x}) \qquad (1)$$

where y is the per-hectare yield of the fictitious agricultural good produced, $\beta\bar{y}$ is the maximum attainable yield, $\mathbf{x}$ is the vector of variable inputs, $\bar{\mathbf{x}}$ is the vector of optimal variable inputs (that is, the vector of variable inputs which allows to obtain the maximum attainable yield $\beta\bar{y}$), and $\mathbf{\Gamma}$ is a square matrix which, in particular, defines the degree of complementarity/substitution between the two variable inputs, pesticides and fertilisers. The maximum attainable yield $\beta\bar{y}$ is composed of two components: $\bar{y}$ which only depends on the considered plot, and β which only depends on the farm technology. In turn, $\bar{\mathbf{x}}$ and $\mathbf{\Gamma}$ only depend on the farm technology. In addition, production requires using a fixed per-hectare amount of salaried labour l which only depends on the farm technology.

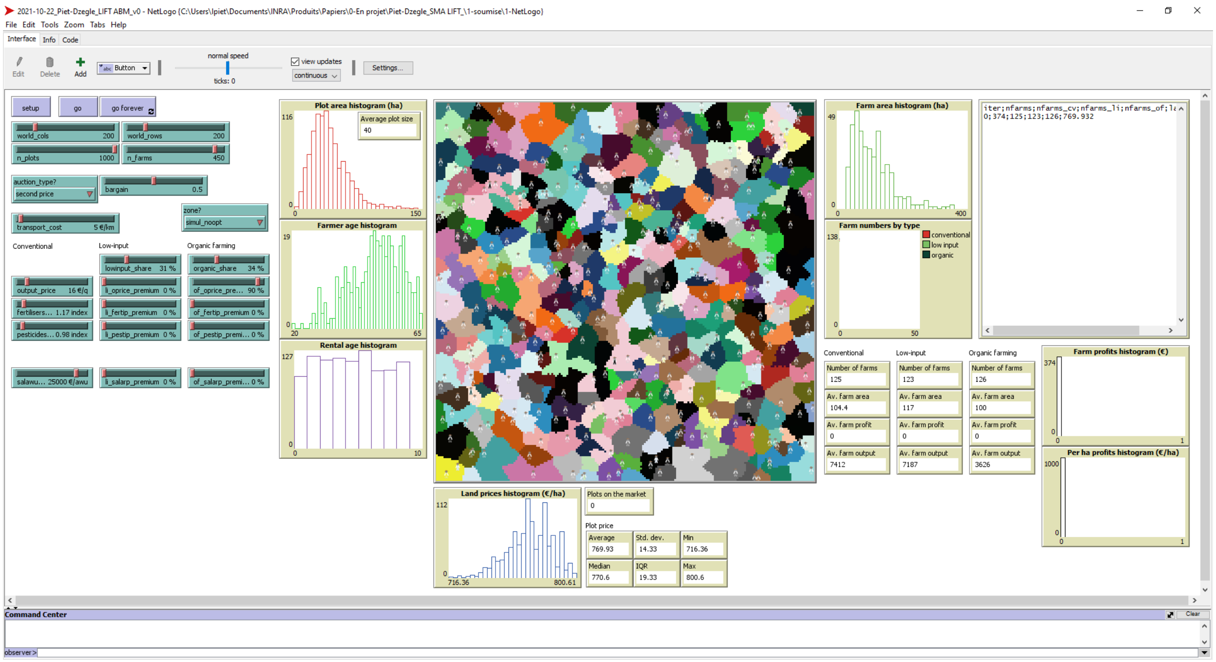
Assuming that the simulated farm agents are price takers, input and output prices are set exogenous and (possibly) differ across technologies. Specifically, the three technologies face the same variable and labour input prices, while organic farming receives a significantly higher output price with respect to conventional and low-input farming, which are equally valued.

Technology parameters (β, $\bar{\mathbf{x}}$ and $\mathbf{\Gamma}$) and price indexes for the conventional and low-input technologies are taken from Femenia and Letort (2016). For the organic technology, the corresponding parameters (including the output price premium) have been estimated in a similar way using French FADN data for the 'Specialised cereals, oilseed and protein crops' type of farming over the 2015-2019 period. Actually, the β parameter for the conventional technology is normalised to 1 so that the plot-specific yield, $\bar{y}$, is that obtained by the conventional technology at best, and the maximum yields attainable by the two other technologies are a fraction of that of the conventional technology.

In the first period of the model, each plot is assigned to the farm agent which is the closest, and is randomly given a rental time between zero and eight (in France, the duration of typical rents is nine years). At the beginning of each successive period, plots may be made available on the land market for two reasons: either the farm agent who used them in the previous period reaches 65 in age and exits, thus releasing all of his/her plots; or the age of the rental contract of the plot reaches nine, so that the rental contract expires and a new contract may be established. Then, the land allocation process is that of a second price sealed bid auction: each farm agent bids on each plot available on the market at a price corresponding to his/her marginal land price, taking into account his/her (technology-specific) variable cost, his/her (fixed) labour cost and an additional transportation cost which only depends on his/her (Euclidian) distance to the plot. Each plot is eventually assigned to the highest bidder at the price expressed by the second higher bidder (thus making a profit corresponding to the difference between the best and the second-best bids). At the end of the period, the characteristics of each farm agent (list of plots, total size, variable and labour input uses, age, etc.) are updated, and a new model period may start.

The proposed ABM is being developed with the NetLogo 6.0.1 platform (Wilensky, 1999). A screenshot of the current model interface is reported in Figure 5.3.

Figure 5.3: Screenshot of the current interface of the developed ABM on the NetLogo platform

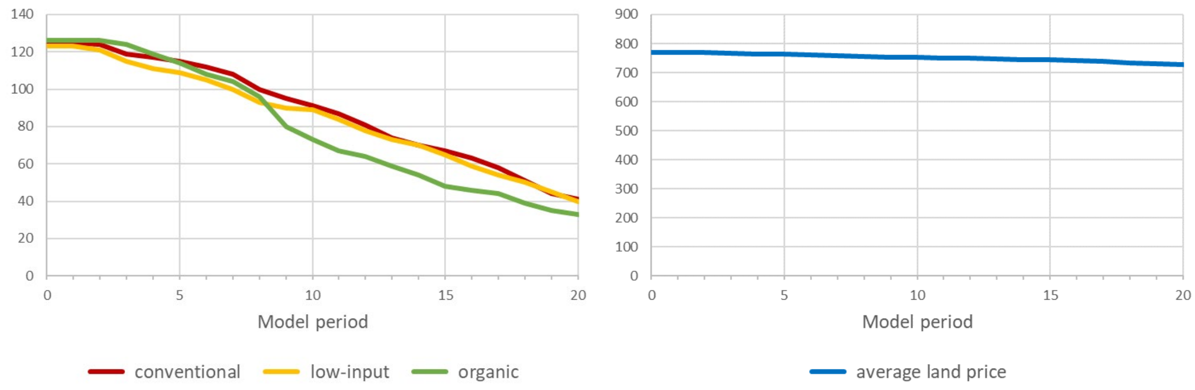


Source: Own NetLogo code development.

The model currently allows to simulate an illustrative policy scenario, which consists in imposing an exogenous 50%-tax on the pesticides price faced by conventional and low-input farming agents, while the input price for organic pesticides remains unchanged.

Figure 5.4 presents two out of the various outcomes of the model for the baseline (without tax) run over 20 periods: the evolution of the number of farms for each technology (Figure 5.4a) and the evolution of the average land price of plots (Figure 5.4b). The baseline is calibrated so that the three technologies are equally distributed among the initial farm agents. It then appears that, in the baseline run, after a phase where the number of agricultural agents decreases in a rather similar way for the three technologies, the number of farm agents of the organic farming type drops in period 9 and remains significantly lower thereafter. Eventually, organic farming agents represents less than 30% of the total farm agents' population in period 20. At the same time, the average price of farmland is steadily declining from an index of 770 in the initial period to an index of 728 in period 20, that is, a 5.5% decrease. Note that in the current version of the model, the price of land can only decline over time because as farms get larger, the additional plots they rent in are further away, implying a higher transportation cost and thus a lower marginal bid for land.

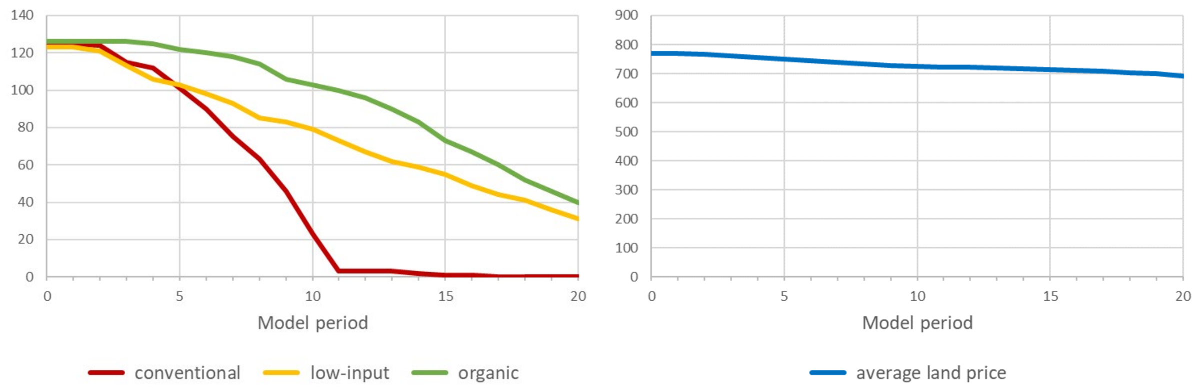
Figure 5.4: Number of farms and average land price for the baseline run of the model



a) Number of farms b) Land price index

Source: Own calculations.

