LIFT

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

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How to improve the adoption, performance and sustainability of ecological farming

Laure Latruffe [1] *, Sophie Legras [1] *, Andrew Barnes [2], Jochen Kantelhardt [3], Vitaliy Krupin [4], Maria Luisa Paracchini [5], Carlo Rega [5], Lena Schaller [3], Luiza Toma [2], Joseph Tzanopoulos [6], Liesbet Vranken [7], Katarzyna Zawalińska [4], Alastair Bailey [6], Zoltan Bakucs [8], Geneviève Bigot [1], Larissa Billaudet [1,9], Michael Böhm [10], Dimitrios Bormpoudakis [6], Wolfgang Britz [11], Mihai Chitea [12], Sophia Davidova [6], Yann Desjeux [1], Julie Duval [1], Sabine Duvaleix [1], Helena Hansson [13], Julia Heinrichs [11], Stuart Henderson [6], Nathalie Hostiou [1], Anne-Lise Jacquot [1], Philippe Jeanneaux [9], Gaëlle Leduc [13], Gordana Manevska-Tasevska [13], Peter Matthews [6], Andreas Niedermayr [3], Mary Ryan [14], Bethan Thompson [2], Irene Tzouramani [15], Kato Van Ruymbeke [7], Lionel Védrine [1], Jacques Veslot [1], Davide Viaggi [16]

[1] INRAE (France), [2] SRUC (UK), [3] BOKU (Austria), [4] IRWiR PAN (Poland), [5] JRC (Italy), [6] UNIKENT (UK), [7] KU Leuven (Belgium), [8] KRTK (Hungary), [9] VetAgro Sup (France), [10] Ecozept (Germany), [11] UBO (Germany), [12] IAE-AR (Romania), [13] SLU (Sweden), [14] Teagasc (Ireland), [15] DEMETER (Greece), [16] UNIBO (Italy)

* Deliverable leaders – Contact: laure.latruffe@inrae.fr and sophie.legras@inrae.fr

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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	KRTK – 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

AECM	Agri-Environment-Climatic Measure
AES	Agri-Environmental Scheme
CAP	Common Agricultural Policy
CGE	Computable General Equilibrium
DCE	discrete choice experiment
EFA	ecological focus areas
FADN	Farm Accountancy Data Network
FSDN	Farm Sustainability Data Network
FSS	Farm Structure Survey
IACS	Integrated Administration and Control System
LPIS	Land Parcel Identification System
LU	livestock standard unit
MEC	Means-End Chain
MOOC	Massive Online Open Course
NGO	Non-Governmental Organisation
PES	Payment for Ecosystem Services
RDP	Rural Development Policy
SAPM	Survey on Agricultural Production Methods
SEM	Structural Equation Modelling
UAA	utilised agricultural area

1 Summary

This deliverable D7.6 of the LIFT project is the final scientific deliverable of the project that was carried out during four years from May 2018 till April 2022. The deliverable summarises the methodologies used and the key results for the main research activities that were carried out in LIFT: definition of ecological agriculture; adoption of ecological approaches; farm performance of ecological agriculture; territorial sustainability of ecological agriculture; trade-offs and synergies across sustainability dimensions and scales; impact of policies; role of stakeholders. Recommendations in terms of policies, data and research needs, are then provided.

2 Introduction

2.1 Context

Agriculture faces the double challenge of feeding a growing population and conserving key finite natural resources and ecological systems. It must do so in such a way as to ensure the sustainability of food production systems, to maintain per capita food consumption, and the sustainability of our wider societies. At the same time, agricultural production of food, fibre and fuel is itself particularly constrained by resource availability. For example, the quantity of farm land is in finite supply, a fact which highlights the need for its efficient use. Moreover, land quality and its productive potential, while naturally heterogeneous, is mainly influenced by farming decisions that dictate the sustainability of farm production.

Just as important, farming in Europe both exists in, and contributes toward the quality of rural landscapes, communities, the environment and a thriving economy through income and jobs. Additionally, farm activities generate external effects that make rural areas more productive and highly valued. Farming contributes to important infrastructure, economies of scale in rural non-farm businesses and the development of businesses unique to well managed rural areas, such as agri-tourism. However, the extent of these contributions strongly depends on the interplay of location factors such as soil, climate or landscape profile and farm management. In addition, different farming systems can provide or, in some cases, damage public goods and ecosystem services including uncontaminated drinking water, clean air, carbon-capture and biodiversity. Many of these externalities can produce feedback which may make farming more viable (*e.g*. increased rate of pollination and natural pest control, access to sufficient water resources, maintenance of soil fertility etc.) and, therefore, farming and rural systems may influence their own sustainability.

Farms implementing ecological approaches are expected to deliver a more balanced bundle of these multiple outputs, marketable or not, compared to more conventional farming practices focused on marketable output. Farms implementing ecological approaches may require, in comparison to more conventional farming, innovative inputs, technologies and contractual arrangements, as well as management and labour with higher skills. However, if ecological agriculture optimises its activity over such a wide range of outputs, it may imply that the marketable output of food, fibre and fuel, and as a result farm income, may fall when compared to more conventional farming systems.

There is, therefore, a pressing need to assess the context in, and the level to, which ecological approaches to farming can promote improved performance and sustainability[1] of both farms and the rural areas in which they are located. Such assessments hence go beyond single farm level, and need to consider how the level of adoption of ecological practices across landscapes influences both performance and sustainability of the combined rural system. Given multiple scales, outputs, public goods and ecosystem services and their complex interlinkages, a question of this dimension quickly becomes very complex and requires consideration of several multidimensional aspects. It is therefore crucial to provide decision-makers with innovative frameworks and decision support tools, based on transdisciplinary understanding (that encompasses agronomic, socio-economic, technological and environmental knowledge) and stakeholders' expertise, to aid any wider adoption process and supports the design of successful policies to help farmers transitioning.

2.2 The LIFT project

In this context, the overall goal of the LIFT research project was to **identify and understand how socio-economic and policy drivers impact on the development of ecological approaches to farming and assess the performance and sustainability of such approaches, taking into account different farming systems at farm, farm-group and territorial scales**.

To meet this goal, LIFT pursued the following objectives:

1. **To investigate the socio-economic and policy drivers that hinder or enhance the development and adoption of ecological approaches to farming**
2. **To evaluate and compare the performance and overall sustainability** of farming systems across different levels of incorporation of ecological approaches and across different scales (from farms to territories)
3. **To propose new private arrangements and new policy instruments** which could improve performance and sustainability, and the development of ecological agriculture
4. To produce comprehensive insights into ecological approaches based on a **wide range of case studies and a mix of relevant methodologies** (qualitative, quantitative, participatory approaches, modelling) **and actors** (scientists and a wide range of stakeholders)
5. To achieve **targeted dissemination of results with free decision support tools and a massive open online course (MOOC)**, and reach out to students, policy makers and farm advisory services.

2.3 Methodological aspects of LIFT

Ecological practices are understood in LIFT as low-input practices and/or practices that are environmentally friendly. The originality of LIFT in this view was 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.

[1] In LIFT performance assessment was meant to reveal how well a function is performed, through an appropriate set of indicators describing farm management and its components. The integrated assessment of performance across a whole range of targets (or objectives) and with a reference to the future (or a hypothetical scenario) is the sustainability assessment.

A wide range of case study areas has been covered by the activities in LIFT, across 13 countries, at the country or regional level. This coverage enabled a wide coverage of European pedo-climatic contexts, types of production and types of ecological practices. Figure 1 shows the location of the case study areas.

Figure 1. Map of the case study areas (in green) covered in LIFT

A mix of quantitative and qualitative methods was used in LIFT: econometric, non-parametric, multivariate and other statistical methods; choice experiments to farmers, consumers and citizens; bio-economic model, agent-based model, regional Computable General Equilibrium (CGE) model; literature review, meta-analysis, textual analysis; expert knowledge, stakeholders' input.

LIFT made extensive use of **existing secondary farm-level data**, from European, national and local sources. The main secondary data source was the farm-level EU bookkeeping data from the Farm Accountancy Data Network (FADN)[2] over several years, and its national extensions to which partners have access. In addition, specific data existing in the project's countries was used, such as farmers' bookkeeping and technical information from local offices, information from local field trials and national or regional statistics (e.g. on employment). LIFT also collected tailored primary data through a wide survey to farmers across the project's case study areas: the **LIFT large-scale farmer survey**. The

2 https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/farms-farming-and-innovation/structures-and-economics/economics/fadn_en

survey gathered information related to 2018 and useful for several strands of analysis in LIFT, relating to locational characteristics, detailed farm management practices (current and future), adoption decisions, farm economic outcomes, employment, working conditions, contracts, policies (see questionnaire in Tzouramani et al., 2019). The survey was carried out face-to-face, online or by phone, depending on the case studies. In total, there were 1,628 completed questionnaires across 12 countries, with the following geographic distribution: 94 in Austria, 67 in England (United Kingdom), 229 in France, 51 in Germany, 108 in Greece, 120 in Hungary, 33 in Ireland, 100 in Italy, 100 in Poland, 52 in Romania, 113 in Scotland (United Kingdom) and 561 in Sweden. Data for a total of 3,429 common variables were collected. Another farmer survey was carried out to 160 farmers in four countries to specifically collect information on farmer working conditions, stress, quality of life. Additional approaches aiming at collecting further primary data were carried out, such as qualitative interviews, participatory techniques and choice experiments, involving farmers and a broad range of stakeholders.

Stakeholders have been substantially involved in the project through direct regular interactions and about four annual local stakeholders' workshops (one per year) that were organised in most case study areas. In total 108 stakeholders' workshops were organised during the project's lifetime, and 1,206 stakeholders were reached in this context. They included various groups, notably farmers' representatives (e.g. unions, farm producer groups), farm advisory services, main actors in the food value chain, and governmental bodies, and related to the local, national or European level. Interactions with stakeholders were crucial for LIFT, as innovative ideas may arise from those who have the best practical knowledge and vision for the future. And some innovations may only be successful when several stakeholders jointly design and implement them. The importance of local stakeholder workshops or other types of interactions lies in their dual information flow. Stakeholders contributed through active participation to numerous issues such as informing the typology of farms, designing the free public tools created in LIFT, assessing territorial sustainability, providing local knowledge on constraints and societal expectations faced by farmers in the case study areas, and giving expert opinions on LIFT's frameworks and outcomes. This helped in providing policy conclusions that are relevant to the reality in the case study areas and the countries covered by LIFT.

2.4 Outline of the deliverable

In what follows, the methodologies used and the key results are presented for the main research activities that were carried out in LIFT: definition of ecological agriculture (section 3); adoption of ecological approaches (section 4); farm performance of ecological agriculture (section 5); territorial sustainability of ecological agriculture (section 6); trade-offs and synergies across sustainability dimensions and scales (section 7); impact of policies (section 8); role of stakeholders (section 9).

Then recommendations in terms of policies, data and research needs are provided (section 10), before briefly concluding (section 11).

3 Defining ecological agriculture

3.1 Building the conceptual frame for an ecologically-based farm typology

In order to understand the specificities of various ecological farming systems and to enable comprehensive and consistent analyses in the LIFT project and beyond, a farm typology was developed in LIFT, i.e. a classification system to group individual farms into groups that are relatively homogeneous with regard to certain features. Different farm typologies can be envisaged, depending on what are the specific characteristics that are considered to cluster farms. To this regard, a main distinction is made in literature between *structural* and *functional* farm typologies. The former consider structural aspects of farms such as size, economic output, labour force, produced output. The latter focus instead on the way farms are managed, usually considering environmental and/or social aspects.

The key requirements of the LIFT typology were to: i) be based on the ecological aspects of farming (functional typology); ii) be applicable to all European farms in any Member State; iii) cover the whole spectrum of farming approaches; iv) be usable in policy-making and by a wide range of stakeholders.

The work has started with a systematic literature review of definitions of the existing ecological approaches to farming and specific farming practices (Rega et al., 2018). The pool of knowledge obtained from the review allowed establishing the main elements of the conceptual framework underpinning the typology. The term 'farming system' was identified as the key conceptual brick, defined as a combination of the main outputs of the farm (crops and livestock), and the management practices employed, which define a *farming approach*. The results from the review were also used to identify farming practices, i.e. specific operations and management choices in the remit of farmers when carrying out crop cultivation and livestock raising activities. Rega et al. (2018) provided the first outline of the typology and a preliminary systematic link between them and specific farming practices. This preliminary concept of the typology was used to get feedback from stakeholders in view of the elaboration of the final version of the typology (see section 3.2).

