LIFT

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

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

LIFT farm typology developed, tested and revised, and recommendations on data needs

Carlo Rega[1], Bethan Thompson[2], Riccardo D'Alberto[3], Andreas Niedermayr[4], Jochen Kantelhardt[4], Penelope Gouta[5], Vasilia Konstantidelli[5], Irene Tzouramani[5], Yann Desjeux[6], Laure Latruffe[6], Larissa Billaudet[7], Maria Luisa Paracchini[1]*

[1]JRC (Italy), [2] SRUC (United Kingdom), [3]UNIBO (Italy), [4]BOKU (Austria), [5]DEMETER (Greece), [6]INRAE (France) [7]VetAgro Sup (France),

* Deliverable leader – Contact: maria-luisa.paracchini@ec.europa.eu

DELIVERABLE D1.4

Workpackage N°1

Due date: M38

Actual delivery date: 30/06/2021

Dissemination level: Public

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

About the LIFT research project

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

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

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

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

Project consortium

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

Table of contents

List of acronyms and abbreviations

CA: conservation agriculture
CAP: Common Agricultural Policy
COP: cereals, oilseeds and protein crops
EC: European Commission
EU: European Union
DG AGRI: Directorate General Agriculture
EFA: Ecological Focus Area
ENRD: European Network for Rural Development
FADN: Farm Accountancy Data Network
FSDN: Farm Sustainability Data Network
GAEC: Good Agricultural and Environmental Conditions
GDPR: General Data Protection Regulation
GHG: greenhouse gas
GMO: Genetically Modified Organisms
ha: hectare
HNV: High Nature Value
ID: (Farm) Identification number
IACS: Integrated Administration and Control System
JRC: Joint Research Centre
kg: kilogramme
LPIS: Land Parcel Identification System
LU: livestock units
MOOC: Massive Open Online Course
MS: Member State
N: nitrogen
NUTS: Nomenclature of Units for Territorial Statistics
SMR: Statutory Management Requirements
TF: Type of farm
UAA: Utilised agricultural area
UK: United Kingdom
WP: workpackage

1 Summary

This Deliverable 1.4 (D1.4) presents the final version of the LIFT farm typology developed in WP1, together with a system of rules to assign individual farms to one or more of the categories defined in Deliverable 1.1 (Rega et al., 2018). These sets of rules, together with the set of data on farming practices to which they apply, have been named "Protocols". The typology is defined as a combination of two main elements: type of farm and farming approach. The type of farm characterises the farm in terms of main production and specialisation and uses the nomenclature defined by Eurostat. The farming approach is a classification applicable to individual holdings based on their type of management, assessed from an ecological perspective. Classifying farms according to a defined typology is a necessary step in LIFT project, in order to carry out subsequent statistical analyses and investigate drivers and obstacles in determining the adoption of ecological farming practices, or to study environmental performances vis a vis other socio-economic aspects. Farming approaches have been identified considering four main ecological dimensions of farming: i) soil conservation; ii) overall input intensity; iii) internal integration and circularity; iv) ecological infrastructure. Building on these, six main farming approaches have been defined: 1) Standard farming; 2) Conservation agriculture; 3) Low-input farming; 4) Integrated/Circular farming; 5) Organic farming; 6) Agroecological farming. Standard farming is mutually exclusive with respect to the other five farming approaches, while the latter are not mutually exclusive.

The protocols are devised as scoring systems whereby individual farms are assigned scores based on a set of examined items. Two main protocols have been developed, one based on microdata from the Farm Accountancy Data Network - FADN (FADN-based protocol) and one using the LIFT large-scale farmer survey (Survey-based protocol). In the FADN-based protocol, considered variables mainly represent costs incurred by farmers for different production inputs. Original FADN data were processed to make them comparable across countries and time by using Eurostat official adjustment coefficients for inflation and price levels across countries. Scores are based on the values that adjusted variables at the individual farm level assume, based on the range and distribution of such values in farms belonging to the same farm type across the entire European Union (EU). In the Survey-based protocol, a set of items from the LIFT large-scale farmer survey representing the level of adoption of farming practices are assessed using expert-based scores. Individual scores are then combined through a system of rules and weights to obtain final synthetic scores for each of the above mentioned farming approaches. The FADN-based protocol allows to assess the belonging of individual holdings to Low-Input farming, Integrated/circular farming, Organic farming and, based on these, on Agroecological farming. The Survey-based protocol enables to evaluate with greater detail the belonging to each farming approach and their combination. The developed protocols here are the results of an interactive and iterative approach where feedback from the pilot application of earlier versions by project partners were used to incrementally refine the protocol. The work on the FADN data also led to the identification of the main data gaps currently present in this database with regard to its use as an environmental sustainability evaluation tool. Suggestions to improve it are made, in the framework of its proposed transformation into a Farm Sustainability Data Network (FSDN).