Figure 5.5: Number of farms and average land price for the pesticide tax scenario



a) Number of farms b) Land price index

Source: Own calculations.

Figure 5.5 reports the corresponding model outcomes for the pesticide tax policy scenario, where the 50%-tax on the input price of pesticides for the conventional and low input technologies is imposed as early as period 2. Figure 5.5a shows that the development in the farm numbers significantly differs from that of the baseline run on several grounds. First, the number of organic farming agents no longer drops in period 9 but rather declines at a slower pace and remains higher than that of the two other technologies. Second, the number of conventional farming agents sharply falls between period 2 and 11 so that there are no agents of this type left after period 17. Third, the number of low input farming agents again declines steadily, though at a slightly faster pace than in the baseline. Overall, the number of remaining farm agents is 38% lower in the policy scenario (71) with respect to the baseline run (114), but they are of the more desirable (agro-ecological) types only, with organic farming agents representing more than half (56%) of the total left-over population. Under this policy scenario, the decrease in the price of land is slightly more important, ending at an index of 693 in period 20, or a 10% decrease (Figure 5.5b).

The results reported above are illustrative of the type of analysis that is possible with the developed ABM. They focused on two kinds of model outcomes, the number of farms of each technology and the average farmland price, but other items could be investigated. These include the overall and technology-specific farm agent profits among economic impact indicators, and the overall and technology-specific use of polluting inputs as a proxy of environmental impacts. The model could be developed to include further important characteristics and processes. First, the quality of farmland can be made heterogeneous by letting the maximum attainable yield $\bar{y}$ vary across plots. Second, it can be taken into account that organic farming agents cannot instantaneously benefit from their technology-specific output price premium for the conventional plots they may rent in over time, but that they rather have to wait for some years (i.e. model periods) before they can do so. Third, the possibility of new farmer agents' entry at each period could be implemented. When all these model developments are implemented, it will be possible to compare the effectiveness and efficiency of innovative, land regulation based, policy measures (such as preferentially targeting the available land towards low-input or organic new entrants) with respect to more standard tax/subsidy tools as the one presented here. Finally, the model runs can be replicated several hundred times in order to obtain robust results from which the potential biases introduced by the various parameters randomly set in each run will be eliminated.

5.5 The role of consumers and FOP-labelling to encourage adoption of ecological practices and the sustainability of ecological agriculture (Belgium)

By developing a harmonised front-of-pack (FOP) labelling system by Q4 2022, the EU wants to reduce the overabundance of sustainability labels on food products. A life-cycle assessment (LCA)-based impact indicator should form a more standardised alternative in reflecting products' environmental impact. Although the intention is to eliminate redundant labels, some remaining credence attributes of food are perceived by consumers in the same domain. For example, there is an incorrect perception among consumers that local and organic products necessarily have a lower environmental impact than their imported or conventional counterparts. Therefore, a discrete choice experiment (DCE) in LIFT WP2, carried out in a Belgian case study area, investigated relative preferences for local, organic, good Eco-Scores and seasonality of vegetables. In particular, it questioned how preferences are expressed when local or organic heuristics conflict with displayed Eco-Scores. Moreover, it was investigated how preferences for the individual attributes are influenced by activating a sustainable vs. unsustainable self-image (see LIFT deliverable D2.3 Barnes *et al*., 2021). Since discussions on the implementation of environmental indices are currently in full swing, this study provides very useful insights for policy makers.

First of all, it adds to the accumulating literature recommending the use of a uniform and objective environmental impact score as FOP-label on food. Where the comprehensibility and activating potential of an Eco-Score have been described earlier, this study places the importance of such a score in a broader context. It showed not only that consumers are in favour or vegetables bundles with better Eco-Scores, it also provided insights in its relative importance compared to other attributes. Surprisingly, the relative importance of Eco-Score was situated in the same order of magnitude as price and origin. While price and origin are very well known to be of major importance in food choices, these results support the growing evidence that Eco-Score could become a high-performing, market-based tool to promote more sustainable food choices amongst consumers. The study also showed that consumers' importance attached to an organic label is only one third of that potentially attached to Eco-Scores. In the European Commission's Farm-to-Fork strategy, organic production and sustainable production are rather unfortunately lumped together (European Commission, 2020). However, this study shows that consumers would attach much more importance to good Eco-Scores than to organic labels.

Second, this study raises a potential threat to Eco-Score's success. As described above, consumers might experience attributes as organic, local and Eco-Score as highly overlapping, with lower environmental impacts as common ground. However, the co-existence of this information on food packages might lead to inefficient choice outcomes. This has been exemplified by the interaction between localness and Eco-Score. Because a local product may possibly have a higher environmental impact and thus a poorer Eco-Score than an imported one, the consumer actually gets an additional source of utility within the same domain. If a product has a bad Eco-Score, more importance is attached to the local aspect as compensation. If the product is imported, more importance will be attached to the Eco-Score as compensation. The prevailing idea that local production is always more environmentally friendly makes that consumers rely less on other environmental information and results in sustainably inferior choices. These findings do not at all imply that origin information should not be shown next to an Eco-Score. On the contrary, concerns about the local economy and quality expectations are more important drivers for local preferences than are environmental concerns and as such it remains worthwhile to display the origin of the products (Kwant, 2021). However, there is a strong need to make consumers more knowledgeable on this difference, so that purchase intentions become more alienated with actual purchases (i.e. consumers who want to buy environmentally friendly are helped by an Eco-Score, just as the consumer who wants to buy local is helped by the origin information).

Third, our study finds that people strongly dislike vegetable baskets consisting solely of seasonal vegetables. While generally consumers are thought to be rather keen on seasonal vegetables, in the longer term they turn out to be keener on having access to a diverse basket of vegetables, both on-season and off-season. This might indicate that if supply of seasonal vegetables is increased, some of these products might remain at the shelves. As such the strategy to mainly devote resources to the production of seasonal products might backfire to producers.

Finally, this study provides insights in how consumers' pro-environmental preferences could be strengthened by activating various self-views. The results indicate that making people uncertain about being a sustainable person could stimulate preferences for seasonal vegetables and good Eco-Scores, yet at the expense of preferences for organic. Preferences for seasonal vegetables and organic can as well be strengthened by making people see themselves as non-sustainable, yet at the expense of preferences for good Eco-Scores. It is notable that preferences for local were hardly influenced by the different self-views. These insights can be used as guidance to steer consumer's preferences in a direction which is in line with the prevailing strategies on production side. The interesting thing about these findings is their broad applicability, as they provide an answer to different political discourses. If one wants consumers to rely more on product environmental footprint based Eco-scores (and less on organic certificates), these results provide a way to steer demand accordingly. However, if one prefers consumers relying even more to organic food products, this study also provides a way to steer demand accordingly. Nevertheless, it should be noted that these findings only hold for the early stages of Eco-Score's implementation. Once Eco-Score becomes more established amongst consumers, deviating results could be observed. Therefore, a re-evaluation of these findings at a later stage would be desirable.

6 A focus on collective-based strategies

Agricultural policies aimed at favouring the adoption of ecological practices have essentially been directed towards individual farms (Baylis *et al.*, 2008; Lefebvre *et al.*, 2015). However, the EU Rural Development Regulation 1305/2013 introduced the possibility for AES payments to be paid to "*farmers,* *groups of farmers or other land managers*" (Article 28, sub-clause 2), recognising that "*In many situations the synergies resulting from commitments undertaken jointly by a group of farmers multiply the environmental and climate benefit*" (Paragraph 22). A rather large body of literature, both theoretical and empirical, addresses the possibility to design agro-environmental policies based on collective, rather than individual, approaches.