By conceptualising farms in terms of functional units managing agroecosystems, and farming approaches as the way the farm manages some key processes governing the functioning of such ecosystems, five key ecological dimensions of farming were identified as the building blocks of the LIFT typology:

- **Soil conservation and health**, i.e. the use of farming practices that maintain good physical, chemical and biological soil conditions, able to guarantee their agricultural use in the long run.
- **Total input intensity**, i.e. the quantity of the different production inputs relative to the farm size in terms of either utilised agricultural area (UAA) or livestock standard units (LU).
- **Internal integration (or circularity)** of farms, i.e. the extent to which the farm is able to produce part of the required production input internally and to close key ecological cycles.
- **The avoidance of specific harmful inputs** such as mineral fertilisers, genetically modified organisms and chemical synthetic pesticides; this is associated, in farms with livestock, to the adoption of animal welfare practices.
- **The presence of seminatural vegetation** in farms, able to support functional and structural biodiversity - pollinators, beneficial predators, birds, small mammals etc.

These five key dimension or *criteria* are linked to some of the key principles of agroecology as defined by the Report of The High Level Panel of Experts on Food Security and Nutrition of FAO's Committee on World Food Security (HLPE, 2019). This preliminary proposal was the basis for interactions with stakeholders, as described in the following section.

3.2 Interactions with stakeholders on the first version of the LIFT typology

Stakeholders were consulted on the first outline of the typology to collect feedback and input in view of the elaboration of the final version. In total, 21 stakeholders from five different case study areas were involved in this exercise, through face-to-face interviews or workshops with two or three stakeholders. Stakeholders represented different sectors of the food supply chain, including farmers and farmers' representatives, officers in regional and local governments, upstream and downstream companies.

The results of this exercise (Bigot et al., 2020) showed that stakeholders did already use some kind of typologisation in their work, with the most commonly recognised category being organic farming, followed by integrated/circular farming, low-input farming and conservation agriculture. On the other hand, stakeholders also reported that the typology would be difficult to apply as such as there were overlaps between different categories. They also confirmed the fact that organic farming was not a detailed enough label to assess the ecological approach of a farm, and stressed the importance of evaluating the direct and indirect use of fossil fuel-based energy to measure farming management intensity. Practices affecting soil conservation and health were also pointed out as a key aspect to consider. Stakeholders also expressed interest in the possibility to use a tool to classify farms, provided that it be user friendly and simple to use.

Overall, the interaction with stakeholders confirmed the relevance of the main ecological criteria identified, but also highlighted the need to clearly define the relationships between the different groups and the rules to assign a farm to one or more categories. This feedback was duly taken into account during the elaboration of the final LIFT typology, as described in the next section.

3.3 The final LIFT typology and the elaboration of the FADN-based protocol and the survey-based protocol

The conceptualisation of the typology and the link with farming practices was further developed and refined, taking into account the stakeholders' feedback and through a pilot analysis on the link between farming practices and farming approaches carried out for three farming types in different geographic contexts.

This exercise provided valuable insights on the use of farming practices as proxies for the identification of farming approaches envisaged by the typology. It was also used to refine the conceptualisation of the typology itself, in particular by defining the topological relationships between the different classes constituting it.

The final version typology is shown in Figure 2 (Rega et al., 2021):

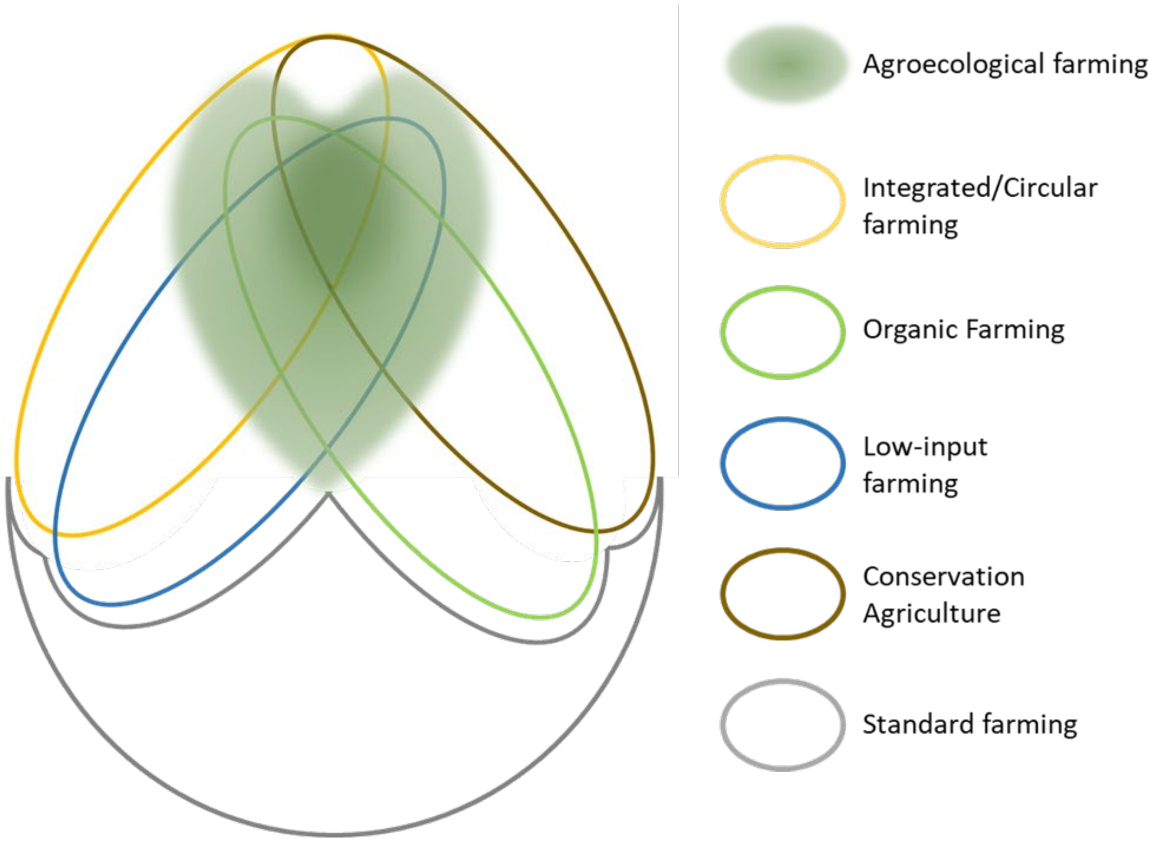

Figure 2. Graphical representation of the LIFT Farm Typology – Rega et al. (2021)

The typology is made by the combination of four main archetypical "farming approaches", associated with the first four main agroecological principles defined above. These farming approaches are named:

- *conservation agriculture*,
- *low-input farming*,
- *integrated/circular farming*
- *organic farming*

A fifth archetype - *agroecological farming* – is associated with farms that perform well with regard to all the four principles and have a good level of seminatural vegetation. Farmers who do not perform well with respect to any of the identified principles are grouped under the *standard Farming* label. The total number of classes making up the typology is constituted by all the possible intersections between the four non-mutually constitutive main approaches, as shown in Figure 2. Standard Farming is the approach identified by default: the farm is assigned in this type when it is none in the five farming approaches listed above.

3.4 The protocols to apply the typology

The implementation of any farm typology depends among other things on the database available to characterise individual farms. The next phase of the work therefore consisted in elaborating so-called protocols to classify individual farms according to the proposed typology. A protocol is defined as a system of rules that, given a set of data on individual farms, enables classifying a holding according to the proposed typology.

In LIFT, two main data sources had been envisaged to implement the protocol, the LIFT large-scale farmer survey (see section 2.3) providing detailed information on farming practices at farm level, and an EU wide dataset, usable to apply the typology outside and beyond the LIFT project.

An analysis of existing EU databases potentially usable for applying the typology was conducted. The following databases were examined: the Farm Structure Survey (FSS); the Survey on Agricultural Production Methods (SAPM); the FADN; the Integrated Administration and Control System (IACS) together with its geographic information system, the Land Parcel Identification System (LPIS).

Considering pros and cons associated with each dataset, the FADN was identified as the most suitable one since it is regularly carried out each year and it is the only source of microeconomic data that is harmonised at the EU level. FADN is also representative of around 90% of total EU utilised agricultural area (UAA) and production. Moreover, as part of the Farm to Fork Strategy, the EU has envisaged the transformation of the FADN into a more environmentally focused Farm Sustainability Data Network (FSDN). Therefore, it was considered that using FADN as a basis for the protocol would contribute to advance along well-established research and policy lines.

Consequently, two different and complementary protocols were elaborated, based on the FADN and the LIFT large-scale farmer survey, respectively. They were both envisaged as scoring systems so that for each of the five key management principles, each variable value is converted into a score in the range 0-4. Each farm thus gets an aggregate score describing the uptake of each of the five key management principles. The farming approaches are defined by setting thresholds to the scoring: if the farm reaches the established threshold, it is ascribed to the corresponding farming approach. Farms which do not reach a minimum threshold in any of the five key management principles are grouped into a separate class named *standard farming*. The two protocols are summarised in the next subsections.

3.4.1 The FADN-based protocol

The proposed FADN-based protocol takes into consideration a selection of variables describing the level of inputs, expressed in monetary terms, purchased or produced by individual holdings. The underlying assumption is that the expenditure for a certain input is a proxy of its actual usage. Farming management intensity is thus considered here in terms of input intensity, expressed as input level per unit of UAA and/or per LU over a one-year period. Intensity considers both the potential impact derived by the local use of the input, as well as the total level of resource depletion and emissions required by the manufacturing of that input. For some variables, FADN data also report the share of input produced internally, which can be used to assess the farm performance with respect to the principle of circularity/integration. A drawback of FADN is that it does not allow to evaluate with sufficient accuracy the aspects of soil conservation and presence of ecological infrastructure on farm. Consequently, the identification of the conservation agriculture approach is not possible with this protocol, whilst the evaluation of the agroecological farming approach is made based on the scores the holding gets with regard to the other three approaches.

After having selected a number of FADN variables, monetary values were processed to account for inflation and price differences between Member States using official Eurostat data to homogenise the whole dataset and allow comparison across time and countries. Subsequently, for each combination of variable and farm type (as defined in FADN), the percentiles of the value distribution across the entire set of available observations (i.e. individual farms from the years 2011 to 2015) were calculated and five quintiles were determined. Then, for each farm, a score was assigned, so that values belonging to the first quintile obtain a score of 4, values belonging to the second quintile get a score of 3 and so on. This allows to minimise the effect of potential outlier values. These partial scores are then aggregated through a system of weights to determine, for each of the five main ecological principles, an aggregate score that determines whether the farm is ascribed to a certain farming approach or not.

3.4.2 The survey-based protocol

The survey-based protocol, based on the data from the LIFT large-scale farmer survey, follows the same overall architecture of the FADN based protocol. The main difference is that it contains more detailed information on a wider set of farming practices, allowing to assess all five ecological principles - but less detailed information on the quantity of specific input used, mainly fertilisers and plant protection product. Another difference is that this information is provided for a sample of farms that, while relevant – more than 1,600 holdings across 13 different countries - does not constitute a statistically representative sample of farms across Europe.

Consequently, in this case, the score associated with the individual items in the survey were not derived by any statistical analysis of the distribution of recoded answer, but through an expert-based evaluation of the contribution of each practice to each of the five main ecological principles. Again, individual scores in the range 0-4 are then aggregated to derive final scores for each key principle through a system of weights and farms are ascribed to each class if this is equal to or greater than a pre-defined threshold score.

3.5 Results and potential applications

The methodological approach described in the previous sections allows to carry out cross-temporal and cross-spatial analysis on the distribution of a given set of farms into the defined classes. An example of the result of this type of analysis is provided in Figure 3, reporting the distribution of specialist dairy farms in Italy and France in 2015, using the FADN-based protocol.

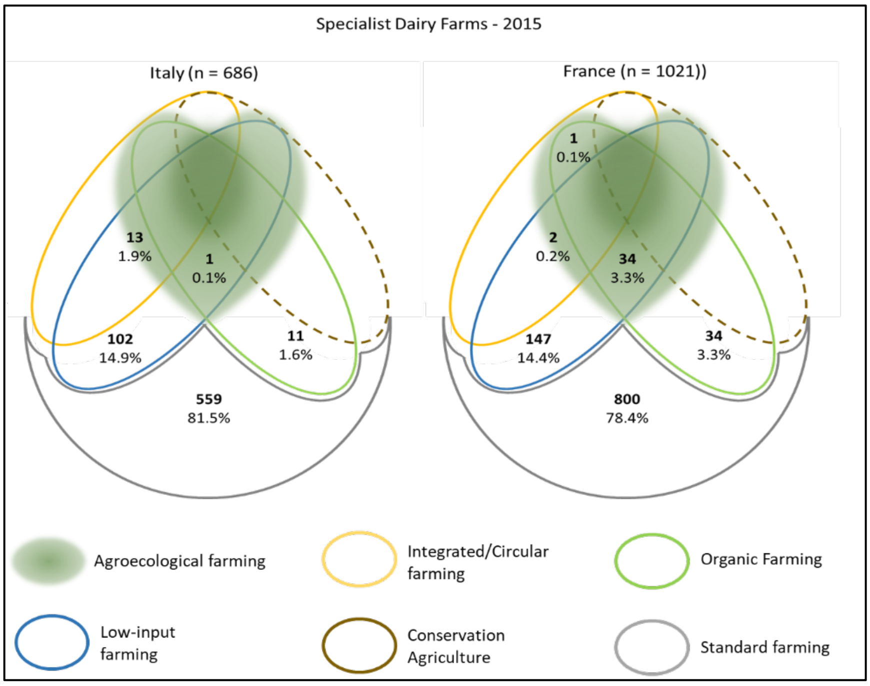

Figure 3. Distribution of Italian and French dairy farms according to the LIFT typology, FADN-based protocol, for the year 2015

Another type of analysis consists in making make cross-country comparisons focussing on a specific agroecological dimension, as shown in Figure 4. Here, the distribution of the scores of the "total Input intensity" principle for dairy farms is provided, which allows to grasp the different level of farming management intensity across the EU Member States.