2 Introduction

The main goal of LIFT WP1 is to develop a farm typology – defined as a classification system labelling clusters of farms having similar characteristics – and a protocol, defined as a set of rules to classify individual holdings according to the typology, using selected farm-level data and indicators. The typology is describing the ecological aspects of farming, and is therefore associated with the adoption of certain farming practices that are considered to have positive environmental effects, or reduced negative environmental impacts compared to conventional management. The LIFT typology aims to cover the whole continuum of farming approaches, from the most conventional to the most ecological ones. It therefore includes the widest range of ecological practices and considers the different aspects and dimensions of farming and management strategies in a holistic frame, rather than focussing on specific practices or approaches. Classifying farms according to a defined typology is a necessary step in LIFT project, in order to carry out subsequent statistical analyses and investigate drivers and obstacles in determining the adoption of ecological farming practices, or to study environmental performances vis a vis other socio-economic aspects.

A first proposal of farm typologies was put forward in D1.1 (Rega et al., 2018), elaborating on the result of a systematic literature review. A refined version of the typology was presented in D1.3 (Rega et al., 2019) finalised in August 2019, integrated with: i) a pilot analysis on the link between farming practices and farming systems carried out on three types of farm in different geographic contexts; and ii) an evaluation of the suitability of existing European Union (EU) databases to identify potential available information usable to characterize farming systems, based on the analysis carried out in Milestone MS2 (Rega and Paracchini, 2019). As a result, the Farm Accountancy Data Network (FADN) was identified as the most suitable EU-wide dataset for the elaboration of the protocol. In parallel, a second protocol has been developed based on the LIFT large-scale farmer survey questionnaire (D2.2, Tzouramani et al., 2019). Feedback on the typology from relevant stakeholders in different parts of the EU was collected in task 1.2, and the results were presented in D1.2 released in February 2020 (Bigot et al., 2020) and have informed the final version of the typology. The concept and the approach for the elaboration of the protocols have been described in Milestone MS3 (February 2020) (Rega et al., 2020a).

The present deliverable is structured as follows: in section 3, the LIFT farm typology is briefly summarised and the concepts and relationships between each category – labelled **farming approach** – are summarised. Farming approach is defined here as a classification applicable to individual holdings based on their type of management, assessed from an ecological perspective. In section 4.1, the main principles of the protocols are explained; in sections 4.2 and 4.3, the general structure of the FADN-based protocol and the Survey-based protocol, respectively, is presented. In sections 4.4 and 4.5 the different protocols are described more in details. In section 5, we report on testing and application of earlier versions of the protocols in different case study areas, and how the feedback informed the final elaboration. In section 6, we discuss the potentials and limitations of the two protocols, and we put forward some suggestions ensuing from the elaboration of the FADN-based protocol to improve the collection of FADN data in view of its transformation it into a Farm Sustainability Data Network.

3 The LIFT farm typology – concepts and rationale

3.1 Conceptualisation of the typology

The LIFT farm typology is a classification system applied to individual farms, based on identified key characteristics of their farming management strategies and adopted farming practices.

The main requirements of the typology can be summarised as follows:

- It shall be applicable to all types of farms, regardless of their specialization, size, location or other characteristics.
- It is strictly based on the ecological aspects of farming. It is acknowledged that other aspects (social, economic) are relevant and can affect the adoption of ecological farming practices.
- It shall cover any intermediate farming approach between the least ecological and the most ecological ones.

The typology combines two main elements: farm types and farming approaches.

In this context, **type of farm** (or, alternatively, farm types) refers to the specialisation of an individual holding in terms of production. The taxonomy used here is the same defined by Eurostat and used in FADN, laid down by Regulation (EU) No 1198/2014. There, farm types are classified into eight general types (TF8 grouping), furtherly subdivided into 14 groups (TF14 groupings) and 22 principal types, in turn further subdivided in particular types of farms (not shown here). Table 1 shows the TF8 and TF14 groupings.

Table 1: Farm Types classification defined by Eurostat and used in the LIFT Typology (TF8 and TF14 groupings)

TF8 grouping	TF14 grouping
No. and description	**No. and description**
1. Specialist field crops	15. Specialist cereals, oilseeds and protein crops (COP)
	16. Specialist other fieldcrops
	60. Mixed cropping
2. Horticulture	20. Specialist horticulture
3. Wine	35. Specialist vineyards
4. Other permanent crops	36. Specialist orchards - fruits
	37. Specialist olives
	38. Permanent crops combined
5. Milk	45. Specialist milk
6. Other grazing livestock	48. Specialist sheep and goats
	49. Specialist cattle
7. Granivores	50. Specialist granivores
8. Mixed	70. Mixed livestock
	80. Mixed crops and Livestock

The **farming approach** refers to the way the farm is managed with regard to ecological aspects, and therefore it is linked to the adoption of specific practices at the field or farm level. Farming approaches have been classified on the basis of the four dimensions linking agronomic management to ecological performance, based on the results of the literature review carried out in D1.1 (Rega et al., 2018 and references therein) and further elaborated in D1.3 (Rega et al., 2019) These are:

1. Soil conservation
2. Overall input intensity
3. Internal integration and circularity
4. Ecological infrastructure

Agroecosystems are complex systems embedded in broader socio-ecological systems. As such, all different aspects characterising them are to some degree interrelated (e.g. the degree of soil conservation is linked to the overall input intensity) and the four dimensions listed above are no exception. This consideration notwithstanding, we maintain that for analytical purposes, these dimensions can be examined relatively independently from each other and can be associated with specific descriptors (quantitative and qualitative indicators) and/or farming practices. This approach is in line with recent holistic assessment frameworks developed to assess farm performances on the basis of ecological principles, like the TAPE tool elaborated by the United Nations' High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (HLPE, 2019). Furthermore, each dimension can be associated to some extent with farming approaches already recognised and partly codified in literature, policy or legislation. This is deemed important to increase their acceptance by stakeholders and potential users of the typology. In the following, the four main dimensions are described more in detail.