A first rationale for the interest in collective approaches to ecological farming management is the spatial dependency between biological processes which leads to the necessity to target areas of higher interest or to ensure that the spatial arrangement of the parcels enrolled under an incentive scheme delivers a sufficient level of environmental services (Parkhurst *et al.*, 2002). In order to improve the environmental performance of AES, Smith and Shogren (2002) and Parkhurst *et al.* (2002) proposed an "agglomeration bonus", a two-part incentive scheme comprising a standard payment and a bonus granted if adjacent parcels from neighbouring farmers are enrolled in the scheme. This type of collective approach is put forward in contexts in which the spatial arrangement of enrolled parcels is crucial for the policy to succeed, in particular to improve the connectivity between fragmented habitats for biodiversity protection. In practice, AES with an agglomeration bonus have been implemented in very few settings. The Conservation Reserve Enhancement Program (CREP) in Oregon (United States) was established in 1998 with the aim of restoring contiguous riparian buffers to help recover salmon and trout species, through the payment of a Cumulative Impact Incentive Bonus (CIIB) to farmers, activated if at least 50 percent of any 5-mile section of streambed is enrolled in the CREP (USDA, 1998). The Ordinance of Ecological Quality in Switzerland was implemented in 2001 and included two types of payments on top of standard payments – quality bonus for ecological compensation areas of great quality and network bonus for ecological compensation areas located in designated corridors (Krämer and Wätzold, 2018). In France, a particular AES dedicated to the preservation of the common hamster comprises a collective payment akin to an agglomeration bonus. **Section 6.1** analyses the terrestrial voles management strategies in France and puts forwards the barriers and opportunities provided by the necessary spatially arranged collective management strategy implemented.

Biological processes are also characterised by threshold effects, meaning that if the total area of land enrolled under an AES is not sufficient, then this may jeopardise the cost-efficiency of the program (Dupraz *et al.*, 2009). The question is then how to increase participation in AES schemes within a given geographically-relevant area, without necessarily looking for contiguity of enrolled parcels. Empirical studies of farmers' willingness to accept (WTA) when joining an AES show that this WTA depends on the degree of restrictions on farming practices conveyed by the AES, on attributes of the contract such as duration, and on socio-economic characteristics of farmers (Falconer and Saunders, 2002; Ducos *et al.*, 2009; Ruto and Garrod, 2009). A payment based on a collective measure of participation has been proposed as an attribute of the contracts that could increase farmers' enrolment in AES, based on the premise of peer-effect type mechanisms (Chen *et al.*, 2009; Beharry-Borg *et al.*, 2012). Multiple reasons why farmers would be incited to participate when informed that other (neighbouring) farmers participate, have been put forward: the "public good" nature of the environmental amenities produced by ecological agriculture (Albers *et al.*, 2008; Epanchin-Niell and Wilen, 2015), the potential direct benefits derived from a public good for agricultural production, and behavioural factors related to how farmers value conforming to a social norm (Dietz, 2002; Pretty, 2003; Chen *et al.*, 2009; Czajkowski *et al.*, 2014). **Section 6.2** presents syntheses results from a pilot experiment and the LIFT large-scale farmers' survey about farmers' views on and responses to collective-based policy approaches. **Section 6.3** provides a theoretical investigation of the impact of minimum participation rules for pollination management. Finally, **section 6.4** studies the role of collaborative networks to encourage adoption of ecological practices and the sustainability of ecological agriculture based on a DCE.

6.1 Collective rodent management (France)

It is only since the 1980s that the outbreaks of terrestrial voles (*Arvicola terrestris*) in France, also known as "mole rats", have been causing problems in the territories they affect. The gravity of the situation, due to the significant damage regularly caused to livestock meadows, strongly challenged agricultural stakeholders and public authorities. Until the end of the 20th century, the first avenue that was explored was the intensive use of chemicals based on anticoagulants, in particular, bromadiolone. However, the limits to the fight by poisoning became evident following damage to non-target species that caused public backlash. Therefore, the need to better understand these dynamics of outbreaks, to identify their causes and to build effective and sustainable control methods, mobilised the efforts of scientists, farmers, professional structures and public authorities. A toolbox combining complementary control methods was gradually implemented in Franche-Comté, then adapted to other areas also affected by the outbreaks. Within the framework of the CAP, the Fonds national Agricole de Mutualisation du risque Sanitaire et Social (FMSE) contracts, financing 75% of the cost of the control practices, were introduced to support the implementation of an early and reasoned control against the terrestrial vole, on the basis of a 5-year commitment. The regulation regarding vole outbreaks (as a pest classified in the second category of sanitary dangers) is rather clear and is supposed to oblige farmers to gather and to plan collective action (there are “mandatory action decrees” at sub-regional scales). But there is neither control nor sanction planned for farmers who do not get involved in collective action. There are main specificities of this risk requiring a high level of coordination: space-related and time-related cycles, high intensity and high frequency, link with landscape and agricultural practices, systemic character at a local scale, difficulty to find out a stable and sufficient premium base. Furthermore, there are limits of the current risk management strategy, focused on “hazard” and ignoring the vulnerability factors. Risk perception is a main limiting factor to collective action because it causes mistrust between stakeholders (lack of vertical coordination) and between farmers (lack of horizontal coordination). Until now, many barriers, diverse by their nature and by the intensity of the blockages they generate, have limited the effectiveness of these collective efforts to the point that a certain demotivation has appeared even within the zones where reasoned and collective practices emerged. Conversely, new promising initiatives are emerging, which are inspired by the positive experiences carried out in the territories which were pioneers in this area.

Barriers to the collective management of terrestrial voles outbreaks

The technical difficulties of the control of the ground vole represent a major challenge. The terrestrial vole is a burrowing animal, able to use the habitat of moles and to spread from the network of already existing galleries. It hardly ever shows up, and by the time it does, it is often already too late: the cycle of pullulation is already well underway. The technical difficulties of the fight also concern the installation of traps, or the disposal of poisoned bait through the distributing rods. Without dedicated training, it is very difficult for farmers to use these tools in a truly effective way.

The second barrier concerns the economic health of agricultural operations. On the one hand, highly remunerative activities, as is the case with the Protected designation of origin (PDO) Comté dairy industry in Franche-Comté, can hamper the implementation of preventive control resources. It seems that when the price of milk is very high, farms have a cash margin that allows them to buy fodder and rebuild the grasslands. This would be particularly the case in the sub-region Jura. Conversely, other agricultural systems, which do not benefit from the same financial windfall, are driven by necessity. However, a difficult economic situation can also dampen momentum. For some farms, advancing the cost of the struggle is perilous. The means are lacking to call on external service providers, or to buy the necessary equipment.

Then, obstacles relate in particular to the working conditions of farmers, in specialised production systems that do not include the risk of pulverisation and its consequences. It is now recognised that the specialisation of farming systems in mid-mountain and mountainous areas is one of the primary causes of the worsening of the outbreaks of terrestrial voles (Delattre and Giraudoux, 2009). The legislative framework of the CAP has contributed to the specialisation of livestock systems and the establishment of an agricultural landscape particularly favourable to the terrestrial vole. The agro-environmental grass premium has for years prevented the reversal of permanent grasslands. Even if this framework has become more flexible, pastoralists have lost the habit of turning over their meadows and still have difficulty perceiving this practice. Among the working conditions that favour outbreaks, we can also cite the isolation relative to the modern functioning of farms. The lack of a cultural base favouring collective work can thus hamper the establishment of an effective collective struggle. In addition, this general observation can be aggravated by old disagreements between neighbours which prevent any dialogue and block the diplomatic efforts of field workers. More generally, we can underline the fact that, for the great majority of the farmers concerned, the practices of control are not integrated within the technical itinerary. They are grafted onto it unexpectedly, and are rather seen as invasive constraints imposed from the outside.

The heaviness and slowness of administrative procedures is also an element that prevents the smooth functioning of the strategy on a collective scale. The demotivation is even greater because of the delays in payments which are more and more frequent. Failure to meet the FMSE compensation deadline endangers the cash flow of the most fragile farms. This awakens the mistrust of farmers, who find themselves entitled to question the consistency and credibility of public policies in the fight against pests.

Other barriers relate to the lack of vertical and horizontal coordination between actors involved in the management of vole outbreaks, leading to a high degree of mistrust among farmers and towards authorities. Consequently, the transfer of knowledge and know-how in collective management of rodent outbreaks is difficult, especially during periods of declining population of voles.

Potential levers for the collective management of terrestrial voles outbreaks

Faced with the technical difficulties that arise for farmers wishing to engage in managing voles outbreaks, rather than setting up long training courses which develop the theoretical aspect of the fight, it would be better to design training courses geared towards learning the necessary gesture and gaze.

Since it is very difficult to accurately assess the level of infestation of a plot, the concept of early control in itself contains the risk of acting too late. This is how many of the people interviewed for this work emphasised the relevance of a continuous, rather than early, rodent management.

Outsourcing the control, by hiring professional trappers, can be a solution for farmers who are short on time and cannot handle the control themselves. However, it is important to stress that outsourcing the management should not translate into disempowering farmers. For the system to be successful, the actors involved in the territory must continue to act as a network and must ensure assiduous monitoring of the plots, in order to relay their observations to the trappers. Good communication between stakeholders is therefore at the heart of this type of system. One of the most successful examples of the outsourcing strategy is undoubtedly the Volvic impluvium in Puy-de-Dôme region. Since no phytosanitary products are used in the area, the collective control is entirely ensured by trapping. However, it is worth noting that the high cost of the 100% trapping strategy was entirely covered by the private company producing mineral water, the “Société des Eaux de Volvic”.