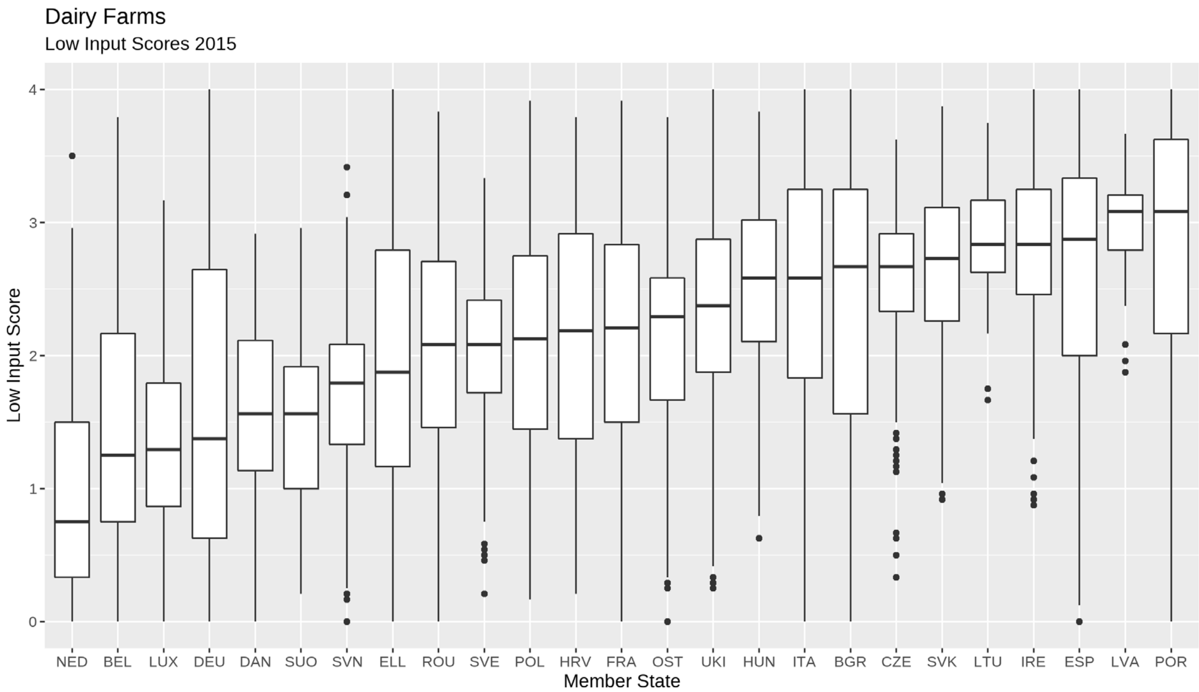

Figure 4. Distribution of the low-input intensity score in EU dairy farms (year 2015, FADN data). The higher the score, the less intensive the farm management.

Potential applications of the LIFT typology include the identification and evaluation of spatial and temporal trends in overall management farming approaches across the EU, which can in turn inform the implementation of agricultural policies at different territorial levels. The typology can also be used in policy evaluation and monitoring, e.g. for better targeting of policy measures or for investigating trends across farming cohorts or over a number of years. This links to several EU policies, most notably the CAP, the Green Deal, The Farm to Fork Strategy and the Biodiversity Strategy, all aiming at decreasing the intensity of EU agriculture and promoting more circularity in farming systems. The latter aspect is also linked to the EU *Circular economy action plan*, another key building block of the Green Deal.

3.6 The LIFT typology-tool

A typology-tool was developed in LIFT to allow an easy and user-friendly application of the developed typology using FADN data[3]. The LIFT typology-tool was built using the programming language R in R Shiny (R Core Team, 2020) and it allows users to use their own accounting data. Stakeholders were involved in the design of the tool through stakeholder workshops during which preliminary versions of the tool were presented. The LIFT typology-tool features an intuitive graphical user interface and a comprehensive glossary, also allowing to access all parameters underlying the protocols, so enabling

[3] The LIFT typology-tool is available at https://agroecology.app.inrae.fr

further development and customised adaptations. The tool assigns individual farms to the classes of the typology and, additionally, enables comparing the performances of any given farm with those of a defined peer group. The LIFT typology-tool provides insights into farm multi-performance and the key determinants of performance. It can be used by agricultural advisors to advise farmers.

4 Adoption of ecological approaches

4.1 Background

The EU Farm to Fork strategy (European Commission, 2020) is an example of a policy desire to promote more environmental practices within our farming systems. These strategies aim to encourage more uptake of ecological and circular economy practices to reduce the negative environmental externalities from the supply of food across Europe. Although, small pockets of farmers have for a number of years been adopting ecological practices, such as diverse cropping mixtures, silvo-pastural systems and low-input farming, the ambition set out in these documents is to ensure that these are adopted at scale to meet publicly stated targets on carbon and biodiversity. Ultimately, an uplift in adoption of these practices requires a matching of the desires of policy and wider society to the goals of the farming community. This would seem key to an effective and sustainable transition.

Farmer decision-making is complex and shaped by external and internal forces. Our current farming systems have evolved in response to a series of internal and external forces. Figure 5 summarises these internal and external forces and provides a hypothesised behavioural framework for understanding the adoption of ecological practices. This presents the internal process of a farm decision-maker that leads to an intention to change to an ecological production practice. Based on an extensive literature review (outlined in Hansson *et al*., 2019) we hypothesise the process of adoption as a dynamic event, where future adoption is likely to be affected by current adoption. The framework suggests several components of decision-making around the type of ecological practices adopted, e.g. agroforestry will have significant long-term consequences for land use, whereas integrated pest management allows more flexibility in planning and targeting.

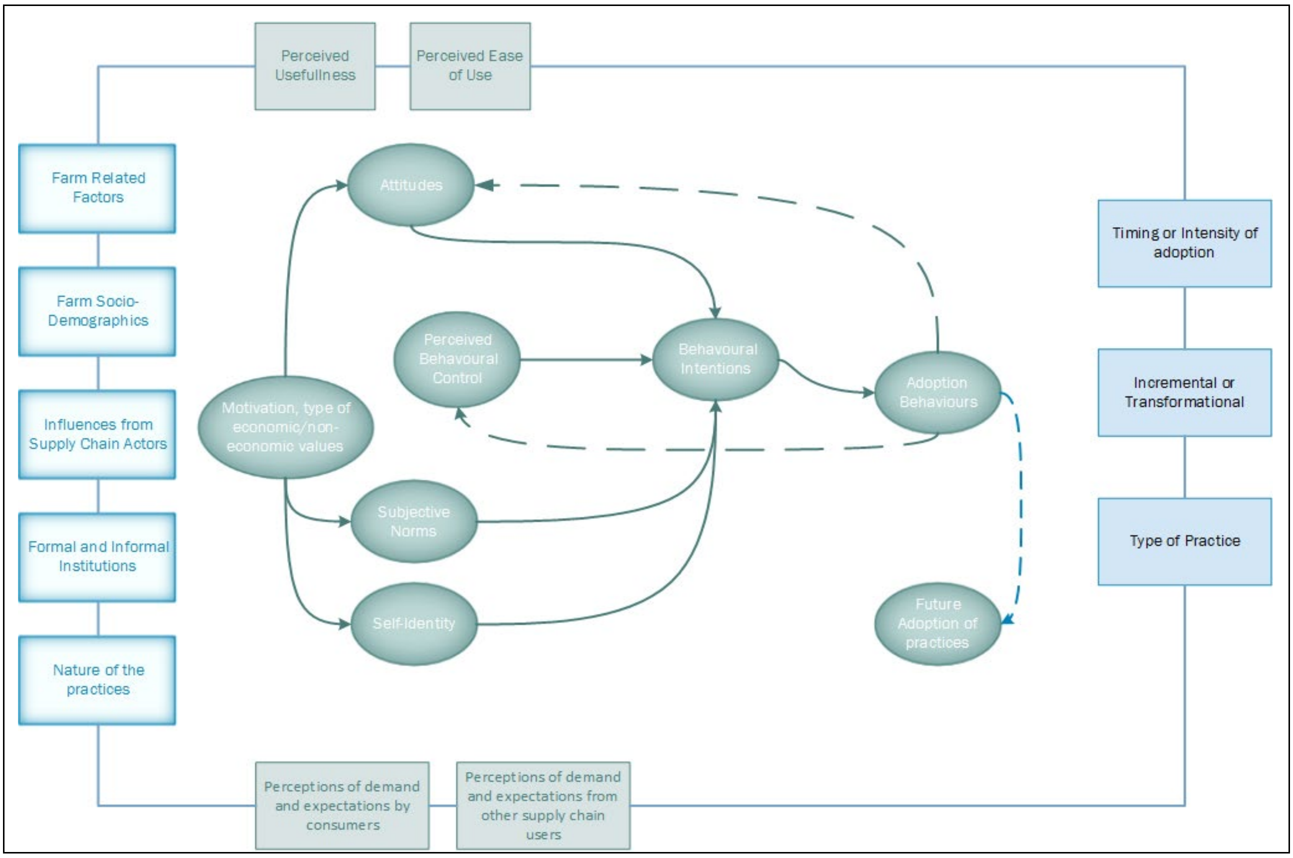

Figure 5. A behavioural model for ecological practice adoption - Adapted from: Hansson et al. (2019)

4.2 Data and methodology

A mixed method approach was adopted to understand decision-making. One of the main methods was the LIFT large-scale farmer survey, that was administered to participants across 13 European countries, namely Austria, Germany, Greece, England, France, Hungary, Ireland, Italy, Poland, Romania, Scotland, France and Sweden. Overall, responses from over 1,600 farmers were collected. As explained above (section 2.3), the questionnaire consisted of a number of sections which covered the characteristics of farming systems, the adoption of ecological practices and detailed motivations for their adoption (see Tzouramani et al., 2019, for further details).

An in-depth qualitative study of Swedish, French and Irish individual conventional and organic farmers was undertaken using the Means-end chain (MEC) approach. MEC assumes a hierarchical relationship (or chain) from perceived product (or practice) attributes, to consequences of these attributes and finally to desired end-states or abstract personal values which are arrived at, taking the consequences of the attributes into account. MEC was extended here to the study of farmers' decision-making, where individual farmers' interviews elicited a detailed understanding about which attributes farmers use to characterise a decision, what consequences they perceive from those attributes and why those consequences are important to the farmers.

Structural Equation Modelling (SEM) is used with observed and latent (unobserved) variables to test a conceptual behavioural model of uptake of ecological approaches and assess the influence that behavioural determinants have on the intentions to adopt ecological practices and current/future adoption behaviour. As each variable might influence behaviour and intentions both directly or indirectly, the variance explained by the model is higher than when other methods, e.g. regression analysis, are used.

4.3 Main results

Our results show that farming objectives are strong predictors of ecological practice adoption. Specifically, the tension between productivity objectives and environmental objectives will lead to a lower likelihood of adoption of ecological practices. This dissonance has been found to lead to a triggering of change in the farm business or preference for the status quo.

All the interviewed farmers (both conventional and organic) held financial, business and productivity motivations. Nevertheless, there were divergences between organic and conventional farmers. While conventional farmers used phrases such as "preserving traditions", "responsibility", and "supporting the family", organic farmers verbalised more social motives such as "morality" and "care for others". Organic farmers tended to show a more complex train of thought with longer chains of different motives which may indicate that organic farmers are more reflective on their activity.

We classified farmer perceptions towards ecological approaches. This was developed based on the perceptions, values, motivates, and attitudes towards ecological farming practices of our European farmers. We found two types that were supportive of ecological practices, but were distinguished by being either enabled or constrained by the supply chain. Two other types were found, one type balanced more productivity with environmental goals and another type showed disinterest towards ecological practices.

The institutional framework which supports advice should provide assurance on practices that will be beneficial for the sustainability of the farm. As peer-to-peer learning was found to be a strong influencer of uptake of ecological approaches, these networks should be expanded to widen participation. However other aspects of agricultural knowledge and innovation systems need to be addressed to support the goal of greater ecological practice uptake. Advisors are key to supporting on-farm decisions and their confidence towards integrating and promoting ecological practices requires targeted developments, such as recognised training and expansion of the skills required to provide farm advice. Moreover, the role of agricultural education and support for training requires a movement across traditional boundaries towards such skills in agri-environmental and forest management, which will support a route to develop and change norms around ecological practices.