The aspect of **soil conservation** refers to all the practices that preserve the physical, structural and biochemical characteristics of the soil as a support for long term agricultural activity. This includes in particular, the prevention or minimization of degradation processes such as soil erosion or compaction, as well as the maintenance of the adequate level of soil water retention capacity, soil organic matter and more in general the preservation and enhancement of soil fertility in the long term. The key farming practices that are associated with this dimension include reduced tillage management, crop rotation and diversification and maintenance of soil coverage throughout the year.

Overall input intensity refers to the total quantity of intermediate inputs used/consumed in the agricultural activity over a certain period of time (one year or a growing season) and usually normalised to a relevant unit (e.g. hectare of utilised agricultural area – UAA or standard livestock unit – LU[1]). The main production inputs considered here are fertilisers (either mineral or organic), plant protection products, machinery, energy and fuel, feed, seeds, water for irrigation and equipment and tools. Human labour is not included as here the focus is on inputs that determines a direct or indirect environmental impact, e.g. in terms of resource depletion, pollution, disturbance to ecological processes etc. In terms of farming activities and practices, the following ones are considered: weeds, pests and plant disease management; fertilisation of cropland; grassland management; type of feed used for livestock; livestock disease management; livestock density; water management; use of machinery and total physical assets; energy management and consumption.

[1] Livestock Unit is a reference unit used by Eurostat for the aggregation of livestock from various species and age on the basis of their nutritional or feed requirement. 1 LU is the grazing equivalent of one adult dairy cow producing 3 000 kg of milk annually, without additional concentrated foodstuffs. See https://ec.europa.eu/Eurostat/statistics-explained/index.php?title=Glossary:Livestock_unit_(LSU)

When considering the overall intensity associated with an input type or practice, two main aspects are taken into account:

- The level of environmental pressure that the input/practice may determine on the local environment, e.g. in terms of air/water/soil pollution, potential damage to flora and fauna, soil degradation, hazard for human health or livestock, disposal of waste/by products produced locally etc.
- The level of environmental pressure that the input/practice may determine at a wider (up to global) scale, e.g. in terms of consumption of energy and raw material to manufacture it, depletion of resources, environmental pressure due to transport, disposal etc.

Internal integration, or circularity. This dimension concerns the degree of reliance on input coming from outside the farm vs input produced on farm. This in turn is linked to the contribution of the farm to the closure of key ecological cycles. One of the main aspects of circularity in farming concerns the nutrient cycle, so a typical example of this farming approach is a holding that integrates crops and/or grasslands and livestock into a single system, where grass/hay and part of the crops are used as feed for livestock and part of livestock manure is used to fertilise crops and grasslands. Similarly, a decrease in the dependence on externally manufactured inputs can be achieved for example through the use of compost or sewage sludge as fertilisers. Other aspects that are evaluated to assess the degree of circularity are the origin of seeds and the production of energy on farm through renewable sources (e.g. solar panels). Since the scale of relevant ecological cycles is typically larger than an individual farm, it is assumed that a good level of integration and circularity can be reached not only (or necessarily) at farm level, but also and especially at a wider scale, typically through exchanges with nearby farms or other local subjects.

Ecological infrastructure. Under this dimension, it is assessed the extent to which the agroecosystem can provide habitat to support biodiversity, including both functional biodiversity (e.g. pollinators, beneficial predators, soil microorganisms) and non-functional biodiversity. The functionality of the agroecosystem at this regard is linked to the presence of seminatural elements or landscape features interspersed in the agrarian matrix, like hedgerows, bushes, herbaceous strips, tree lines and single trees, ponds, wet areas etc. Besides supporting biodiversity and insects-depending ecosystem services (pollination, natural pest control), these elements are also important for the supply of several ecosystem services, like carbon sequestration and protection from soil erosion.

The consideration of these ecological dimensions of farming has led to the identification, besides Standard farming, of five main categories of farming approaches. This was done by identifying a detailed list of farming practices and management strategies from literature and associating them with the identified ecological dimensions (Rega et al., 2018 and 2019). The identified farming approaches are:

- Conservation Agriculture (CA)
- Low-Input farming
- Integrated/Circular farming
- Organic farming
- Agroecological farming

and are described as follows.

The set of practices and farming approaches focussed on soil conservation as defined above are often referred to in literature and policy as **Conservation Agriculture** (CA) (Rega et al., 2018). Here, CA is defined as a farming approach aimed at preserving soil structure and long-term fertility, mainly through the adoption on reduced tillage, crop rotation and diversification, and soil cover. CA is now an established farming approach in Europe (Kertész and Madarász, 2014) and it is actively promoted by the European Conservation Agriculture Federation (ECAF; https://ecaf.org/). In the current Common Agricultural Policy (CAP), specific agri-environmental measures labelled conservation/conservative agriculture have been proposed by Member States or Regional Authority (see e.g. the good practice reported by a report of the European Network of Rural Development (ENRD), Meredith et al., 2021).