One of the ideas that could be put forward is that the outbreaks of terrestrial voles do not only concern agricultural populations, but do indeed affect the entire economic and social sphere that inhabits rural mountain territories. In this sense, it could be relevant for public communities to be part of the driving forces behind the launch of control systems. Likewise, private firms concerned with the use of the territory's resources could also get involved in the fight (as was the case for Volvic). This financial boost is sometimes necessary for a collective synergy between farmers to begin under good conditions.

Finally, the status of the FMSE compensation paid by the State to farmers who request it, is being questioned. Are these contracts intended to financially cushion the economic impact of outbreaks on affected livestock systems? Should not they rather be considered as support tools and support the integration of control practices into the technical itineraries of farms, over the long term? Entering a results-based system of payments, in which the FMSE funds would be linked to the effective adoption of the necessary practices, is increasingly put forward as a key point for future outbreaks management. Indeed, the action of the FMSE in terms of controlling outbreaks can be called into question if all the farmers in the area do not participate. The benefit of the management strategy that is put in place by the collective is veiled by those who do not act and who allow the phenomenon to resume and spread. To stem this free-riding behaviour, a mandatory control decree was introduced in Puy-de-Dôme region in 2017 on certain particularly sensitive sectors, still with no penalty for non-compliance, but an increasing monitoring system.

6.2 Determinants of farmers' participation in collective-based strategies (EU countries)

Understanding farmers' potential participation in collective-based approaches is crucial to the design of effective policy strategies. The growing literature on the reasons why farmers engage in AES (Vanslembrouck *et al.*, 2002; Peerlings and Polman, 2009; Christensen *et al.*, 2011; Ma *et al.*, 2012) shows that besides technical constraints and expected profits, behavioural factors play a role in farmers' decisions to enrol (or continue to enrol). The literature in social psychology and behavioural economics put forward the importance of social norms in decision-making: conforming (or not) to a behaviour or to a common rule generates feelings of self-esteem (or guilt), and influences the choices that people make (Dietz, 2002; Pretty, 2003; Czajkowski *et al.*, 2014). Chen *et al.* (2009) analyse the role of social norms on farmers in the context of re-enrolment in a PES in China. They show, with a choice modelling approach, that the main driver of re-enrolment is knowing that neighbouring farmers also intend to re-enrol. Kuhfuss *et al.* (2016a) also apply a choice modelling framework and confirm this result with French farmers, who are more prone to state their intention to re-enrol when informed about the percentage of neighbours which intend to carry on pro-environmental practices after the end of an AES. Besides informational nudges, collective bonuses, paid to farmers in case of a local minimum participation threshold, have also been studied. Theoretical analyses include Dupraz *et al.* (2009), in a non-cooperative framework, and Zavalloni *et al.* (2019) in a cooperative framework. Kuhfuss *et al.* (2016b) adopt a choice modelling approach and show that the introduction of a conditional collective bonus in an AES can improve the participation rate and the cost-efficiency of the scheme.

In this section we present some results from two survey exercises undertaken in the LIFT project: a few questions dedicated to innovative policies in the LIFT large-scale farmer survey (see LIFT deliverable D2.2 Tzouramani *et al*., 2019) in seven partner countries, and a pilot field experiment in three partner countries. Both address the determinants of farmers' participation in collective-based policies.

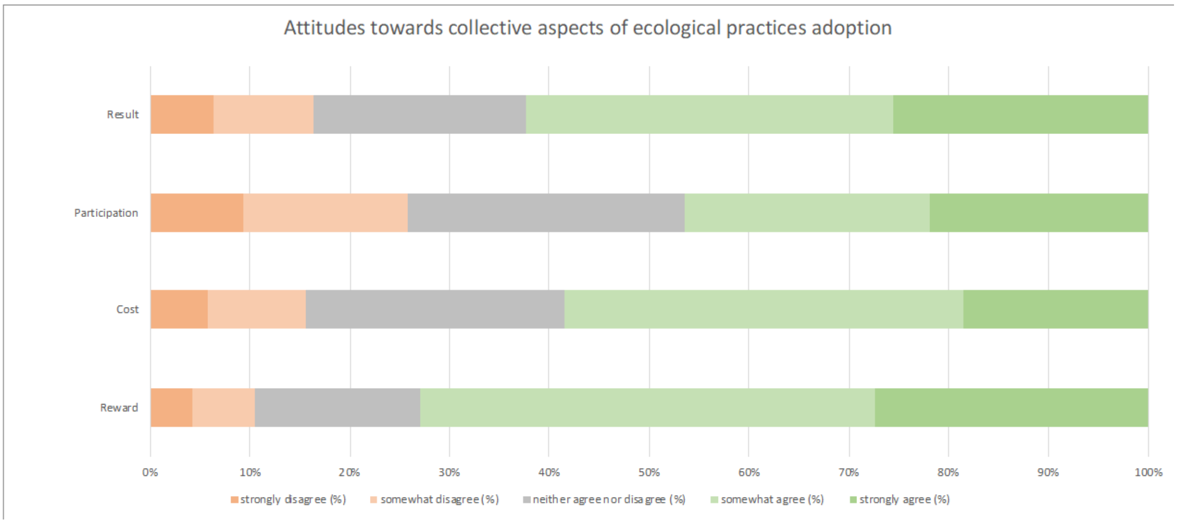
6.2.1 Determinants of farmers' acceptance of collective-based approaches

In the questionnaire for the LIFT large-scale farmer survey (Tzouramani *et al*., 2019) a specific group of questions regarding "Future policies" was included, dedicated to gather respondent's opinions on some aspects of potential future policies, in particular on collective-based approaches. In this section, we present some results from this survey, specifically on the determinants of farmers' acceptance of collective-based approaches, measured through 5-point Likert-scale questions labelled from "*strongly disagree* (=1)" to "*strongly agree* (=5)". Two questions relate to a general acceptance of collective-based approaches : "*Collaborative efforts in the adoption of ecological practices between neighbouring farmers should be rewarded*" and "*I am keen to participate in an agri-environmental scheme in which the amount of subsidy I receive depends on both me and my neighbours' uptake of new practices*"; one assesses farmers' assessment of cost-saving potential of a widespread adoption : "*I can think of ecological practices for which adoption by a sufficient share of neighbouring farmers would lower my cost of adoption*" and one raises a potential concern that could decrease farmers' preference of collective approaches: "*The environmental impact of my uptake of an ecological practice can be impeded by my neighbours' decisions*".

This group of questions of the LIFT large-scale farmer survey was answered by a total of N=489 farmers, in seven countries: Ireland (N=30), France (N=131), Germany (N=50), Greece (N=104), Romania (N=50), Poland (N=92), and Sweden (N=32).

Figure 6.1 shows the repartition of answers from the farmer respondents to the four collective-related questions, pooling responses for all seven countries. A large share of farmers express agreement with the fact that collective efforts should be rewarded (more than 70% somewhat agree or strongly agree); however, the share of farmers keen on actually participating in a scheme with a collective aspect drops (around 45%); also, the share of farmers opposed to participation (somewhat disagree or strongly disagree) is higher. Statements relating to costs and environmental results are less divisive. Appendix 11.1 presents the same figures by countries, from which it appears that attitudes towards collective approaches are very heterogeneous by country.

Figure 6.1: Attitudes towards collective aspects of ecological practices adoption (pooled)



Note: Result: "*The environmental impact of my uptake of an ecological practice can be impeded by my neighbours' decisions*"; Participation: "*I am keen to participate in an agri-environmental scheme in which the amount of subsidy I receive depends on both me and my neighbours' uptake of new practices*"; Cost: "*I can think of ecological practices for which adoption by a sufficient share of neighbouring farmers would lower my cost of adoption*" ; Reward: "*Collaborative efforts in the adoption of ecological practices between neighbouring farmers should be rewarded*".

Source: Own calculations.

To further analyse the determinants of farmers' attitudes towards collective-based policies for the adoption of ecological approaches, we estimated the following empirical model:

$$Attitude\ towards\ collective_i = \beta_{0+}\beta_1 country_i + \delta X_i + u_i \quad (2)$$

Where $Attitude\ towards\ collective_i$ is farmer *i*'s ranking for one of the four variables of attitude towards collective approaches (Reward, Participation, Cost and Result) or a variable summing the answers to all four variables). X_i is a vector of independent variables, including farmer's characteristics (age, education level, sex, years of experience in agriculture, whether he/she has already participated in an AES), farm's characteristics (production type, utilised agricultural area (UAA) owned, management structure, location in less favoured area (LFA), Natura 2000 area or Water directive area) and country. When attitude toward collective is measured by the summing variable, model (2) can be estimated by linear regression.