The results highlighted above, and further results in Barnes et al. (2021), allow us draw the following key messages.

- The decision-making framework developed and tested through a large-scale farmer survey, along with detailed interviews with farmers, is robust to assess the adoption of ecological approaches and their balance towards productivity and other goals.
- Our findings emphasise the importance of respecting heterogeneity within current EU farming and, thus, supporting targeted interventions within these populations to encourage and support the transition to ecological farming.
- This classification of the ecological perceptions of four farmer types may provide a way to approach how messages are tailored around the goals of EU Farm to Fork and other agri-environmental support policies, but also give an indication of which interventions may support a transition towards a more favourable ecological outlook. Each type is more or less likely to adopt ecological practices and this will affect how the stated goals of Farm to Fork can be reached.

- Whilst we find most farmers perceive themselves to be part of the farming community, there are few other similarities between our farming types.
- That identities can change, and positive ecological identities are allowed to emerge if enabled, is also encouraging for shifting policy goals towards more ecological approaches.
- A main motivator for perceiving to be constrained are issues within the supply chain. Within the EU Farm to Fork Strategy, there is an aspiration towards changing supply chains which may enable more ecological identities to emerge.

4.4 The LIFT adoption-tool

An adoption-tool was developed in LIFT[4]. It is a user-friendly online application that enables users to understand the factors associated with ecological practice adoption, and to input farm data to obtain the likelihood of that farm being an adopter of ecological practices. It provides information about adoption rates of ecological practices, as well as the characteristics of the target population exhibiting higher probabilities of adoption. The tool model is an ordinal regression model estimated using the LIFT large-scale farmer survey and FADN datasets. LIFT adoption-tool was built using the programming language R in R Shiny (R Core Team, 2020) around three modules: 'Explore' allowing the user to explore data collected through the LIFT large-scale farmer survey; 'Interpret' allowing the user to see information about the relationships between predictor variables and ecological practice adoption; and 'Predict' where the user can input data about a real or hypothetical farm and farmer. The LIFT adoption-tool has been tested by stakeholders in nine EU countries, and can be used in different types of European farming systems. It allows users to examine what is driving uptake of ecological practices but also what may encourage farmers to adopt ecological practices in the future. Hence, it could be used as an educational tool but also as a means to provide more robust predictions for future scenarios of uptake.

5 Farm performance of ecological agriculture

In the LIFT project, four dimensions of farm-level performance, namely technical-economic, private-social, environmental, as well as employment-related performance have been assessed and compared along the gradient of ecological approaches implemented on farms. As a basis for the analyses, literature reviews on measurable indicators of these different dimensions of farm performance have been conducted. Performance analyses were then carried out for different European case studies on regional, national and transnational levels. The assessments were performed through bio-economic modelling, and through modelling and statistical approaches based on secondary data (EU FADN or local accountancy data) and specific survey data (including the LIFT large-scale farmer survey).

5.1 Farm technical-economic performance

The analysis of farm technical-economic performance was geared towards three aims. First, to refine and apply quantitative profitability and productivity indicators across several case studies, second, to fully establish efficiency models at regional and national case study level for the assessment of farms' technical-economic performance, and third, to execute profitability and productivity indicators and efficiency models in order to compare farms depending on their degree of ecological approaches and to understand drivers and performance gaps. A broad variety of locally specified efficiency models was

[4] The LIFT adoption-tool is available at https://sruc-lift.shinyapps.io/adoption_tool

developed, as well as a transnational model focusing on dairy production. In all participating regions or countries, farms with different degrees of uptake of ecological practices were identified and compared with each other. Still, all case studies followed a similar structure and included some common elements in terms of the applied methods. In particular, a set of common indicators of technical-economic farm performance was implemented in several regions (Niedermayr et al., 2021).

A main finding is that there is no uniform picture with regard to the technical-economic farm performance depending on the degree of ecological approaches adopted. Instead, the wide variety of farm types and biophysical, socio-economic and political framework conditions present in the EU matters and acts, besides the degree of uptake of ecological approaches, as drivers of farm technical-economic performance and leads to heterogeneous outcomes. This heterogeneity needs to be considered by policy makers and can most likely best be addressed by a broader policy framework, which provides legislators the necessary flexibility to adjust measures to region-specific framework conditions, in order to foster the economic viability of farms in the context of an ecological transition of EU agriculture.

5.2 Farm private-social performance

The analysis on farms' private-social performance in LIFT aimed at investigating farmers' working conditions depending on the degree of ecological approaches adopted, from conventional to agroecological. Farmers' working conditions were analysed in several dimensions, such as work time, work organisation, quality at work, work complexity, satisfaction, stress, farmers' self-identity, and social relations (Hostiou et al., 2021). Besides the degree of uptake of ecological approaches, multiple other factors determine farmers' working conditions, such as the composition of the workforce, or the region. In order to perform a comparative analysis of farmers regarding private social performances among the five European case studies involved, a quantitative framework of social indicators relating to working conditions was developed. Principal component analysis was conducted to further analyse and describe relations between these indicators relating to working conditions, workforce composition and farm structure, using data from a specific survey carried out in LIFT to 123 farms across five European case studies.

Results highlight that farmers' working conditions differ across European regions. There was a broad diversity with regard to gender among case studies: female farm managers were most often present in both Austrian case studies (Salzburg und Umgebung and Steyr-Kirchdorf) and in the French Puy-de-Dôme case study, compared to the French Brittany case study, Crete in Greece and Ireland. Differences in working conditions in Ireland and Crete, compared to the other case study areas, are probably due to contextual factors, such as the predominant agricultural systems (e.g. permanent crops in Crete compared to livestock farming in Ireland) and the availability of off-farm employment. The degree of uptake of ecological practices alone cannot explain differences in working conditions in the sample composed of the five European case studies, as results clearly depend on study areas and production systems. Still, results show that working conditions depend on the adoption of ecological practices. Despite indications that such adoption increases working hours and decreases the time for holidays and days off, farmers expressed overall positive feeling with regard to the adoption of ecological practices. Results are clearly not uniform, but rather farm and farmer specific.

5.3 Farm environmental performance

Farm environmental performance was evaluated across three dimensions, (i) qualitative description, (ii) quantitative evaluation, and (iii) monetary assessment of ecosystem services. All three dimensions were informed by a systematic evidence synthesis. The analyses proceeded in a pyramid approach, in which the broadest analysis is presented first, and all subsequent analyses presented an increase in nuance and complexity. Four main approaches were applied: (i) farm bio-economic modelling enabling the computation of environmental indicators for a specific case-study farm; (ii) computation of environmental indicators and comparing them across farms depending on their uptake of ecological approaches; (iii) farm efficiency, including in the efficiency model both economic and environmental inputs or outputs on the farm; and (iv) environmental damage computed at the farm or the plot level (Van Ruymbeke et al., 2021a).

Results show that farms that are more ecological tend to show higher environmental performance, but the opposite can also be found, depending on the degree of ecological approaches, the indicator of environmental performance, the type of farming, among others. Similarly, drivers of farm environmental performance depend very much on the context. In particular, the effect of subsidies on efficiency has been found to be positive, negative or not significant depending on the case study. Overall, results show that an increasing uptake of ecological approaches may have a positive effect on environmental performance. But the impact on ecosystem service provisioning is even more nuanced, with trade-offs and/or synergies occurring depending on the co-adoption of ecological approaches.

5.4 Employment effects of ecological farming at the farm level

The analytical work centred on the employment effects of ecological approaches within the continuum from conventional to agroecological. It analyses the differences in the quantity of labour used based on FADN data, and carries out an econometric analysis of returns to skills according to the degree of uptake of ecological approaches, based on the LIFT large-scale farmer survey data.

The FADN-based analysis indicated a consistent picture across EU Member States. At low level of external inputs and capital intensities, which proxies farms employing ecological approaches, the use of labour increases. However, beyond certain thresholds of input and capital intensities, there is a switch to a substitution effect. This implies that conventional farms, characterised by intensive use of externally purchased inputs or capital, tend to employ less labour. It was also found that the adoption of ecological approaches will increase the use of hired labour, strengthening the existing trend of substitution of hired for family labour. Returns to skills in ecological farming have been estimated based on the data from the LIFT large-scale farmer survey and this analysis has only covered LIFT case study areas. The explorative picture based on the survey data has been expanded by a common econometric analysis of the case study areas in France and England. The comparative study raised questions about the educational systems in the two countries, which could influence the innovative capacity to employ new farming technologies.

5.5 Overall summary and outlook

Overall, the results of the farm-level performance analysis show that an increasing uptake of ecological approaches in the EU will significantly shape farm performance. However, besides mostly positive environmental effects, mixed effects on farm technical-economic performance, on private-social performance and employment are to be expected. Furthermore, effects will be clearly shaped by regional contexts. Therefore, policy should provide larger flexibility under a common EU wide framework to adjust measures to the regional context. Furthermore, policies should support farmers in their transition to a deeper integration of ecological approaches. In particular, policies should be orientated towards a decrease in transaction costs of hiring farm labour to ease the wider adoption of ecological approaches.

6 Territorial sustainability of ecological agriculture

6.1 Spatial dependencies in patterns of adoption at local and regional levels

To assess territorial sustainability in the LIFT project we firstly carried out, for the first time in the literature, a meta-analysis of the spatial distribution of ecologically-friendly agriculture, incorporating systems (e.g. integrated production), bundles of practices (e.g. green control measures) and single practices (e.g. conservation tillage) (Bormpoudakis and Tzanopoulos, 2021). We opted for a qualitative meta-analysis, as we were mainly concerned with the significance, extent and location of the phenomenon of spatial clustering and/or dispersal, and less so on its absolute quantitative magnitude. Our study had three aims. Firstly, we reviewed the evidence on spatial clustering of ecologically-friendly agricultural practices and systems. Secondly, we conducted a qualitative analysis of the variables that influence the spatial distribution of ecologically-friendly agricultural systems and practices as ascertained using spatial models only. Thirdly, and finally, we conducted a qualitative analysis of the variables that have a spatial spillover effect, i.e. farmer's or administrative unit's characteristics that can influence neighbouring farmers or administrative units. We maintained a local and regional focus throughout the study. We performed a literature search on Scopus, and after retrieving circa 6,000 documents, we narrowed down our sample to 39 relevant papers published in peer-reviewed journals. From this sample of 39 papers we reviewed the evidence on spatial clustering across ecologically-friendly agricultural practices and systems, and recorded methodological aspects of the literature. To analyse the factors that influence the spatial distribution of ecologically-friendly agricultural practices systems, we focused on those studies that used some kind of formal spatial statistical test to study those processes, a total of 26 studies. Finally, we focused on eight studies that used spatial statistical models suited to the assessment of spillover effects, to study the variables that have spatial neighbourhood effects.

We found that geographical and farming system biases in the literature hinder global and regional/local understanding. We also found that spatial clustering is a prominent feature of ecologically-friendly agricultural practices and systems, although perhaps not as universal as commonly presented - especially at the local and regional scales and modulated by crop, system, and geographical context. By reviewing the variables that influence ecologically-friendly agricultural practices and systems adoption or uptake, we argued that while some variables do seem to have a clear effect, more research is needed for the majority of variables – especially regarding variables that might have spillover effects. Arguably, this is not just a case of more research along previously followed lines, but research that focuses on different locales and scales, diverse systems and practices, and using both (the right) quantitative and qualitative methodologies.

6.2 Socio-economic impact of ecological agriculture at the territorial level

We then investigated the socio-economic effects of ecological approaches to farming through implementing two participatory approaches, namely Delphi exercise and Q-method, at the level of a case study area. The focus was on how people and other productive assets are employed and remunerated by ecological approaches to agriculture, particularly those aspects that can influence employment, and drive the prosperity and vitality of local communities and some rural businesses (Bailey et al., 2021).

The Delphi exercise presented qualitative information extracted from stakeholders in the following four steps. First, the researchers built a presentation of differences between ecological and conventional farming approaches in each case study area. Second, stakeholders elaborated on how they understand ecological farming approaches to exist in each case study area. Third, stakeholders developed a scenario of adoption of ecological approaches to farming depending on two factors: pattern (ecological farms forming clusters or randomly spread within the territory) and rate of adoption 10 years in the future. After establishing this scenario across two rounds, the stakeholders explored the socio-economic effects of their adoption scenario. The Q-methodology presented a set of statements developed through previous stakeholder workshops and the farming media. After stakeholders sorted these statements, factor analysis was applied to the sorts to study the key stakeholder perspectives of the socio-economic effects of the perceived adoption of ecological practices 10 years in the future.