Low-Input farming refers to farms where the overall level of input is significantly lower than the average level of farms belonging to the same farm type across a certain area of analysis, in this case the whole EU (Rega et al., 2018; 2019 and references therein). Importantly, what is assessed is the aggregate input level considering a variety of faming activities as listed above (fertilisation, pest management, use of machinery, irrigation, consumption of energy and fuel, seeds and plantings) so this category is a priori compatible with the use of specific inputs e.g. synthetic chemical pesticides or mineral fertilisers.

Integrated/circular farming is directly linked to the degree of internal integration and closure of the nutrient cycle as described above, i.e. the level of reliance on internal vs external inputs. Integrated/circular farms are those that are able to produce a significant amount of the production input on the farm and that present a higher degree of closure of ecological cycles compared to the average of holdings belonging to the same farm types. The most significant aspects to this respect include the own production of feed for livestock, manure and other organic fertilisers, seeds and energy (Rega et al., 2018; 2019 and references therein).

Organic farming is intended here as any holding that complies with the requirements defined by Council Regulation 834/2007 and Commission Regulation 889/2008[2]. For crop production, the main requirements include prohibition of the use of GMOs, mineral nitrogen fertilisers and synthetic pesticides; crop rotation with inclusion of leguminous crops and the use of organically produced seeds and propagating materials. The maximum quantity of manure input allowed is 170 Kg N/ha/year. For livestock, the main requirements are that feed shall be of organic origin, natural methods for reproduction must be used, access to outdoor grazing must be granted and total stocking density shall be such as not to exceed 170 kg N/ha/year (corresponding to 2 LU/ha). Landless livestock production is prohibited, except if the farm has established cooperation agreements with other organic operators for spreading surplus manure. Requirements on animal welfare also apply.

Agroecological farming refers to 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): 1) Recycling. Preferentially use local renewable resources and close as far as possible resource cycles of nutrients and biomass. 2) Input reduction. Reduce or eliminate dependency on purchased inputs. 3) Soil health. Secure and enhance soil health and functioning for improved plant growth, particularly by managing organic matter and by enhancing soil biological activity. 4) Animal health. Ensure animal health and welfare. 5) Biodiversity. Maintain and improve diversity of species, functional diversity and genetic resources and maintain biodiversity in the agroecosystem over time

[2] These regulations have been repealed by Regulation 848/2018 entered into force on June 17th, 2018. However, they are used here as reference here as the date of application of the new regulation has been postponed to January 1st, 2022 by Regulation 1693/2020. So, during the lifetime of LIFT, the reference regulations for farmers were those of 2007-2008. For the purpose of the present work, however, the new and the old regulations can be considered equivalent for the farm typology and when applying the protocols

and space at field, farm and landscape scales. 6) Synergy. Enhance positive ecological interaction, synergy, integration, and complementarity amongst the elements of agroecosystems (plants, animals, trees, soil, water). Agroecological farming thus combines, to some extent, all the features of the previous approaches. A distinction here should be made between agroecological farming as intended in the LIFT typology and the broader concept of Agroecology. The latter is defined jointly as a science, a set of practices and a social movement (HLPE, 2019 and references therein). The six principles listed above are part of a wider set of 13 principles that consider the entire food system including aspects such as co-creation of knowledge, social justice and fairness, value chains, diets and cultural values. Importantly, agroecological farming in LIFT can be considered as a subset of the concept of Agroecology *sensu* HLPE (2019) referring to the ecological principles applicable at field and farm level.

The **Standard farming** label refers to any farms that does not present to a significant extent any of the features of the previous classes. This can thus include in practice a variety of situations, the common denominator being that the farm has a medium to low performance in each of the main ecological dimensions described above. This label thus only partially coincides with the predominant use of "conventional farming" in literature, which is generally used in contraposition to organic farming and thus simply encompasses any farm that is not organic. Here, we use Standard farming also to highlight that even farms which do not belong to any of the above-described approaches are anyway supposed to comply to a set of basic environmental requirements comprising, in the EU, the ones defined in the Good Agriculture and Environmental Conditions (GAEC) and Statutory Management Requirements (SMR), which may also evolve in time.

As all classifications of complex domains such as farming, the typology should not be considered as a rigid taxonomy. This means that the classes making it up are not mutually exclusive (except for the standard one) and a single farm can belong to more than one farming approach. Also, belonging to one class does not imply, a priori, belonging to another one (i.e. no farming approach is a subset of another class). In formal terms, the typology can be represented as a system of partially overlapping sets as shown in Figure 1 below. The final typology thus comprises all the possible resulting combinations of farming approaches, e.g. Conservation Agriculture-Low-Input, Organic-Integrated/circular etc. As it will be detailed in the next section, Agroecological farming requires a certain level of performance in all the dimensions, but not necessarily achieving in each of them the same level required to belong to the classes. Furthermore, in the Survey-based protocol, another dimension concurs to the definition of agroecology, namely the presence of seminatural vegetation on farm, not represented in Figure 1 (as not directly associated to a single farming approach). Consequently, Agroecological farming cannot be topologically represented as a defined set like the other approaches, but rather as a region in the space where the probability of being agroecological is higher. This is rendered in Figure 1 with the green region where the colour gradient indicates the probability of being agroecological (the darker the green, the higher the probability). This probability is 1 (i.e. the farm is surely agroecological) at the intersection of the four different approaches, and decreases while moving away from this "core" region.