Preliminary results indicate that country, location in a LFA, production type and participation in AES are the main significant determinants of farmers' views on collective schemes. Greek and Romanian farmer respondents have expressed significantly higher scores for collective schemes than other nationalities. This echoes the analysis developed in LIFT Task 6.1 (Leduc *et al*., 2019; Leduc *et al*., 2021) that highlighted perspective country-specific discourses about ecological agriculture and how they are translated into official documents. Having already been involved in an AES also significantly increases farmers' interest in collective-based schemes, denoting a reinforcing learning curve. Those who are familiar with AES are more prone to continue engaging in such schemes. Furthermore, farmers with mixed crops as their main production type expressed lower interest for collective scheme, while pig farmers showed a significantly higher positive attitude toward those schemes. Finally, being located in a LFA significantly decreases farmers' scoring of collective schemes.

The significance of country and participation in AES is confirmed when model (2) is applied to individual questions (Reward, Participation, Cost and Result) and estimated by ordered logistic regression.

These results contribute to the understanding of farmers' willingness to participate in AES, in general, and in collective-based AES, in particular. The advantage of the LIFT large-scale farmer survey data is to allow a cross-country comparison of farmers' attitudes toward collective-based schemes; and indeed, country is shown to be a significant determinant of these attitudes.

6.2.2 A cross-country pilot-experiment on collective approaches to ecological practices adoption

In this section we present the result of the pilot of a proposed experiment on farmers' participation in a collective-based AEM. Due to the sanitary context of these last two years, it has proven difficult to go beyond the pilot testing phase of the protocol, in three LIFT partner countries: France, Romania and Germany.

In connection with the previous section, the objective of this experiment is to test the impact of the nature of the participation threshold, that activates the collective bonus, on farmers' adoption of ecological practices. Specifically, we want to test whether defining the threshold as a share of surface enrolled, or as a share of participating farmers, affected farmers' level of adoption of ecological practices.

We proposed a framed lab-in-the-field economic experiment (List, 2004) with a non-standard, professional subject pool (Thomas *et al.*, 2019). The recourse to non-standard participants is expected to increase the external validity of the framed experiment (Carpenter *et al.*, 2005; Heinrich *et al.*, 2010; Ferré *et al.*, 2017).

The experiment is organised in three steps: (1) a series of questions to elicit farmers' loss aversion following Wang *et al*. (2017); (2) the four treatments and (3) some questions to gather socio-economic information from the farmers (the protocol is provided in Appendix 11.2).

In each treatment, the farmer, endowed with 100 hectares of agricultural land, was put in the position to decide between the implementation of two practices, to produce the same good, sold at the same price, but with different costs: practice A, the standard one, and practice B, the ecological one, also the more expensive. The farmer was asked to allocate a number of hectares to practice A and a number of hectares to practice B. The farmer was also informed that in his/her area were a total of 10 farmers, all owning 100 hectares.

Treatments differed in how subsidies, in the frame of AES, were introduced in the decision-setting, leading to the income functions given below:

- Treatment 1 (T1): no subsidy

$$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + (\boldsymbol{hectares}_{\text{ecological}} * \mathbf{50})$$

- Treatment 2 (T2): individual subsidy that compensates for the extra cost of practice B

$$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + (\boldsymbol{hectares}_{\text{ecological}} * \mathbf{100})$$

- Treatment 3 (T3): individual subsidy that compensates for the extra cost of practice B + collective bonus if more than 500 hectares in the region are farmed with the ecological practice

$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + (\boldsymbol{hectares}_{\text{ecological}} * \mathbf{110})$ if more than 500 hectares in the region are farmed with the ecological practice

$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + (\boldsymbol{hectares}_{\text{ecological}} * \mathbf{100})$ if less than 500 hectares in the region are farmed with the ecological practice

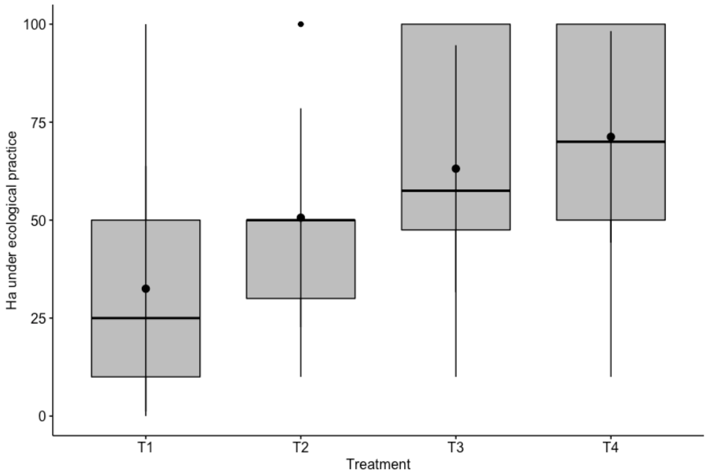
- Treatment 4 (T4): individual subsidy that compensates for the extra cost of practice B + collective bonus if more than five farmers in the region contribute to farming at least 500 hectares with the ecological practice

$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + (\boldsymbol{hectares}_{\text{ecological}} * \mathbf{110})$ if more than 5 farmers in the region contribute to farming at least 500 hectares with the ecological practice

$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + (\boldsymbol{hectares}_{\text{ecological}} * \mathbf{100})$ if there are either less than 500 hectares farmed with the ecological practice or less than 5 farmers using the ecological practice.

In this pilot test, all farmers (N=14) were subjected to all four treatments, in the same order. Figure 6.2 provides a comparison of the number of hectares chosen to be farmed with the ecological practice in each treatment. Wilcoxon Matched-Pairs Signed-Ranks tests show that treatments T3 and T4, with a collective incentive, both induce significantly higher use of ecological practice than the baseline, whilst T2 alone does not. Note that three respondents, out of 14, have not modified their decision over the course of the treatments, staying at a share of 50% of 100% of hectares farmed under ecological practice.

Figure 6.2: Comparison of hectares under ecological practice in the four treatments



Source: Own calculations.

Due to the low number of participants in the pilot phase of the experiment, the determinants of enrolment of hectares under ecological agriculture cannot be analysed in more details at this stage. However, this pilot implementation of the experiment is very promising to increase knowledge about farmers' participation in collective-based areas. Building on the debriefing sessions led with farmers having participated in the experiment, and on other stakeholders' involvement (stakeholders' workshops and LIFT large-scale farmer survey), a revised version of the protocol is being produced, taking into account the environmental context of the scheme. Indeed, farmers tend to express much more positive attitudes towards collective-based strategies when the ecosystem services at stake are easily visible and monitored.

6.3 Pollination services and minimum participation rules (Italy)

The objective of this research is to assess different public and private measures to incentivise the provision of pollination services and the cooperation among farmers on the allocation of habitat to pollinators. Cooperation among farmers on productive ecosystem services such as pollination and biological pest control is likely to lead to Pareto improvement with respect to uncoordinated efforts (Cong *et al*., 2014). However, free-riding issues plague the possibility of cooperating as farmers prefer to rely on the provision of these ecosystem services by others (Bareille *et al*., 2020).

More specifically, we analyse three measures. The first one is a traditional AEM, where farmers are paid a flat-rate payment per area allocated to habitat. This measure provides the policy benchmark to which we compare two innovative solutions. The first innovative solution is a collective measure. Under this measure, a bonus is paid to farmers who decide to cooperate on habitat provision, in case the total habitat area is greater than an exogenous threshold. We call this threshold minimum participation rule (MPR). The second innovative measure is a private one and it represented by a price premium on fruit sales for those farmers that cooperate on habitat provision.

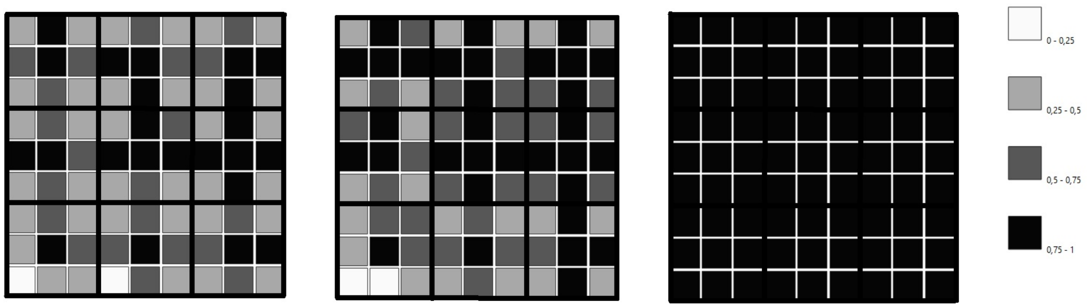
The analysis of the three measures is based on a spatially-explicit ecological-economic model that is introduced in a coalition formation game (Carraro and Siniscalco, 1993; Zavalloni *et al*., 2019). Farmers are the decision-makers of the model and face two orders of decisions. The first decision is on land allocation. Farmers are endowed with a number of plots, and a share of these plots is covered by permanent and fixed crops (fruits). Farmers decide on the share of arable land to allocate 1) to cultivations of annual crops or 2) to natural habitats for pollinators. The benefits of allocating land to habitat is that pollinator abundance increases the yields of fruits. However, the abundance of pollinators decreases with the distance to the habitats. The second decision is on whether to cooperate with other farmers or not on the management of habitat. The formation of a coalition of cooperating farmers is hence endogenous to the model. The resulting coalitions are those that are stable. The stable coalitions are those for which there is no farmer who intends to defect, and no farmer who intends to become a member.