Four key results were derived from the Delphi exercise and the Q-methodology. First, a higher adoption of ecological farming approaches, especially so at a 50% adoption rate, was mostly thought by stakeholders in the Delphi exercise to lead to an increase in skill level and quality of life in on-farm employment. This is as a result of an increased diversity of farming enterprises on farms using ecological farming approaches, the interest generated from this, the knowledge of natural processes and biology required, engagement with nature and change in machinery that is coming into the industry. Strongly related to this need for skills is a predicted increase in the number of advisers and civil servants to deal with more complicated farms and incentives as well as the monitoring of ecological effects on farm. An increase in required skill level is repeated across all Q-studies.

Second, especially where farms are clustered together, Delphi exercise respondents predicted an increase in the trade of inputs such as manure and compost, as well as more sharing of capital and labour. Q-methodology highlighted that these clusters may support a stronger social movement, more consumers buying local food and increased collaboration between farmers. Supply chains are expected to become shorter as farmers sell more directly and there are fewer intermediaries upstream of the farming sector. As farmers collaborate more with each other on environmental objectives, trading inputs and sharing best practices, farmer relationships should improve in rural communities.

Third, Delphi exercise found that the anticipated effects of contracting, machinery purchasers, and machinery traders and dealers are mixed. Stakeholders were certain that machinery use will change and therefore new skills will need to be learnt, but the wider effect on machinery purchase is uncertain. However, stakeholders concluded that a greater specialisation in machinery will occur leading to changes in farm management as well as the suppliers of this machinery. Q-methodology highlighted that ecological practices will not mean the end of machinery and a lot more labour – often machinery will be useful in weeding and reducing physical labour as technology has significantly improved and skills are improving too in order to use these technologies.

Fourth, Delphi exercise respondents argued that although rural populations might be little affected by ecological farming, a shift in people moving from urban to rural settlements, and thereby a higher rural population density, might contribute to higher local consumer demand. The Q-methodology highlighted that where there is high adoption of ecological farming, rural areas are expected to become more attractive, as landscapes will have a greater variety of crops instead of fields of monocrops.

6.3 Environmental impact of ecological agriculture at the territorial level

Finally, we provided insights on the environmental impact, which is termed more precisely the agri-environmental impact, of ecological farm management practices using the ecosystem service concept at the territorial level through a two-pronged approach (Van Ruymbeke et al., 2021b). First, we presented an indicator framework which uses, on the one hand, evidence derived from an extensive systematic literature review quantifying the potential supply of 17 ecosystem services from 26 different (ecological) farm management practices, and, on the other hand, local stakeholder-derived ecosystem service weights (reflecting the relative ecosystem service demand) to obtain an overall agri-environmental impact indicator for a given ecological farm management practice. We applied the indicator framework in three case study areas across Belgium (Hageland-Haspengouw) and England (North Kent and the High Weald area). Second, we presented results from a discrete choice experiment (DCE) in which we quantified preferences for aesthetic value of integrating ecological farm management practices into an agricultural landscape in Flanders (Belgium), England, and Hungary.

Through the composition of agri-environmental impact indicators we found that semi-natural habitats had the highest agri-environmental impact at territorial level in North Kent and the High Weald area, while in Hageland-Haspengouw this was cover crops. However, cover crops had the second highest agri-environmental impact in North Kent and the High Weald area, while semi-natural habitats had the second highest agri-environmental impact in Hageland-Haspengouw. Also obtaining a high agri-environmental impact at territorial level across the three case study areas was extensive livestock systems, intercropping and crop-livestock integration. While conventional farm management practices generally have a lower agri-environmental impact than agroecological farm management practices, we found that the latter may also have low agri-environmental impacts. This demonstrates that while certain agroecological farm management practices have a tendency to have a positive impact on potential ecosystem service supply, the demand for ecosystem service is what determines whether the potential benefits are realised in an area. This variation in demand illustrates that not all farm management practices are suited for all geographic and socio-economic contexts, as that farm management practices that have a high agri-environmental impact in one region may perform poorly in another, highlighting the importance of considering local demand when determining agri-environmental impacts of farm management practices.

From the DCE carried out to quantify preferences for aesthetic value, we found that, similarly to the findings from the agri-environmental impact indicators, ecological management practices which target increasing (bio)diversity and maintaining green corridors within a landscape, such as semi-natural habitats and cover crops, illicit strong positive preferences from the general public. Our findings illustrated that considering local context and demand is important when evaluating agri-environmental impact of farm management practices based on ecosystem services.

Overall, results from these two agri-environmental impact assessments indicate that there is a context-specific component to the agri-environmental impact of ecological farm management practices. The presented results provide interesting insights for land management decisions and policy recommendation in that they illustrate that, at the territorial level, ecological farm management practices which are applied at a larger scale and which focus on maintaining landscape (bio)diversity and green connectivity, seem to have the highest agri-environmental impact regardless of the context. Further, we demonstrated that when considering the agri-environmental impact of more localised farm management practices e.g. cover crops, or farm management practices which result in more permanent, obtrusive changes to the agricultural landscape, it is important to consider the local contexts and ecosystem service demands.

7 Sustainability of ecological agriculture: trade-offs and synergies across dimensions and scale

The work explained above focussed on evaluating the performance of ecological approaches to farming along with the social/employment, economic and environmental dimensions separately. We then aimed at incorporating these findings into a holistic evaluation of overall sustainability of ecological approaches to farming, considering trade-offs and synergies that may occur on the one hand between different spatial levels (i.e., farm and territorial level), and on the other hand between the different dimensions of sustainability (i.e., social/employment, economic and environmental). For this, three levels were considered: evaluating the sustainability of ecological approaches to farming at the farm level, evaluating the sustainability of ecological approaches to farming at the territorial level, and combining insights from the two levels to give a holistic overview of sustainability performance of farming systems. Novel methodologies were applied, to evaluate sustainability within each task, relying on data from the LIFT large-scale farmer survey, data from FADN, a systematic evidence synthesis, and stakeholder engagement. Analyses were performed for a large number of case study areas.

7.1 Assessment of farm level sustainability of ecological farming

An indicator system at the farm level, integrating all performance dimensions (technical-economic, environmental, private-social as well as employment effects) was developed and applied. The approach compares the performance of farms in five ecological groups from the LIFT farm typology (conservation agriculture, low-input farming, integrated/circular farming, organic farming, agroecology) as well as possible combinations of these groups; the least ecological group being referred to as standard farming (see section 3). This approach allows to depict whether ecological farms perform differently and have different trade-offs and synergies than standard farms (Niedermayr et al., 2022).

Taking up the example of dairy farms and using FADN data, three groups of farms applying ecological approaches are observed in Austria, namely integrated/circular farms, organic farms and farms combining integrated/circular and organic farming, while in France, the very large part of farms are standard farms while among ecological farms, the main ecological types are integrated/circular farms and organic farms (on Figure 6 the percentages of farms in each group with respect to the overall sample are expressed in the legend).

The resulting spider web in Figure 6 gives decision makers an overview of how the different dimensions are interrelated. On the spider web, standard farms are normalised to zero and are the benchmark for ecological farming approaches, whereas values above/below the black line indicate better/worse performance. In the Austrian example (left spider web), dairy farms that apply organic farming practices perform better than standard farms from an environmental perspective. In terms of social and employment-related indicators, however, organic farms perform worse and with regard to economic indicators, the positive performance being strongly shaped by the payment of subsidies. For the French sample (right spider web) the same finding can be drawn as regards the higher environmental performance of ecological farms compared to standard farms, while the difference is less marked in terms of social/employment performance.

Identical analyses were carried out in the LIFT project for numerous countries, regions and farm types, giving policy makers an in-depth view regarding farm level sustainability performance of ecological approaches in the EU. Apart from FADN data (as in the above example), the approach developed was also applied to primary data, namely the LIFT large-scale farmer survey and the bio-economic model FarmDyn, providing more nuanced indicators in the social and environmental sustainability dimensions. However, our approach also shows that European farm-level data bases provides insufficient information to establish such an integrative performance assessment; in particular private-social, but also environmental information is missing. Thus, European farm-related data bases need to be further developed for a continuous monitoring of the effects of CAP on all performance dimensions.

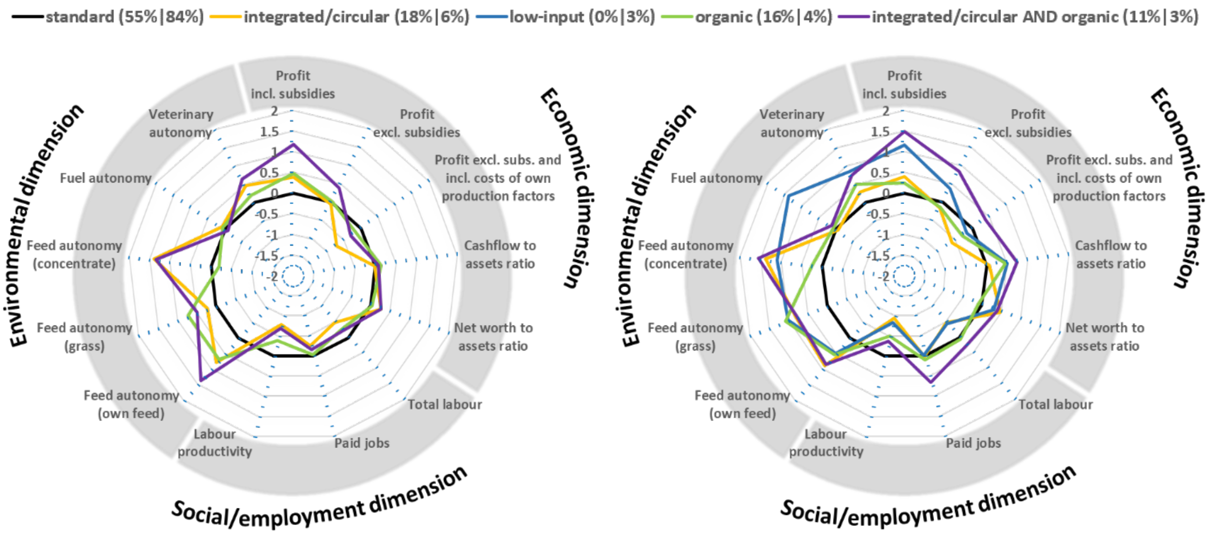

Figure 6. Overall farm level sustainability based on FADN data (year = 2015) in Austria (left, 787 farms) and France (1,005 farms), for specialised dairy farms differentiated by degree of ecological approaches (percentages of farms in each group in parentheses (Austria|France)) – adapted from Niedermayr et al. (2022)

7.2 Territorial sustainability assessment of ecological agriculture

We then performed a territorial level sustainability assessment of alternative scenarios for the adoption of ecological farming approaches for 16 case study areas across Europe. Given that there are many approaches to sustainability assessment depending on the theoretical framework, the assessment aims, and data used, we started with a review of the sustainability assessment literature in relation to agriculture and territorial scale issues, to identify the most appropriate methodology for this assessment. The limited availability of landscape-scale data, the use of scenarios, and the need to rapidly apply a straightforward methodology across diverse case study areas, favoured a qualitative assessment of each adoption scenario in terms of their impacts against a set of regionally-specific sustainability objectives. Moreover, because territorial impacts can reflect many interacting cause-effect relationships, network analysis formed an optional extension to the assessment, to explore the patterns of influence underpinning scenario performance.

In order to define the sustainability objectives, an initial long list of possible objectives was created through a review of the academic and policy literature, followed by stakeholder consultation to produce a final short list of objectives for each case study area. Performance against these objectives was assessed for four ecological farming adoption scenarios that differed in terms of the rate (high or low) and distribution (clustered or dispersed) of adoption in 10 years' time. The ecological practices being adopted in these scenarios were identified based on Delphi exercises with stakeholder panels conducted as part of LIFT work on territorial sustainability (see section 6.2). Each scenario was described as the product of a set of drivers of change, and these drivers were tabulated against the objectives to produce an assessment matrix for each scenario. Groups of experts and stakeholders completed these matrices by deciding how the state of each driver in each scenario impacted each objective. The different driver impacts on each objective were aggregated to show the scenario's overall performance – an example of the resulting assessment output is shown in Figure 7. For the High Weald case study area in England, the matrices were also used to create network graphs to show the interacting cause-effect relationships between drivers and impacts, and network analysis was used to identify system features that were especially influential in determining overall sustainability performance (Matthews et al., 2022).