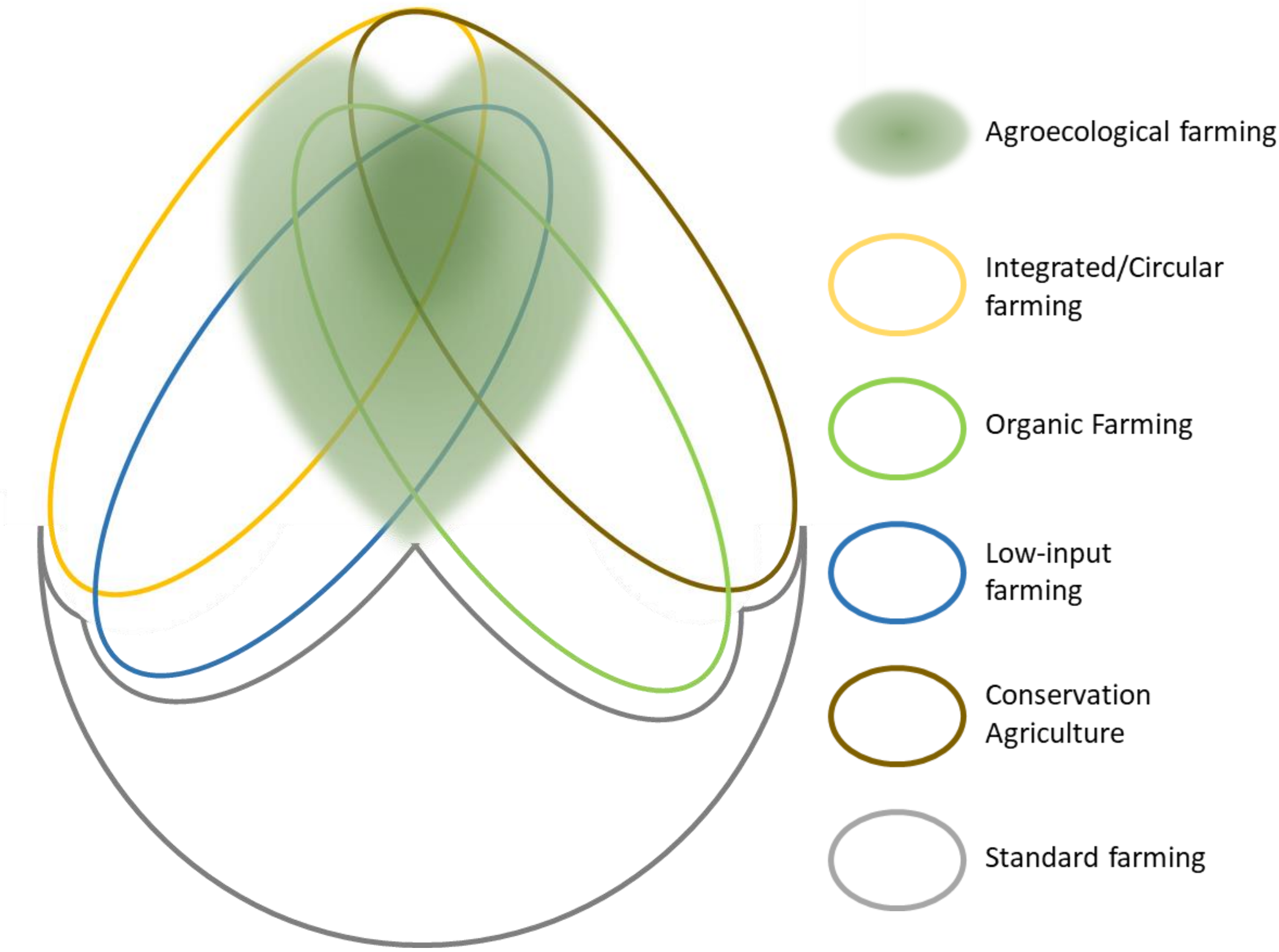

Figure 1: Schematic representation of the farming approaches of the LIFT farm typology

3.2 Relationships between the different farming approaches

As argued, the identified farming approaches Conservation Agriculture, Low-Input farming, Integrated/Circular farming and Organic farming are related to different, though linked, ecological dimensions of farming, while Agroecological farming has a certain level of performance in each of these dimensions. In the following we further elaborate on the relationships between the different approaches, pointing out overlaps and differences.

Whilst *Conservation Agriculture* is aimed at improving the overall environmental performance of farms and can determine lower consumption of certain inputs (e.g. less use of machinery for tillage), it does not imply a priori an *overall* low level of input, nor any degree of integration/circularity or significant presence of permanent landscape features (cover crops and other types of soil covers like crop residues are not considered as such, though they might have a positive effect on biodiversity). As such, it is distinguishable from the other identified approaches.

In the same way, *Low-Input farming* does not imply a priori any degree of integration/circularity, nor the avoidance of specific inputs as required by the organic regulations. For example, an olive orchard can be extensively managed overall, but still mainly rely on externally purchased inputs, including mineral fertiliser and synthetic insecticides, which would exclude it from the organic and circular approaches.