We numerically solve the model over randomly generated landscapes characterised by different degrees of spatial autocorrelation of fruit tree covers. We compare the outcome of the coalition formation game with those generated by full-cooperation among farmers (grand-coalitions, or GC hereinafter) and those generated by no-cooperation (Nash-Equilibrium, or NE, hereinafter), without policies and with the measures previously described.

We calibrate the model on fruit farms from Emilia-Romagna (Italy). We assume that there are 9 farms, each of them endowed with 9 plots. Given 9 farmers, there are 2^9-9+1=504 possible coalition structures, i.e. partition of farmers when there is only one non-trivial coalition. Moreover, we generate 81 random landscapes such that the Moran's I statistics on the fruit areas take successively the value of 0 (totally random landscape) to 0.8 (very high spatial autocorrelation), with a step of 0.01.

Not surprisingly, full cooperation among farmers (GC) yields the highest profits, which are on average 13.8% higher compared to the NE. However, the GC is not stable and hence cannot spontaneously appear. When cooperation is addressed as a choice by the farmers (the outcome of the coalition formation game), coalitions are rather small and are composed by only two farmers. Partial cooperation increases the aggregate profits by 2.5% with respect to the NE but remain 9.9% lower than the NE. Similarly, the NE is characterised by the lowest habitat area (57.68%), whereas the GC would allocate all arable lands to habitats. The landscapes of stable coalitions (SC) lead to higher habitat areas than the NE (65.06% on average). These results are depicted in Figure 6. 3.

Figure 6.3: Average habitats as shares of arable land over the 81 simulations for (a) the NE, (b) the SC and (c) the GC.

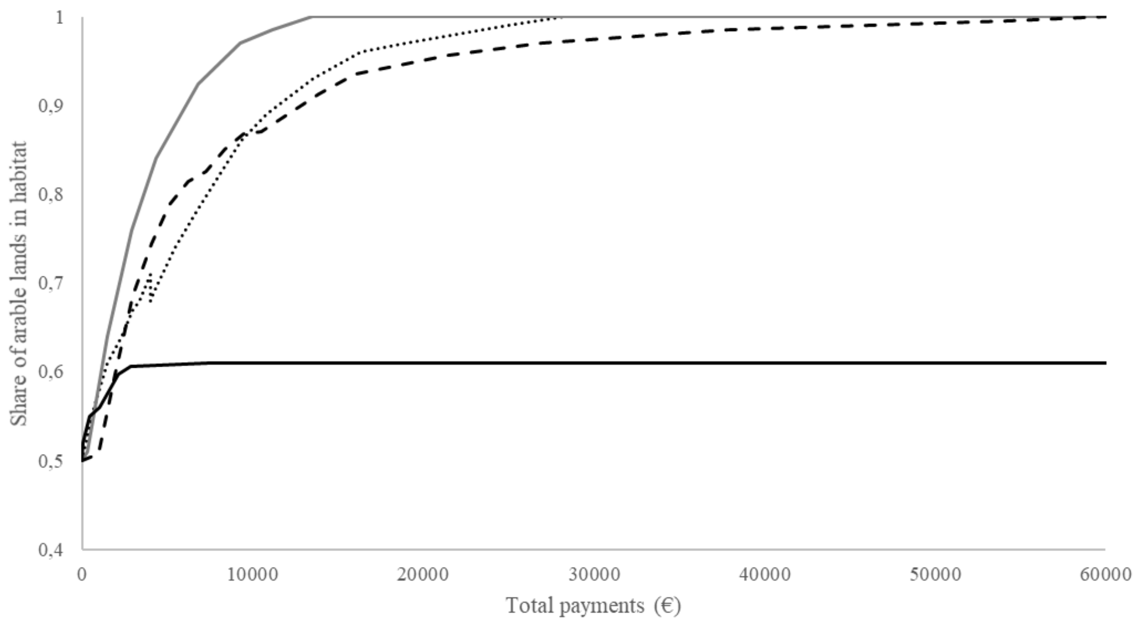


(a) (b) (c)

Source: Own calculations.

How do the different policies affect land use decisions by the farmers? What are the most effective policies? Figure 6.4 displays the share of habitats at the landscape scale according to the total expenditures of the alternative policies. The MPR policies display the highest range of effectiveness. A low threshold (20%) is the most efficient measure while increasing such a threshold to 50% causes a substantial reduction in the efficiency of the measures. The traditional per-hectare payments have an intermediate budget-effectiveness. The price premium is, on average, almost as efficient as the per-hectare payments.

Figure 6.4: Average share of arable lands devoted to habitats according to the total payments (in €)



Note: the per-hectare payments (dotted line), the price premium (dashed line), the MPR with a threshold of 20% (solid grey line) and the MPR with a threshold of 50% (solid black line). The averages were computed on the 81 simulated landscapes and on (i) the SCs with at least two farmers for the MPR and price premium, and (ii) all SCs for the per-hectare payments (which also include the NE).

Source: Own calculations.

To summarise, the traditional per-hectare payment is likely not to be the most efficient measure to incentivise habitat conservation in case of productive ecosystem services such as pollination. Innovative instruments, such as the inclusion of MPR that links the payments to cooperation among farmers, seem to be more efficient. However, these novel instruments probably need to be dealt with care, as a wrong design can be counterproductive.

6.4 The role of collaborative networks to encourage adoption of ecological practices and the sustainability of ecological agriculture (Belgium and France)

Under the European Green Deal and the new CAP 2023-2027, ambitious goals are set to improve environmental conditions and biodiversity in agricultural landscapes across Europe. Aside from payments derived from enhanced conditionality, farmers are incentivised to go further in their implementation of ecological farm management practices (e.g. agroforestry) through the new eco-schemes to achieve these goals (Agriculture and Rural Development, 2020). Financial incentives aside, when it comes to adoption of ecological farm management practices, the cognitive barriers farmers face when switching to management practices are often overlooked. Nonetheless, evidence demonstrates that a lack of know-how and sense of cohesion amongst farmers regarding management practices is equally as restrictive as a lack of economic means; particularly when specialised equipment is involved (Liu *et al*., 2018; Mozzato *et al*., 2018). Collaborative networks - formal and informal networks designed to share, manage, and/or exchange equipment, labour and/or immaterial resources between farmers *(Lucas et al*., 2018) - offer an opportunity for farmers to overcome economic barriers by sharing mechanisation and labour costs, as well as overcoming cognitive barriers by sharing experiences and know-how regarding (the application of) ecological management practices (Groupe de Bruges, 2014; Lucas *et al*., 2018). In a DCE carried out across three case study areas in Belgium and France, preferences amongst farmers to engage in collaborative networks aimed at overcoming cognitive and economic barriers through the sharing of knowledge, labour and machinery were assessed. A secondary aim of the DCE was to link characteristics of such collaborative networks to the adoption of ecological farm management practices to identify whether adoption could be favourably influenced through increased horizontal collaboration.

In France, collaboration amongst farmers is led by the CUMA (Coopérative d'Utilisation du Matériel Agricole, formal machinery sharing cooperative), which allows its members (farmers) to share their resource such as machinery, sheds, or workshops. In 2015, there were 12,260 CUMAs in France with 212,000 members (approximately 25 members per CUMA), which represented 464 million Euros of investment and 551 million Euros of turnover, i.e. 53,000 Euros of turnover per CUMA (FNCUMA, 2015). In Belgium, collaborative behaviour amongst farmers is far less engrained within the farming system. Nonetheless, horizontal collaborative networks have been increasing in prevalence in Belgium, with subsidies distributed to 59 horizontal collaborative networks focussed on joint machinery purchasing between 2000 and 2005, accounting for a total investment of 41 million Euros (Departement Landbouw & Visserij, 2007).

From the results of the DCE it was found that preferences to join collaborative networks varied between respondents based on their previous experience with collaborative behaviour. Respondents who had previous and/or current experience with collaborative behaviour were found to have a stronger preference to join collaborative networks. Likewise, those respondents without any previous experience demonstrated an aversion to joining such collaborative networks. Unfortunately, the small sample size meant that interactions between characteristics of collaborative networks and ecological farm management practices could not be estimated, such that no evidence could be found in support of collaborative networks increasing adoption rates of ecological farm management practices. Nonetheless, the preferences observed for knowledge and labour sharing illustrate there is a demand for such collaborative behaviour amongst farmers in Belgium and France, and highlights the need for policy-makers to invest in fostering collaboration amongst farmers, whether it be formal through collaborations such as the CUMA, or informal farmer-led collaborations.

While the impact of collaborative networks on adoption of ecological farm management practices remains to be assessed, results from this DCE seem to imply there is at least a demand amongst farmers to overcome certain cognitive barriers through collaboration with fellow farmers. Further investigation into the ability of collaborative behaviour amongst farmers to influence adoption of ecological farm management practices is thus warranted, as this might provide relevant insights into how adoption rates in Europe can be increased, particularly under incentivising payments schemes such as the eco-schemes.