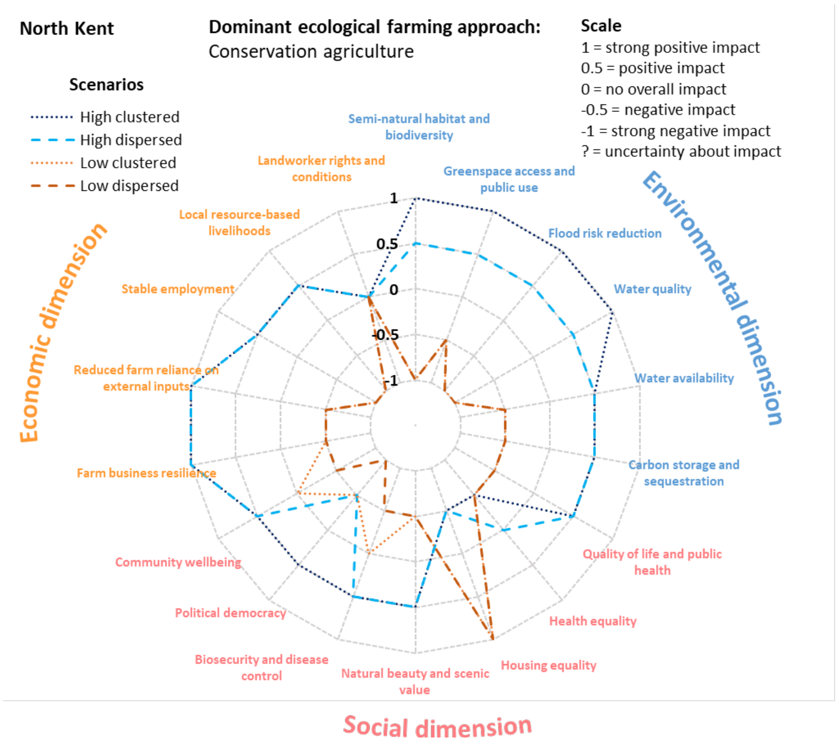

Figure 7. An example of the qualitative assessment output, showing performance of alternative ecological farming adoption scenarios against territorial sustainability objectives for North Kent, England, UK. Assessment scores have been converted into a simple ordinal scale (where strong positive impact = 1, positive impact = 0.5, no overall impact = 0, negative impact = -0.5, strong negative impact = -1) (Matthews et al., 2022)

The qualitative impact mapping showed that territorial sustainability performance tended to be strongest when the ecological farming adoption rate was high, and when adoption was clustered (although the impact of adoption distribution was typically smaller than the impact of adoption rate). The same overall pattern was seen when considering only the environmental and social dimensions of sustainability, but economic performance was mainly impacted by the rate, and not the distribution, of adoption. These results suggest that the practices identified by stakeholders as relevant to future ecological adoption scenarios tend to be appropriate for achieving the region's specific sustainability objectives, and that the spread of ecological farming approaches can sometimes deliver 'win-win-win' outcomes that reconcile performance across different sustainability dimensions. However, no one scenario was best for every objective in a case study area, so even if high clustered adoption of ecological farming makes an overall positive contribution to sustainability at the territorial level, realising this scenario in practice will still involve navigating some trade-offs between objectives.

The High Weald network analysis highlighted key pathways and barriers accounting for differences in scenario performance. Information exchange among farmers on the benefits of ecological practices (facilitated by organisational and advisory support, and use of technology) was a major contributor to the strong sustainability performance of a high clustered adoption scenario. The network graphs also indicated how territorial sustainability performance of ecological farming may be due to a combination of farm- and landscape-level processes, and suggested areas of interaction between these farm- and landscape-level processes. As an example, strong farmer interpersonal relationships could enhance information exchange that promotes ecological practice uptake on individual farms, but also encourage greater coordination of land management and collaboration between farms.

7.3 Synergies between farm, farm-group, and territorial sustainability of ecological farming

Finally, a multi-scale sustainability assessment framework was developed, in which findings from farm-level multi-dimension performance (section 7.2) and territorial sustainability assessment (section 7.3) were combined through the incorporation of a multi-criteria analysis, stakeholders' sustainability objectives, and descriptive analysis. The aim was to reveal the linkages and compromises between farm and territorial level performance of farming systems across the three dimensions of sustainability; economic, social and environmental. Further, determinants of adoption were linked to the sustainability performance of farming systems to ensure a holistic overview of farm system performance and to obtain policy-relevant recommendations (Van Ruymbeke et al., 2022).

The proposed framework adopts a five-step approach. In a first step, the various farm-level sustainability indicators computed from FADN data (section 7.1) are aggregated into a single performance indicator for each dimension (social, economic and environmental). These three indicators are then supplemented with a second environmental indicator evaluating environmental performance of farming systems based on the potential supply of ecosystem services. Incorporating this second environmental indicator is done to provide additional insights on environmental performance, which may otherwise be missed if focussing only on data quantifying the use of external inputs, as is the case with the FADN data indicators. In a second step the aggregated performance of the farming systems within each dimension is normalised such that the highest and lowest performing systems within each dimension are given a value of 1 and 0 respectively, with all other farming systems obtaining a value between 0 and 1 relative to the highest and lowest performing systems. In the third and fourth steps, the sustainability dimensions (derived from the territorial sustainability analysis, section 7.3) are used to attribute weights to each of the considered dimensions, which are then used to perform a weighted aggregation for each farming system across the different dimensions. The final output is a single case study-specific indicator representing the sustainability performance of a farming system respective to the other considered farming systems. In the final step, the results from step four are linked to key factors influencing the sustainability objectives within each case study by considering the sustainability matrixes designed in the territorial sustainability analysis (section 7.2). These insights can then be used to inform policy decisions by looking at drivers of adoption. The framework was applied to several case studies.

Though the framework has so far only been applied to a handful of case study areas, result seem to illustrate that the highest sustainability scores are calculated for those farming approaches which combine management practices from two or more approaches. The sustainability assessment framework allows to identify which farming systems are sustainable in a given region. Relying on a publicly available panel-dataset that is updated annually (the FADN), the framework is highly flexible and easy to adopt by interested parties outside of the LIFT project. By engaging local stakeholders in identifying the weights attributes to each of the aforementioned dimensions, the framework not only benefits from incorporating insights from various actors with local expertise, but also from incorporating region-specific characteristics.

8 Impact of policies on the development of ecological agriculture

The context of the LIFT project has been characterised by a strong shift of the policy agenda towards sustainability and resilience. The New Green deal, the Farm to Fork and the Biodiversity Strategies have established strong targets in the direction of decreasing pollutants (nitrogen, pesticides) and increasing organic farming. The new CAP will introduce changes that will be likely to produce new research questions in terms of measure design and evaluation. The most relevant contribution of LIFT findings concerns an in-depth understanding of acceptability and behavioural aspects facing measure implementation.

8.1 Policy context

The CAP reform has implemented part of the wider policy needs and objectives set by New Green deal, the Farm to Fork and the Biodiversity Strategies. The new regulations (2021/2015, 2016, 2017) were published on 6/12/2021, setting the new objectives of the future CAP: (1) to ensure a fair income to farmers; (2) to increase competitiveness; (3) to rebalance the power in the food chain; (4) climate change action; (5) environmental care; (6) to preserve landscapes and biodiversity; (7) to support generational renewal; (8) vibrant rural areas; and (9) to protect food and health quality.

While the basic structure of the CAP has not changed, the new CAP brings 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 level. 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. In this regard, our analysis of the justification of ecological approaches in Rural Development Policy (RDP) documents (section 8.2) highlights heterogeneity in ways in which Member States convey ecological agriculture to stakeholders.

The main measures of interest for agroecological and low-input farming are likely the basic payment for sustainability attached to the enhanced conditionality scheme; voluntary ecological payments in the first pillar; future agri-environment-climatic measures in the second pillar (AECM). Several existing measures suffer from low participation and unclear effectiveness, which can also be improved based on insights provided by the LIFT project (section 8.3). This allows a support for a better design of existing policies and a more aware design of new implementation options (such as collective and result-based), which require a more thorough understanding of farmers' and other actors' behaviour (section 8.4). In practice, several other measures may be relevant. For example, innovation, farm advisory services and knowledge transfer measures may be addressed to sustainability concerns. The same applies for value chain-related measures, e.g. producers' organisations.

The policy change has attempted to address at the same time two of the main drivers of recent societal concerns, i.e. climate change and world food needs. During the project, the COVID-19 outbreak has partially refocused the agenda, highlighting the need for flexible and resilient food systems. In the end of 2021, the increase in prices of key inputs (energy, fertilisers) and agricultural prices, started in the end of 2021 and exacerbated by the war in Ukraine from February 2022, has driven attention to market drivers of technology adoption. This is causing the reconsideration of some of the current policy provisions and higher attention to the role of agriculture as promoting multiple private and public goods and contributing to ensuring a certain level of self-sufficiency of primary goods.

8.2 How are ecological approaches justified in RDP documents?

Differences at societal level in attitudes, understanding and problematising of environmental impacts of agriculture should contribute to the determination of society's choices of policy measures as well as the promotion and justification of those measures. Consequently, it was assumed that differences in RDP policy measures promoting ecological practices across EU Member States, originate from differences in societal understanding of externalities in agriculture.

The policy discourses used in the RDP of Sweden, France, Bavaria, Hungary, Poland and Romania were investigated to depict and justify the support of ecological approaches across three programming periods of the CAP (Leduc et al., 2019; Leduc et al., 2021). The use of discourse analysis aimed to understand the policy justifications that were associated with ecological approaches and especially the type of public goods that were promoted for implementing these approaches.

Our results revealed differences and similarities in societal views about ecological approaches among the studied EU Member States, as well as the type of ecological approaches that were recognised at national policy level. Overall, results showed that ecological approaches were mostly promoted within a multifunctional discourse and more precisely, promoted as providing the public goods of biodiversity, protection of the environment and traditional modes of production. Furthermore, the absence of the CAP neoliberal discourse within the RDP showed that these approaches are advocated as serving most and foremost national interests instead of being promoted on external markets.

Agroforestry together with biodiversity-based and organic farming were the most frequently mentioned farming systems in the policy documents. Hence, the type of public goods identified from this analysis as policy justifications for ecological approaches could be used to justify supporting a larger set of ecological farming systems besides organic farming, and therefore contributing to the further development of ecological agriculture.

Finally, the types of policy discourses identified in this analysis could provide useful information for future research to investigate whether policy goals fit farmers' personal objectives and whether this, in turn, influences farmers' adoption of ecological approaches. This may prove particularly relevant given the delivery model of the CAP 2023-2027, with increasing flexibility given to Member States to devise their strategic plans covering all CAP measures.

8.3 How have past and current policies encouraged/discouraged the adoption of ecological approaches?

Against the background of the ambitious goal of the EU to achieve an increasing uptake of ecological approaches in its farming sector, it is crucial to assess how past and current public policies and governance systems implemented in the EU have affected the adoption of ecological approaches and the performance of ecological agriculture at the farm, farm-group and territorial levels. Various studies have been carried out in the LIFT project to contribute to this question, adopting various approaches (econometric analyses, meta-analysis, treatment effect analysis, bio-economic model, regional CGE model) (Védrine et al., 2021).

While payments for ecosystem services (PES) are major instruments available to governmental or private organisations to support the conservation of ecosystems that provide environmental services, their implementation is very heterogeneous. In this context, it is necessary to identify how the design of a PES affects its success. In this respect, the meta-analysis performed in LIFT is the first to analyse the impact of PES-schemes design on both their effectiveness, measured as the probability to increase ecosystem service provision, and their efficiency, assessed based on the level of additionality. We show that these two possible measures of PES performance are driven by different characteristics of PES schemes, including contract length, reference design and payment constraint. Furthermore, the monitoring system in place to ensure compliance, both in terms of by whom and how often it is performed, appears as a key driver of performance of PES. We show that regular third-party monitoring is more conducive to increased ecosystem service provision compared to one-off internal monitoring. Our meta-analysis also shows that contrary to common expectations, result-based payments are not more efficient than practice-based payments.

As regards empirical assessments carried out in LIFT, results highlight some drawbacks of currently implemented schemes, namely that current CAP subsidies received by farmers may reduce the technical efficiency of extensive farms, suggesting that the current type of subsidies may not be adequate for extensive technologies. In terms of pesticides management, the results put in perspective that the secondary benefits from crop diversification, besides pesticides reduction, could be important for farmers by way of decreased productivity loss. In addition, farmers' incomes are not affected by their ecological practices, once the extra cost of these practices has been covered by the subsidy or promote some efficiency gains. The real cost of the transition is therefore on average well compensated by these payments. Our results also advocate policy compensation schemes that take into consideration the income forgone, given the regional potential, both in terms of agricultural production and environmental endowments.

8.4 What innovative approaches to policy design to increase the uptake and performance of ecological approaches?

In 2020, 13.5% of total UAA in EU-27 were enrolled in an AECM[5]. Given the increased focus on environmental targets, increasing the participation of farmers in AECM and other voluntary approaches, publicly or privately financed, is crucial. Innovative approaches may prove useful to increase adoption of ecological approaches. They are defined here as strategies that have not, or only scarcely, been implemented, including public subsidies based on results (individual or collective) or

[5] https://agridata.ec.europa.eu/extensions/DashboardIndicators/Environment.html?select=EU27_FLAG,1 accessed online March 29th 2022

private financing of ecological approaches via PES. These strategies have been investigated in LIFT (Legras et al., 2021).