As for *Integrated/Circular farming*, whilst the use of some internally produced inputs contribute to decrease the overall input intensity as defined above (e.g. manure vs mineral fertiliser or self-produced electricity), this does not imply a priori that the overall input intensity of such farms is comparatively lower than the average, as the farm may have an intensive use of some other inputs that by definition cannot be produced or recycled internally (e.g. diesel, machinery, synthetic pesticides). Similarly, circularity in the use of certain input does not imply a priori the use of soil conservation practices (e.g. conservative or no tillage) characterising CA.

The principles of *Organic farming* as defined by EU regulations overlap to a certain degree with each of the three main dimensions described above. However, these overlaps are less marked when *legally binding requirements* are considered. In terms of soil conservation, regulation 834/2007 states that as a principle, organic plant production shall use tillage and cultivation practices that maintain or increase soil organic matter, enhance soil stability and soil biodiversity, and prevent soil compaction and soil erosion. However, no strict requirements on such aspects are then detailed in implementing regulation 898/2008. Similarly, organic production aims at an overall decrease in the use of inputs, but strict requirements, as seen, are imposed only on some aspects (mainly fertilisation and plant protection products for crops), while no limitation applies on the use of other inputs such as water, fuel, energy or machinery. EU regulations also prescribe that utilised feed is grown organically and should preferably come from within the farm, but only the first one is a strict requirement and farmers are allowed to make arrangements with other farmers from within the region for the purchase of feed. Whilst the stocking density limit of 2 LU/ha limits landless and very intensive livestock raising, this threshold exceeds what is generally considered extensive/low-input livestock management especially in hilly or mountainous areas[3].

In fact, studies on the actual implementation of organic farming in Europe report that compliance with legal organic requirements may be compatible with quite heterogeneous farming approaches, which may more or less depart from the principles stated in the EU regulation, ranging from low-input, crop-livestock integrated farms to management strategies resembling conventional farming (see e.g. Navarrete, 2009; Darnhofer et al., 2010; Petit and Aubry, 2016). Therefore, Organic farming is treated in the LIFT typology as a standalone category that does not entail a priori circularity, overall low-input or high uptake of soil conservation practices.

Finally, *Agroecological farming* is considered as a standalone category but requires a certain level of performance in each of the considered ecological dimensions. What is in fact important from an agroecological perspective is that the farm adopts an holistic approach encompassing to the extent possible all the ecological dimensions of farming, rather than performing very well in one of them but poorly in the other ones. In practical terms, when this is assessed through the set of rules and scores of the protocols, this requires the belonging to at least one approach as represented in Figure 1, with the constraint that the farm should reach a minimum score in each of the considered dimensions (see also Figure 3 in next section).

[3] For example, in the frame of CAP context indicator C.33 on *Farming Intensity* (see also section 3.1), *extensive grazing* is defined for areas where livestock density <1 LU/ha of forage area, see: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/cap-indicators-c33_2019_en.xlsx

4 Protocols to apply the LIFT typology

4.1 General principles and rationale

In the context of LIFT, a "protocol" is defined as a system of rules that, given a set of data on farm management practices and input/output figures, enables classifying an individual holding according to the typology described in section 3. The building blocks of the protocol are thus the following (Figure 2):

1. Farm types, used as an input information
2. Data and indicators on farm characteristics and management practices
3. A set of codified rules to combine the information of points 1 and 2, producing as result a classification of the farm according to the farming-approaches defined by the typology (i.e. the location of the farm in the space represented in Figure 1).