7 Conclusion

Growing societal concerns about the environmental damage caused by current food production systems have led to an increased ambition for agricultural policy (European Commission, 2020). Within current discussions about the future of the CAP, this deliverable aims at shedding light on some innovative aspects of public policy design and of private involvement through the funding of PES, aiming to increase the efficiency of the incentive schemes.

The different analyses presented in sections 5 and 6 echoed statements collected during the stakeholders' workshops. Stakeholders expressed concern about results-based approaches, due to the difficulty to properly monitor farmers' contribution to the improvement of a given environmental result. The Barren program example (section 5.1), where a hybrid payment scheme is implemented based on a measure of individual results, highlights the important role of advisors, and of the whole monitoring process, to ensure the success of such a scheme. The analysis of PES for methane reduction (section 5.3) puts forward that a results-based approach may not be the most satisfactory option in terms of costs or environmental improvement. Regarding the interactions between AEMs, PES, future eco-schemes and consumer-driven price markup, sections 5.2, 5.3 and 5.5 provide some insights about how this may affect the uptake of ecological approaches. As of now, eco-schemes were perceived as useful to maintain agro-ecological practices, AEMs to transition from one system to the other and PES to fill in gaps in the current policy landscape. How eco-schemes will actually be implemented in the different MS, and their interactions with the AEMs, will be of great importance in the next CAP programming period. Regarding collective approaches, section 6.3 shows that minimum participation rules have the potential to increase the environmental result of AEMs, while section 6.4 shows that there is a demand amongst farmers to overcome certain cognitive barriers through collaboration with fellow farmers. Section 6.2 brings some insights about the determinants of farmers' openness about collective strategies – it this regards, country of residence is a very significant determinant, echoing the work undertaken in Task 6.1 on discourse analysis. Finally, stakeholders stated that collaborating is not a new way of managing farms' resources, but engagement in such collaborations is not feasible if the environmental benefits are not clear. Even when the beneficial impacts are clear, section 6.1 puts forwards the barriers, alongside opportunities, provided by the necessary spatially arranged collective management strategy for terrestrial vole outbreak management.

The new CAP will introduce changes that will likely produce new research questions in terms of measure design and evaluation. The most relevant contribution potential by LIFT concerns an in-depth understanding of acceptability and behavioural aspects facing measure implementation. This will allow a support for a better design of existing policies and a more aware design of new implementation options (such as collective and results-based), which require a more thorough understanding of farmers' and other actors' behaviour. In addition, several existing measures suffer from low participation and unclear effectiveness, which can also be improved based on insights provided by the project. The analysis of the future CAP framework also confirms the focus set by the LIFT project on agglomeration bonuses and other forms of collective solutions, as well as on private arrangements and results-based actions. An investigation of policy (measure) mixes in the framework of CAP Strategic plans will be key to ensure relevance and contextualisation of the policy-relevant results. The question of incentives mixes, their piling up and the potential synergies and trade-offs arising, is indeed one the crucial point raised by stakeholders during the workshops organised in the different LIFT case study areas.

8 Deviations or delays

None

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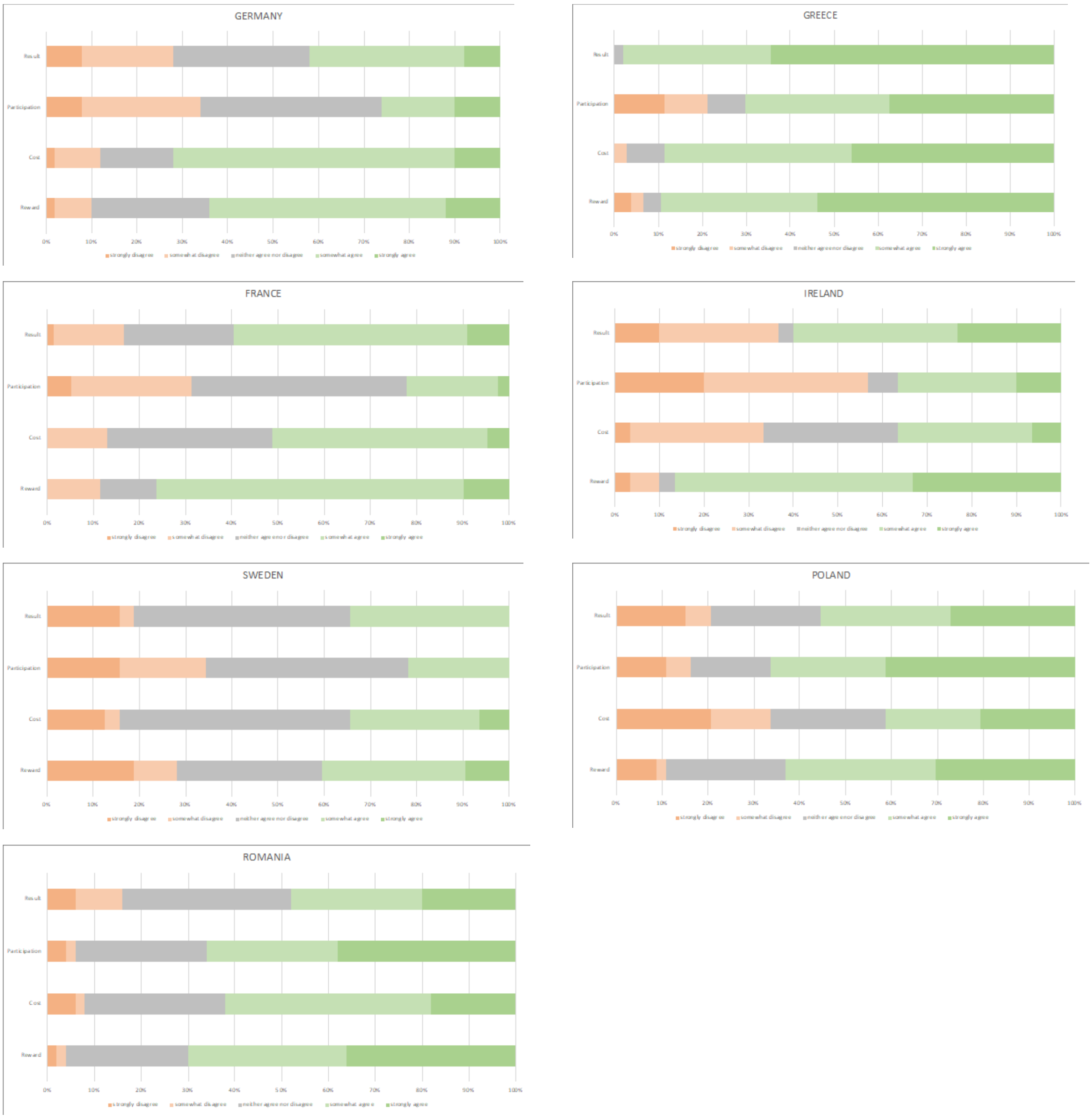
10 Appendix

10.1 Appendix 1: Attitudes towards collective approaches by country

See section 6.2.1

Figure 11.1: Attitudes towards collective aspects of ecological practices adoption (by country)



Note: Result: "*The environmental impact of my uptake of an ecological practice can be impeded by my neighbours' decisions*"; Participation: "*I am keen to participate in an agri-environmental scheme in which the amount of subsidy I receive depends on both me and my neighbours' uptake of new practices*"; Cost: "*I can think of ecological practices for which adoption by a sufficient share of neighbouring farmers would lower my cost of adoption*"; Reward: "*Collaborative efforts in the adoption of ecological practices between neighbouring farmers should be rewarded*".

Source: Own calculations.

10.2 Appendix 2: Test experimental protocol (English version)

See section 6.2.2

Dear Participant,

Thank you for accepting to participate in this 30-minute online survey. The survey consists of three parts: an introductory part with a few questions about your preferences, the experiment requiring you to make managerial decisions, and the final part with a few questions about your agricultural enterprise.

Part 1: questions regarding your preferences

1) Imagine you had to decide whether or not to participate in a gamble. If you enter the game, you have a 50% chance of losing or winning. The sum you can lose is given. For the gamble shown below, how high would the possible gain X have to be, so that you would be willing to join the game?

50% chance	Loss of 25 €
50% chance	Gain of X €

X would have to be at least _______€ so that I would be willing to join the game.

2) Please also have a look at the second example. For the gamble shown below, how high would the possible gain X have to be, so that you would be willing to join the game?

50% chance	Loss of 100 €
50% chance	Gain of X €

X would have to be at least _______€ so that I would be willing to join the game.

Part 2: the experiment

Now, you will take over the role of an arable farmer in a fictional area that counts a total of 10 farmers. You have to decide which agricultural practices you want to apply on your farmland. Your decisions will affect your farms income. Your farm comprises 100 hectares of utilisable land. For each hectare you can decide between two different agricultural practices: a conventional practice or an ecological practice. The ecological practice is more costly to implement that the conventional one. The sum of hectares farmed according to both practices has to match 100 hectares.