8.4.1 Results-based approaches

Results-based approaches, as opposed to practices-based or inputs-based ones, have received increasing interest in the policy arena. Since farmers or land managers receive payments for the delivery of specific environmental outcome, they have greater flexibility about the means to reach this outcome. Examples of results-based approaches in Europe include the Humus-Program in Austria, the mosaic perennial crops schemes in Spain and the Burren Programme in Ireland. However, the small number of examples of implementations of such approaches makes it difficult to evaluate in a systematic manner their efficiency as compared to input-based strategies.

Stakeholders engaged in LIFT activities expressed concern about results-based approaches, owing to the inherent uncertainty associated with the provision of environmental outcomes due to weather conditions, for instance. They also expressed scepticism about the ability of assessors to accurately measure improvement in ecosystem service provision due to farm management. The study of the Barren programme confirms the crucial role that the monitoring system plays in the success of a results-based approach. Advisors have played a major role in providing technical assistance about potential ecological approaches to implement, monitoring and assessing environmental improvements in direct link with the farmers.

8.4.2 Collective-based approaches

The EU Rural Development Regulation 1305/2013 introduced the possibility for agri-environmental subsidy (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). Environmental rationales for collective-based approaches include the spatial dependency between biological processes, that necessitate targeting of enrolled parcels, and threshold effects, for which a given participation rate is needed to ensure the attainment of the environmental target. Behavioural factors such as peer effects have also been put forward as interesting features of collective-based approaches that may increase participation.

Stakeholders engaged in LIFT activities 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. 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 grassland management. Besides the environmental context, our results show that the careful design of the collective-based schemes is paramount to ensure their success.

We also showed a large heterogeneity in farmers' willingness to participate in collective-based schemes. Whilst further work is needed on the determinants of this willingness to participate, the country of residence is an important factor. This echoes other LIFT results, and further supports the interest in investigating the future strategic plans in the next programming period of the CAP.

8.4.3 Mixing/piling up of measures

The future eco-schemes, financed under the first pillar of the CAP, widen the portfolio of voluntary schemes proposed to farmers to facilitate the uptake of ecological approaches. Indeed, besides publicly financed schemes, under the two CAP pillars, there is an increasing interest for, and use of, PES by the private sector directed to farmers. Whilst there is still uncertainty about how the Member States will make use of this new instrument, stakeholders engaged in LIFT activities expressed some concerns about how the piling up of measures might deter/encourage participation of farmers. Eco-schemes were perceived as useful to maintain ecological practices, AECM were considered as useful tools for transitioning from one farming system to another, and PES were viewed as filling in policy gaps. As the objective of reducing agriculture's contribution to greenhouse gas emissions gains momentum, the question of competition between already functioning PES and potential eco-schemes or AECM may arise.

9 Role of stakeholders in the development of ecological agriculture

9.1 Involvement of stakeholders in co-creation of knowledge

Intense interactions with stakeholders within the LIFT project further confirmed the importance of co-creation of knowledge. Involvement of stakeholders with various backgrounds and representing different groups allows to ensure a complex understanding of an issue based on transdisciplinary approach. Ecological farming in this sense is especially sensitive, as understanding of practices and approaches from the standpoint of different stakeholder groups varies.

While the fundamental research introduces increasingly more definitions and classifications for ecological approaches in farming, for the majority of stakeholder groups their practicality and transfer to either policy dimension or on-farm implementation are most important. In this sense the research outputs need to be suited to the needs of particular stakeholder groups, which would be the boost of adoption of ecological approaches, both by being incentivised based on the top-down approach, as well as being tested, verified and implemented on a large scale on the farm level, thus giving the necessary feedback about the performance and effectiveness of such approaches.

Understanding of the need to intensify implementation of ecological approaches in farming does exist among the stakeholders, especially on the farm level. Yet there are issues that still withhold many of farmers from adoption of such approaches, as highlighted in the LIFT project (see previous sections). These affect both the adoption rate and performance of ecological farming, despite clear understanding of its environmental benefits.

Within the conducted research in the LIFT project, numerous stakeholder groups were targeted and engaged in activities, which included farmers, farmers' representatives (unions, farm producer groups), agricultural advisors, value chain actors (processors, wholesalers, retailers), other economic actors (producers of inputs, banks, insurance companies), policy-makers, government and local self-administration representatives, citizens' associations and non-governmental organisations (NGOs, as well as consumers. While these groups differ, there is an understanding of goals set in the European policies, including the European Green Deal, and the determination to encourage the adoption of ecological approaches in farming or supporting such transformation.

In LIFT, stakeholders' engagement was crucial as regards the development of the LIFT typology and LIFT typology-tool (section 3), the design of the LIFT adoption-tool (section 4), the analysis of territorial socio-economic impact of ecological farming through Delphi exercise and Q-methodology (section 6.2), and the assessment of territorial sustainability (section 7.2).

9.2 Stakeholders - practitioners implementing the knowledge

Farmers are the practical implementers of farming practices, thus it is important to prepare research findings in a suitable and understandable formats. Close cooperation of researchers with agricultural advisors seems to be a perfect synergy to transfer the new knowledge about environmentally-friendly farming practices. Performance of such approaches needs to be conveyed to farmers, as there are still many prejudices, which hinder intensification of adoption in particular countries. By bringing different groups of stakeholders together and establishing exchange of views, it is possible to clear doubts and support the adoption of ecological approaches by farmers.

Studies showed that financial incentivisation for implementation of ecological approaches still plays a key role in perception of farmers. While such incentivisation is a part of the upcoming CAP in order to work toward climate-neutral, environmentally and biodiversity-friendly agriculture, there is a need to also search for other forms of incentives, as expectation of financial support affects the rate of adoption of ecological approaches, distorting the understanding of the essence of ecological farming and its role for the society. In current conditions financial incentivisation is justified to boost the uptake of ecological farming, yet change in farmers' attitudes and education system will be needed in order to maintain the transformation rate in case of decreasing (whether intentional or forced) EU financial support. In this regard, work on the demand side is also needed to be directed towards the change of consumer habits and increase of healthy food products in the diet, as well as work towards limiting the food waste and food loss.

In this context, LIFT outputs have been, and continue to be, transferred to stakeholders through various means, including EU-wide webinars, local dissemination in national languages (via workshops, newsletters, leaflets), as well as Ecological Fact Sheets[6], summarising the key facts of ecological farming and LIFT findings in LIFT case study areas and policy brief. In addition, a free MOOC has been developed to disseminate LIFT findings and methodologies[7]. The LIFT MOOC allows stakeholders to learn about ecological approaches to farming and exchange opinions among platform users. The LIFT MOOC contains nine modules grouped in four major topics: LIFT typology; drivers of adoption of ecological pratices; drivers of performance; and policies supporting the development of ecological approaches in agriculture. In addition, a forum module has been created allowing users to discuss and ask questions, as well as a webinar serie module to go further with a case study. Innovative learning methodologies are used in the LIFT MOOC: short videos, serious games, multiple-choice questionnaires, slideshows, quizzes to self-assess knowledge, some testimonies, key figures, and simulators. The LIFT MOOC especially targets students, farm advisors, actors in the food value chain and government agents, but some modules could also be used by any citizen willing to learn more about ecological farming.

For the sake of knowledge co-creation, at least two conditions need to be fulfilled. First, the methods of targeting stakeholders have to be specific for each target group. In LIFT we targeted 1,200 stakeholders divided into 5 groups: (1) farmers and farmers' representatives (e.g. unions, farm producer groups); (2) up- and downstream companies, retailers, other economic actors (e.g. banks); (3) governments and local administration; (4) citizens' associations (with objectives towards environment, communities, etc.); (5) NGOs and consumers. Therefore, different tools were applied to target them (e.g. surveys, workshops, hybrid forums, interviews) and to exploit the knowledge from them (e.g. Delphi, Q method). Second, the interaction between researchers and stakeholders have to

[6] Available at https://zenodo.org/record/6416170#.YlYAJd86_IU

[7] The LIFT MOOC is accessible at https://lms.agreenium.fr/course/index.php?categoryid=56&lang=en

be mutual. It means that, for each specific method of interactions, not only the stakeholders provide inputs but also receive outputs from researchers (see Figure 8 for examples).

DELPHI & Q METHOD

The Delphi method attempts, first, to collect the views and opinions of a number of informed people and, second, to harmonise these views across a panel of experts. Delphi exercise was applied to investigate the views of participants on the development of ecological farming approaches and its socio-economic consequences at a 10 year forward perspective. The Q-methodology presents a Q-set of statements that the Delphi has developed and, through factor analysis, studies the key stakeholder perspectives of the socio-economic effects of the perceived adoption of ecological practices in 10 years in the future.

INPUT FROM STAKEHOLDERS	OUTPUT FOR STAKEHOLDERS
Stakeholders co-designed the future scenarios of adoption of ecological approaches by farms (They characterised **ecological and conventional farms** and defined **patterns of adoption**, on-farm **employment effects** across the study area, employment effects on industries supporting farming, supply chain effects, and effects on rural communities).	Presentations provided to stakeholders inspired them to think and explore the possible agricultural futures for the region and how they fit into that future. **Development of creative and abstract thinking (cognitive skills).**

HYBRID FORUM

The hybrid forums can be described as public discussions with the aim of constructing a common project around a defined challenge. By definition, in the heart of Hybrid Forum there are the controversies, because their existence triggers the process of learning and co-producing something new.

INPUT FROM STAKEHOLDERS	OUTPUT FOR STAKEHOLDERS
Each workshop leader had to find a **controversies** to explore, for that reason the topics vary in each case study report. **Example: Is ecological farming profitable?**	What is at stake for the stakeholders is not just expressing oneself or exchanging ideas, or even making compromises; it is not only reacting, but constructing. In our case it is equivalent to **co-production of knowledge.**

LARGE-SCALE FARMER SURVEY

A large-scale farmer survey was carried out in the LIFT project, collecting information from 1,628 farms across LIFT case studies areas in 12 European countries. The survey collected primary qualitative and quantitative data at the farm level and that data that is comparable across a large geographical area, across different production sectors, as well as across different farming practices/systems.

INPUT FROM STAKEHOLDERS	OUTPUT FOR STAKEHOLDERS
The information gathered relates to the **practices used on the farm**, the **drivers behind the adoption** of these practices, the **farm's structural and economic characteristics**, the on-farm **labour force**, the farmer's feeling towards future agricultural policies and general characteristics of the farmer and the farm.	**The MOOC platform** (Massive Online Open Course) - it allows stakeholders to learn about ecological farming and exchange opinions among platform users. **LIFT Typology Tool** - helps the stakeholders to categorize their farm in the LIFT typology. **LIFT Adoption Tool** - serves to predict the degree of ecological practice adoption of a farm.

MULTI-CRITERIA ANALYSIS

The application of a participatory Multi-Criteria Analysis developed an ex-ante impact assessment for improving the knowledge about proposed policy instruments to address the barriers to the adoption of agroecological practices and to the necessary changes in the governance dimension of the farming systems in the 15 case study countries.

INPUT FROM STAKEHOLDERS	OUTPUT FOR STAKEHOLDERS
Stakeholders in case studies assessed and ranked policy instruments according to pre-determined objectives and criteria enabling co-learning about different preferences and the potential of policy instruments to address barriers of transitions to agroecology. The criteria were developed through a consultation with European-level experts in policy implementation and evaluation.	Improved understanding of the expected **performance and relevance of the policy instruments** with respect to transitions to agroecology. Enhanced capacity of stakeholders to assess **synergies and conflicts among policy instruments** and to identify the most innovative instruments to support the agroecological transition.

Figure 8. LIFT stakeholders' specific co-creation of knowledge in LIFT

9.3 Stakeholder interactions and communicational constraints

An important aspect of stakeholders' involvement in knowledge co-creation are the formats and intensity of interactions. A major communicational constraint arose in the form of the COVID-19 pandemic in 2020, which to some extent distorted the previously functional communication channels with stakeholders, thus hindering the information flow and knowledge transfer.

Pre-COVID, interactions with stakeholders took the form joint events with numerous participants and support group learning and mutual exchange of information, also enabling to create bonds between various stakeholders and their groups. Interaction formats included written consultations, personal interviews, interactive sessions in project meetings, workshops with different participatory methods, focus groups and other. The response ratio was relatively high, with most targeted stakeholder groups being responsive and ready to cooperate.

Stakeholder interactions during the COVID-19 pandemic were highly affected in the first months, yet in the following months both the stakeholders and researchers successfully adjusted to the situation. The use of distance communication tools increased the participation in research for some groups of stakeholders (isolated farmers were, by contrast, disfavoured in this respect). Despite this adjustment and the possibility to achieve planned project objectives, stakeholder communications, especially between various groups of stakeholders, were highly affected. This showed the importance of unconstrained communication and networking among the stakeholders and their groups, which allows them to understand issues of each other and adjust in order to achieve the mutual goal. The interaction formats implemented during the COVID-19 allowed fruitful communication between researchers and stakeholders, but communication and exchange of knowledge between stakeholders themselves were hindered to a large extent. This is caused by the fact that most activities were organised virtually, which needed shorter presentations, more frequent breaks, little possibility of informal discussions, active engagement of fewer stakeholders, fewer discussion topics per event, need for reading materials to be sent to participants before the event and difficulties in implementing new elements during the meetings. Overall, these constraints also affected the openness and readiness of particular stakeholder groups to participate in joint events. Thus, farmers were less willing to participate, and even less – to voice their opinions, while on the other hand, the government representatives or policy-makers were still open and willing to actively interact. These experiences show the need to adjust to circumstances and take them into account to make sure no stakeholder group is left behind. This applies especially to the farmers, who are among the key target groups and practical implementers of ecological approaches.