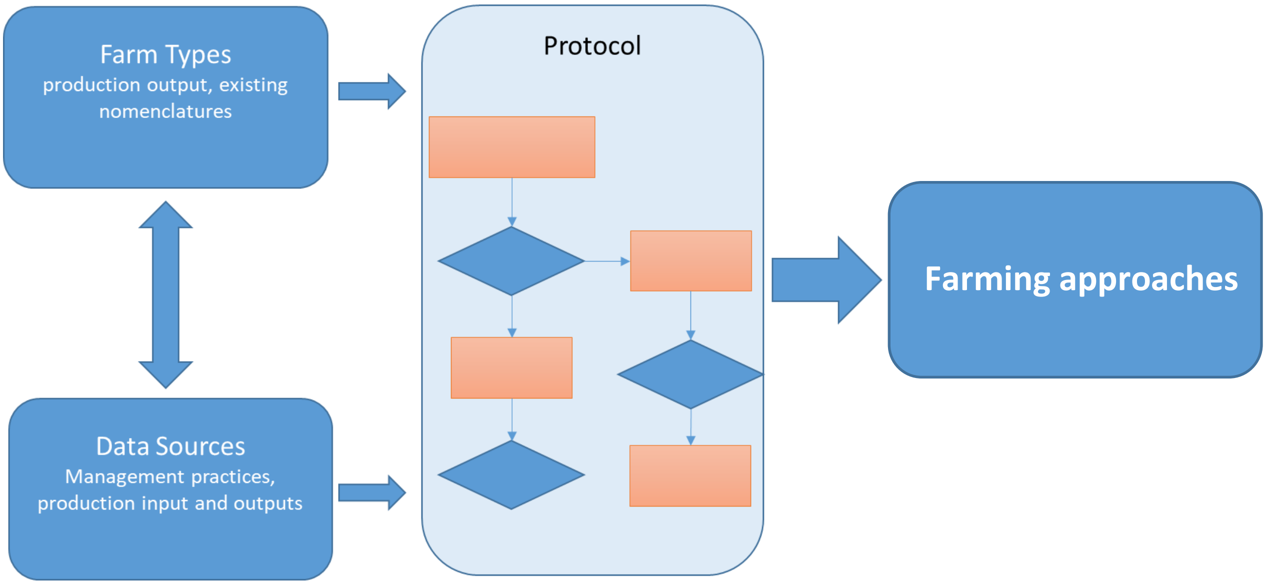

Figure 2: Schematic representation of the LIFT protocol (rhombi represent formulae, rectangles input/output)

As for data sources, one of the objectives of the LIFT project is that the typology shall be applicable with both primary and secondary data. Primary data have been collected as part of the work carried out in the project through a large-scale survey to farmer (Tzouramani et al., 2019). Concerning secondary data, different EU wide datasets have been considered and examined in MS2 (Rega and Paracchini, 2019). These included the Farm Structure Survey; the Survey on Agricultural Production Methods; the Farm Accountancy Data Network (FADN); the Integrated Administration and Control System (IACS) and its geographic information system, the Land Parcel Identification System (LPIS). The FADN was eventually considered as the dataset fit for purpose for the protocol based on secondary data. The resulting FADN-based protocol is described in the next section.

4.2 The FADN survey: characteristics, potentialities and limitations

The FADN was selected as the most suitable dataset for the purposes of the project as it presents the following characteristics:

- FADN is regularly carried out each year
- It is the only source of microeconomic data that is harmonised at the EU level, i.e. the bookkeeping principles are the same in all EU Member States
- It is representative of a significant share of existing EU farms (circa 90% of total UAA and production)
- It contains information on key production inputs among those deemed relevant in the ecological dimensions described above and, for some of them, it distinguishes between externally purchased and on-farm produced inputs.

As it will be detailed in section 4.4, the underlying idea is to use input expenditure and level of self-production, as a proxy to measure the two dimensions of overall input intensity and degree of integration/circularity described above.

There are, however, limitations associated with the use of FADN for this purpose, as the survey was originally designed as an economic account, not focusing on farming practices. Consequently, not all the ecological dimensions considered in the typology can be assessed at farm level on the basis of FADN. In particular, not enough information is provided on soil conservation farming practices and the presence of seminatural features. Concerning production inputs, the information collected is mainly reported in monetary terms rather than in physical quantities; therefore, the value of production input may change across years and countries due to price fluctuations and differences in price level across the Member States. Furthermore, though the sample is defined to be representative of over 90% of EU farming, it only includes holdings that are considered "commercial", i.e. it excludes a certain share of small farms. Finally, whilst standard variables aggregated at national level are freely accessible through the Eurostat site, microdata at farm level are not and may be made available upon request following an ad-hoc procedure, subject to the final decision of a specific committee.

There are nonetheless additional considerations in favour of the use of FADN for the purposes of LIFT, in spite of the identified limitations. Firstly, the survey is well known to farmers across the EU, as well as the nomenclature for the classification of types of farm, which is also adopted in the typology. Secondly, the use of FADN for the classification of farms and the assessment of sustainability at farm level has been advocated in the scientific literature. For example, Andersen (2017) proposed a method to identify and describe EU agricultural landscapes based, inter alia, on FADN data, including the following three dimensions: a) scale of production, b) specialisation and land use and c) intensity of farming. The latter dimension includes three classes defined in terms of economic output per hectare, using FADN data on farms' production (the higher the output, the more intensive the management). Kelly et al. (2018) reviewed the use of FADN-based farm evaluation approaches and concluded that FADN infrastructure and database offer considerable potential for assessing sustainability at farm level, although several shortcomings were also identified and possible improvements were proposed.

From the policy side, in the context of the CAP 2014-2020, an indicator labelled "Farming Intensity" is part of the set of Context Indicators (C.33) and classifies farms in three levels: low, medium and high intensity. The measurement of intensity is in turn based on the agri-environmental indicator "Intensification – extensification", defined as the sum of input costs incurred by the farm per unit of factor of production (in general land). The considered inputs are fertilisers, pesticides and purchased feed; input level is calculated as expenditures per hectare in constant national input prices using again FADN data on input costs incurred by farms, which allows to deduct price fluctuations and inflation but does not allow to consider differences of inputs' prices between countries (Eurostat, 2017). Furthermore, the European Commission has recently launched a proposal, originally contained in the

Farm to Fork Strategy (European Commission, 2020) for a regulation to expand the scope of the current FADN data collection to include more indicators on environmental and social practices. The purpose is to convert the FADN into a Farm Sustainability Data Network (FSDN).[4] Therefore, the work on the FADN-based protocol proposed here can be considered as an advancement along well-established research and policy lines.