Step 1- In this first part, your farm's income is calculated in the following way: the conventional and ecological practices allow for the cultivation of crops for which you receive a profit contribution (= contribution margin minus fixed costs such as rents) of 100 points per hectare. You also get 10000 points from business activities other than arable farming, such as animal husbandry or paid labour. However, the ecological practice entails more costs than the conventional one (for example for increased workload or material). These costs amount to 50 euros per hectare farmed under the ecological practice. In other words, the profit contribution from the ecological practice is of 50 points per hectare.

Your farm income is then calculated as follows:

$$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + (\boldsymbol{hectares}_{\text{ecological}} * \mathbf{50})$$

Which of the following statements is correct?

O The ecological agricultural practice does not cause any additional costs.

O The farm comprises less than 100 hectares of agricultural land.

O My income in points is determined through the choice of the agricultural practice(s). The sum of the areas farmed according to agricultural practice A and agricultural practice B should not be more or less than 100 hectares.

How many hectares would you like to farm according to the conventional agricultural practice? [ ]

How many hectares would you like to farm according to the ecological agricultural practice? [ ]

Reminder: Both agricultural practices allow for the production of agricultural goods. The ecological practice is better for the environment, but more costly to implement. The sum of hectares has to be equal to 100.

With your decision, your achieve a result of [ ] points.

Step 2- Now, all farmers applying the ecological agricultural practice will receive an additional payment, because it is better for the environment than the conventional agricultural practice. The additional payment amounts to 50 points per hectare farmed according to the ecological agricultural practice. This additional payment covers for the extra cost of the ecological practice, so that your farm's income in points can thus be calculated with the following equation:

$$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + (\boldsymbol{hectares}_{\text{ecological}} * \mathbf{100})$$

Which of the following statements is correct?

O The difference to the first part is that the profit contribution per hectare increases.

O The additional payment amounts to 50 points per hectare. The profit contribution of 100 points per hectare remain the same like in the first part.

How many hectares would you like to farm according to the conventional agricultural practice? [ ]

How many hectares would you like to farm according to the ecological agricultural practice? [ ]

Reminder: Both agricultural allow for the production of agricultural goods. The ecological practice is better for the environment, but more costly to implement. The sum of hectares has to be equal to 100.

With your decision, your achieve a result of [ ] points.

Step 3- Now, farmers applying the ecological agricultural practice will receive an additional payment defined as follows: a guaranteed payment of 50 points per hectare, plus an additional payment of 10 points per hectare if at least 50% of the total utilised land in the region is farmed with the ecological practice. Since the region counts 10 farmers with 100 hectares each, 500 hectares in total have to be farmed with the ecological practice to activate the additional payment. Your farm's income in points can thus be calculated with the following equation:

$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + \left(\boldsymbol{hectares}_{\text{ecological}} * \mathbf{110}\right)$ if more than 500 hectares in the region are farmed with the ecological practice

$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + \left(\boldsymbol{hectares}_{\text{ecological}} * \mathbf{100}\right)$ if less than 500 hectares in the region are farmed with the ecological practice

Which of the following statements is correct?

O The difference to the previous part is the possibility of an additional payment of 10 points per hectare if 50% of the total utilised area is farmed with the ecological practice.

O If I farm with the conventional practice I may receive the additional payment of 10 points per hectare if 50% of the total utilised area is farmed with the ecological practice.

How many hectares would you like to farm according to the conventional agricultural practice? [ ]

How many hectares would you like to farm according to the ecological agricultural practice? [ ]

Step 4- Now, farmers applying the ecological agricultural practice will receive an additional payment defined as follows: a guaranteed payment of 50 points per hectare, plus an additional payment of 10 points per hectare if at least of the total utilised land in the region is farmed with the ecological practice by at least 50% of the farmers in the region. Since the region counts 10 farmers, this means that the additional payment is activated if at least 5 farmers use the ecological practice on at least 500 hectares.

Your farm's income in points can thus be calculated with the following equation:

$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + \left(\boldsymbol{hectares}_{\text{ecological}} * \mathbf{110}\right)$ if more than 5 farmers in the region contribute to farming at least 500 hectares with the ecological practice

$\boldsymbol{Income} = \mathbf{10000} + (\boldsymbol{hectares}_{\text{conventional}} * \mathbf{100}) + \left(\boldsymbol{hectares}_{\text{ecological}} * \mathbf{100}\right)$ if there are either less than 500 hectares farmed with the ecological practice or less than 5 farmers using the ecological practice.

Which of the following statements is correct?

O The difference with the previous part is the possibility of an additional payment of 10 points per hectare if at least 5 farmers use the ecological practice to reach the 500 hectares threshold

O If more than 5 farmers use the ecological practice on a total of 400 hectares, they get the 10 points per hectare bonus.

How many hectares would you like to farm according to the conventional agricultural practice? [ ]

How many hectares would you like to farm according to the ecological agricultural practice? [ ]

Part 3: questions about you and your agricultural enterprise

Q1	Please indicate your age in years

Q2	Please indicate your gender
	☐ male ☐ female

Q3	Indicate your highest general education school leaving certificate
	☐ No schooling ☐ Primary school ☐ Middle school ☐ High school– agricultural ☐ High school – non-agricultural ☐ University – agricultural ☐ University – non-agricultural

Q4	Indicate the main production type of your farm in 2019
	☐ Specialist cereal, oilseed and protein crops ☐ Specialist other fieldcrops (dry pulses, potatoes, sugar beet, fibre crops, hop, tobacco, cotton, sugar can, other industrial crops, root crops, field vegetables) ☐ Specialist horticulture ☐ Specialist wine ☐ Specialist orchards (excluding olives) ☐ Specialist olives ☐ Specialist dairy milk ☐ Specialist cattle ☐ Specialist sheep and goats ☐ Specialist poultry

	☐ Specialist pigs ☐ Mixed crops ☐ Mixed livestock ☐ Mixed crops and livestock ☐ Other

Q 6	Are you currently participating, or have you previously participated in agri-environment schemes (AES)?			
		Currently participating	Previously participated	Never participated
	Organic scheme	☐	☐	☐
	Other AES	☐	☐	☐

Q7	Environmental attitudes / identity To what extent do you agree with the following statements?					
		Strongly disagree 1	2	3	4	Strongly agree 5
	Good farming requires using all available acreage as efficiently as possible in order to maximise yield	☐	☐	☐	☐	☐
	It is important to increase the size or intensity of my farm operation in order for my business to survive	☐	☐	☐	☐	☐
	Technological advances will ultimately reduce the environmental impact of conventional agricultural practices	☐	☐	☐	☐	☐
	The environmental risks commonly associated with industrial agriculture are offset by the ability to efficiently produce food products for a growing world population	☐	☐	☐	☐	☐
	The primary role of farms is the production of food and related agricultural products, the protection of the environment is separate from this purpose	☐	☐	☐	☐	☐
	Natural areas on my farm are important but they can't be allowed to interfere with agricultural production	☐	☐	☐	☐	☐

	Programmes to protect soil and water resources should emphasize approaches that primarily benefit agricultural production	☐	☐	☐	☐	☐
	Natural areas are only important to maintain if they provide productivity benefits for my farm	☐	☐	☐	☐	☐
	As a farmer, protecting the environment is an important part of my job	☐	☐	☐	☐	☐
	Agricultural practices that degrade the natural landscape damage the profession of farming	☐	☐	☐	☐	☐
	Sustainable agriculture is an innovative approach to the challenge of addressing environmental problems and remaining profitable	☐	☐	☐	☐	☐
	A successful farmer is someone who continuously evaluates the environmental impact of their farm and adopts new approaches to protect the environment	☐	☐	☐	☐	☐
	As a result of modern agricultural practices, farmers must exert more effort now to protect the environment than was necessary in the past	☐	☐	☐	☐	☐
	The natural areas on my farm are part of the heritage of my land and should be maintained for the benefit of future generations of farmers	☐	☐	☐	☐	☐
	As a farmer, how I farm my land has the potential to negatively impact the quality of the rural landscape	☐	☐	☐	☐	☐
	Protecting the natural areas on my farm improves the quality of life for other members of my community	☐	☐	☐	☐	☐

Q 8	Perception of environment and climate change In the last five years (or since you began farming if sooner) have you observed an increase or a decrease in the following:					
		Decrease 1	2	3	4	Increase 5
	Extreme weather events	☐	☐	☐	☐	☐
	Insects	☐	☐	☐	☐	☐
	Birds	☐	☐	☐	☐	☐
	Mammals	☐	☐	☐	☐	☐
	Soil erosion	☐	☐	☐	☐	☐
	Flooding	☐	☐	☐	☐	☐
	Soil quality	☐	☐	☐	☐	☐
	Other changes observed to land and the environment (please specify /________________/)	☐	☐	☐	☐	☐