All in all, we can observe that COVID-19 had more negative than positive impact on empowerment of the stakeholders. First, that is due to less mutual interactions among the stakeholders, second due to limited formats of the interactions (pre COVID-19 both printed and electronic materials were possible). Those limitations impacted the overall return ratio from the stakeholders and also affected the openness (some stakeholders were afraid of being recorded, or afraid of talking if some people were hiding behind avatars, etc.). The only aspect not affected was the electronic materials because those were used before, even during the real events. Second, we can see that in terms of impact on stakeholders' empowerment, the stakeholders were more affected by limited output than from lower provision of inputs. As for positive aspects in terms of inputs, the stakeholders provided ready-to-use electronic data for research, which was of better quality because no mistakes were done during hand writing. Besides, quite often also the number of stakeholders involved was higher, as those who could not travel before could now join the meetings. However, those stakeholders with better internet connection and more skilful in internet communication were often invited, and therefore there may be a selection bias in terms of age or education.

10 Recommendations

The numerous findings and outputs generated in the LIFT project gave rise to several recommendations as regards the development of ecological agriculture in Europe. These recommendations are listed here in terms of policy recommendations, and data and future research needs.

10.1 Policy recommendations

- In terms of policy measures, **policy should provide larger flexibility under a common EU wide framework** to adjust measures promoting ecological approaches to the regional context and to best support farmers to adapt to new conditions. In other words, LIFT findings support the need of **targeted interventions to encourage and support transition** as a way to manage the heterogeneity within current EU farming. It is also recommended to **consider that environmental performance at the territorial level is context-dependent and ecosystem service demand-dependent**, when identifying which management practices are most favourable to target environmental objectives.
- The typology approach emerges as a useful tool to baseline and monitor progress towards a policy goal. Continual monitoring of change through annual surveys, e.g. the FADN outlined above, would provide a powerful tool for understanding change in these farmers. In this context, **current EU monitoring and evaluation frameworks should be geared to a better consideration of the different agroecological dimensions** constituting the typology. For instance, the LIFT Low-input farming score is conceptually and methodologically aligned to the current "Farming Intensity" CAP Context Indicator. The latter can be refined and improved along the lines outlined in the typology. Similarly, synthesis indicators informing on the degree of internal circularity of EU farming like the one used on the typology are missing. An adoption of such indicators can be useful in monitoring the dependence of EU farms on external inputs, a potentially vulnerable aspect of the EU agricultural systems, as the recent crisis in Ukraine has highlighted.
- The **development of the FADN into the FSDN** is an unprecedented opportunity to boost the monitoring and evaluation capacity of the European Commission. Efforts should be put into this process to maximise the added value of this activity. There is now a consolidated body of research on potential and limitations of the FADN as a tool for assessing the environmental sustainability of EU farms that should be used. Consultation of stakeholders during the process is key too. Efforts to fill the data gaps can be significantly reduced by putting together in a common framework information already collected from different sources: this includes information available in the IACS, the LPIS, and indicators of the Performance and Monitoring Evaluation Framework of the CAP.
- Ecological farming practices likely increase on-farm labour needs and can negatively impact the economic performance of farms. **Higher incentives to maintain economic returns** (such as environmental payments), reflecting regional conditions, might therefore be warranted to stimulate a wider adoption of ecological farming practices. Labour market policies should seek to decrease transaction costs for farmers when hiring/firing farm labour to **allow more flexible adjustments of hired labour**, however without jeopardising the working conditions of hired labour which is often precarious and low-waged.

- Based on the above, also **innovation is a key area of intervention in order to escape the strong trade-offs between environmental and economic sustainability**; innovation needs to be made more effective through systems approach linking incentives, innovation and education and by further linking innovation measures with sustainability objectives.
- A **balanced use of a mix of different policy tools is needed**, including collective and result-based payments, as well as value chain contracts; in addition, an appropriate mix of regulation and incentives might be needed for specific areas of intervention.
- Connection **between policy measures and market strategy** on a regional level is also key for the success of ecological agriculture.
- One of the **main motivators for constraint in adoption is the supply chain**. The Farm to Fork Strategy is more explicitly moving towards engaging the supply chain and this may support greater engagement to ensure ecological identities emerge.
- It is important for policy design **take into consideration that spatial clustering** is a prominent feature of ecological farming systems and practices, although perhaps not as universal as commonly presented - especially at the local and regional scales and modulated by crop, system, and geographical context. Agricultural policy should be designed to promote an increase in the rate and clustering of ecological practice adoption to achieve territorial sustainability goals, with the rate of ecological practice adoption to be regarded as a priority over increasing the clustering of adoption.
- Quality organisational support and advice, along with accessible technologies for farm assessment and communication, in order to **increase the dissemination of information on ecological practice performance among farmers**, should be a priority for cost-effective interventions to improve farm and territorial sustainability performance. Also, **agricultural education** should adjust its curricula to cover the broad skill set necessary for the implementation of ecological approaches to farming, in order to encourage a successful adoption of ecological technologies, especially to decrease costs of their adoption or even enable increased economic performance. Besides specific skills, also transversal abilities are more and more important for the development of a mindset capable to translate in more effective business models based on ecological agriculture
- **Interactions with stakeholders are necessary for higher acceptance of "greening" the EU policies. However, those interactions need to be mutual** - knowledge taken from the stakeholders as inputs needs to be exploited and to come back to them as output from researchers. That is the way of co-creation of the knowledge. The LIFT adoption-tool and LIFT typology-tool are examples where input came from data collected via surveys to farmers and to stakeholders, and researchers exploited the data with their knowledge into the practical tools, which are the outputs for the farmers and stakeholders. The tools enabled the farmers and stakeholders to use their knowledge in the way that they would not be able to create themselves alone, even though they had the data before.
- **Co-creation of knowledge has to be stakeholder-specific**. Each group of stakeholders requires different and suitable participatory approach; and the targeting matters also because the outputs need to be suitable as well.
- **If we want to make a transition towards ecological approaches, stakeholders need to have incentives for the change**. There is a need for consistent interactions between researchers cooperating with policy makers (who set up the targets and linking of the payments to certain

ecological approaches), then advisors (who, being the closest to the farmers, can explain how farmers should implement the ecological approaches), and farmers or other stakeholders (who need to understand how they can benefit from the change).

- **Incentives for stakeholders are needed to keep them involved in research projects and stay active in co-creation**. One of such incentives is empowerment. Stakeholders need to feel they have impact, that their opinions matter and that they have a real "power" to contribute to the policy and research. However, the difficulty is that there is a difference between business lobbying and stakeholders' involvement. The latter not always allows direct impact, it is more influence for indirect and forward-looking changes. Hence, it is important to empower stakeholders via such tools like voting, participation in public consultations, etc.

10.2 Data and research needs

- In the frame of the development of FADN into the FSDN, it is pivotal to envisage the **collection of data on farming practices currently not covered**, mainly regarding soil management techniques and biodiversity. This regards in particular data on tillage management, soil cover, crop rotation, organic fertilisation (including with animal manure) and presence of landscape features. On the input side, physical quantity of chemical fertilisers has been collected since the accounting year 2014. This is a major advancement, but the reliability of such data and their consistency should be improved. Lack of more detailed and informative data on the use of plant protection products stands out as one of the main data gaps, that should be filled in view of the objectives of the new CAP and the targets set by the Farm to Fork and the Biodiversity Strategy 2030.
- The **addition of attitudinal questions to the FADN** would help to provide a robust baseline for understand the different types of farmers and their approach to ecological approaches. Moreover, their inclusion in annual FADN assessments would allow monitoring of progress and change within these types to understand change.
- The acceptance and robustness of the proposed LIFT typology and associated protocols would be enhanced by **expanding the pool of experts and stakeholders contributing to the definition of the typology protocol** (namely scores, weights and thresholds currently adopted). The proposed frame allows to be flexibly adjusted to this regards without major changes to its core structure.
- **Understanding how farmers view bundles of practices** could be further investigated. At present we rely on voluntary adoption of practices but if packages of practices were promoted, it would be interesting to understand whether certain practices are easy or hard to integrate within the farming systems. Thus, if we are to meet goals around a sustainable agricultural system, but also meet requirements which respond to climate and biodiversity emergency, then bundles of practices would be more effective.
- **Cultural ecosystem services related to farm management practices** are severely understudied, both at small (farm-level) and large (territorial-level) scales.
- The living labs approach will be promoted through the next Horizon Europe call, however these tend to reflect the coalition of willing partners and could lead to biased information for policy making. **Understanding how to engage farmers in living labs** who start from the perspective of disinterest towards ecology and the environment is key to ensuring successful engagement in these schemes.

- **Attention should be provided to workforce composition on farms (gender, number of workers, use of hired workers)** in order to understand and support the changes in on-farm working conditions induced by the adoption of ecological practices.
- On-farm working conditions depend on many factors, and not only on the degree of adoption of ecological approaches, such that no clear picture emerged from the LIFT analyses. **Further understanding the drivers of on-farm working conditions and their interactions** is necessary, such as the time since the start of the ecological transition, the type and the combination of ecological practices used, farmers' own attitude or objectives, their skills and attitude toward experimenting.
- There is evidence that the adoption of ecological approaches drives up on-farm labour use. Further research should therefore provide **a comparative study of best practices in farm labour use in the EU**: i) in the area of employment law concerning agriculture to provide policy insights on how to build more flexibility in the market for hired farm labour and ii) in the area of agricultural education and practical training.
- More studies on the **clustering (or randomness and dispersal) of ecological farming systems** beyond organic farming (e.g. agroecology, regenerative agriculture, etc.), especially at the international and national levels, are needed to inform different targeting and dissemination policies. More generally, more research is needed on **spatial patterns in the adoption of particular practices** since different practices have their own spatial distribution and patterns of adoption, often with regional and or local characteristics, and aggregated analysis might provide conflicting results.
- Further research is needed to expand the study of **socio-economic impact of ecological farming to more countries across and beyond Europe** to increase the generability of the results.
- Within country level, the generability of the findings of **perceptions on the socio-economic impacts of ecological farming outlined by farming experts could be further improved by a large-scale survey** with a representative sample from the interests groups.
- An **assessment of the quality of results of primary studies in Europe that look at the impact of farm management practices on ecosystem services** is needed, as there are few evidence syntheses following recognised guidelines for good-practice. Furthermore, more attention should be paid to reporting standards and improving quality of evidence syntheses in environmental performance studies in Europe.
- Future research should prioritise **reconciling the assessment framework used in LIFT for territorial sustainability with farm-level sustainability assessments**. This would depend on being able to express ecological farming adoption at the landscape scale in terms of the combination of assessed ecological practices being adopted at the farm level. If this challenge can be overcome, the resulting multi-scale assessment would help to identify possible areas of alignment or disconnect between sustainability performance at the farm and territorial level.
- More rigorous, quantitative, survey-style **research on stakeholder preferences / prioritisation of territorial sustainability objectives** could be used to assign weights to sustainability objectives, and therefore provide a way to compare different scenarios using this assessment framework, especially when trade-offs between performance against different objectives occur.

- Research on farm performance should consider the distribution of performance and the possible **generation of spatial, temporal and social inequalities through the adoption of ecological framing approaches**. The methodological challenge is to integrate equity and inequality, and to engage a policy dialogue on how to achieve an equitable transition.
- In order to benefit fully from ex-post policy evaluation to inform future policy design, it is key to **anticipate data requirements at the early stages of policy design, or implementation**, by ensuring dialogue between researchers and policy makers early in the process.

11 Conclusion

The LIFT project's objective was to contribute to knowledge on the development of ecological agriculture, the latter being understood as a broad range of farming systems, in Europe. Based on numerous analyses targeting different issues and levels, a mix of methodologies, secondary and primary data, and a strong involvement of stakeholders, the research activities carried out in the LIFT project showed that there is a strong potential to develop ecological farming on a large scale in Europe, and highlighted several key areas to be addressed by policies and future research.

In order for agroecology or other ecological farming systems to be impactful, they need to become 'mainstream'. This requires an ecological transition of the whole European farming sector, covering not only farms in specific contexts already open for such change, but also standard farms. The analyses and tools developed in LIFT inform policy-makers whether ecological farms perform differently and have different trade-offs and synergies than standard farms. While this is an important step, further targeted policies, further research and further development of databases in this direction are needed to realise broad adoption of agroecology in Europe.

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