4.3 The LIFT large-scale farmer survey: characteristics, potentialities and limitations

The LIFT questionnaire was designed specifically to survey the adoption of farming practices by farmers, so the information on farm management relevant for the environmental dimensions of the typology extractable from it is more detailed compared to the information provided by FADN microdata, which allows to have more granularity and cover all the farming approaches constituting the typology. Specifically, the protocol is based on the information provided in section 2 of the questionnaire, "Current and future production practices" (Tzouramani et al., 2019, pp. 16-42). The main difference between the FADN-based protocol and the Survey-based protocol is therefore that the first is mainly based on the measurement of selected quantitative variables mainly representing farming production inputs, whilst the latter is mainly based on the evaluation of the adoption of specific farming practices. On the other hand, section 2 of the LIFT large-scale farmer survey questionnaire provides comparatively less information on the amount of input used. In fact, some limitations on the degree of details to be provided by farmers had to be introduced to make its compilation viable without imposing an excessive burden on respondents. Consequently, quantitative information on the use of some specific inputs (e.g. fertilisers) is available only in discrete classes: for instance, the quantity of applied mineral fertiliser is expressed in 4 ranges, <50 kg N/ha, 50-100 kg N/ha; 100-150 kg N/ha and >150 kg N/ha. For many practices describing area-based interventions, the extent to which the practice is applied in terms of share of applicable area (usually the entire UAA, sometimes, only arable land) is provided in discrete classes too (≤5%; >5%-≤ 25%; > 25%-50%; >50-75%; >75-100%). More detailed quantitative data on some input usage is available in section 4 of the LIFT large-scale farmer survey questionnaire, but the compilation of this section was optional, so the number of farmers who filled it is significantly lower and not all Member States included in the project are covered. Furthermore, the questionnaire was designed specifically to obtain primary data not available in existing data sources; therefore, the choice was to elaborate on two complementary protocols that can be used alternatively depending on data availability.

Other important differences between the LIFT large-scale farmer survey data and FADN data concern the size and statistical representativeness of the sample and the temporal dimension. The FADN sample includes about 80,000 individual farms each year, and the sampling design adopts a system of weights carefully defined to make the sample statistically representative for different farming types and economic sizes of farms across Europe. As said, the FADN survey is replicated each year, and long temporal series are available. The LIFT large-scale farmer survey is an ad-hoc, once-only survey applied to a significant, but comparatively smaller, sample of farms (1,628 respondents) from 12 different EU Member States carried out in the context of a research project. The objective of this farmer survey was to collect detailed information on-farm practices, farmers' attitudes, and farm structural and economic characteristics, in order to carry out farm-level analyses on the adoption of ecological practices and performance of such practices. The information was collected for the year 2018.

The characteristics of these two data sources determined the different approaches and rationales adopted in the design of the two protocols. The common features are the overall aim – a system to

[4] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12951-Conversion-to-a-Farm-Sustainability-Data-Network-FSDN-_en

classify individual farms according to the typology – and the general architecture, devised as a set of **scoring systems** applied to different variables (FADN-based protocol) or items of the questionnaire (Survey-based protocol). The main conceptual difference is that in the FADN-based protocol, the identification of the scores is mainly data-driven, i.e. derived by statistical analyses on the underlying dataset, whilst in the Survey-based protocol scores are assigned based on expert judgements, as explained in detail in the next subsections.

Scoring systems are a commonly adopted approach for the measurement of farm environmental, social and/or economic performances. Examples of such approaches and assessment tools include the IDEA framework (Indicateur de Durabilité des Exploitations; Zahm et al., 2008); MOTIFS (Monitoring Tool for Integrated Farm Sustainability; Meul et al., 2008) or the SOSTARE model (Paracchini et al., 2015). More recently, the FAO has proposed a Tool for Agroecology Performance Evaluation (TAPE), devised as a scoring system applied to 10 core criteria covering economic, social and environmental aspects, furtherly articulated into 35 individual indicators (FAO, 2019). These systems have the advantage of being relatively intuitive (usually, the higher the score, the better the performance) and can be easily applicable without hard computational efforts once the methodology is established. Accordingly, a similar approach has been adopted here for the design of the two protocols, the main difference being that the scores in the case of LIFT do not represent an overall metric of the farm performance in terms of sustainability, but are used to determine whether a farm belongs or not to any of the six main farming approaches defined in section 3. That is, scores are used for a classification purpose, not for ranking.

In both protocols, the evaluation of whether a farm belongs to any of the farming approaches defined by the typology (except agroecological farming) is carried out independently, i.e. each protocol is composed of specific sub-protocols referring to the different farming approaches. In each case, a set of indicators are examined and are converted to a score according to specific rules. Each indicator is also associated with a weight. The final score for each sub-protocol is defined as the weighted average of individual scores. The latter range from 0 to 4; if the resulting weighted average is ≥ 3, the farm is considered to belong to the examined farming approach. If this threshold value is reached relatively to more than one farming approach, the farm is assigned to belong to more than one class (e.g. Low-Input and Integrated/Circular). The assignation to the *Agroecological farming* approach is based on the consideration of the total scores that the farm gets summing the scores obtained for each of the examined approaches (plus, for the Survey-based protocol only, additional scores on the presence of seminatural vegetation). As a general rule for both protocols, the farm needs to reach a minimum aggregate score and also minimum scores for each farming approach, though lower than the thresholds needed to be classified in that approach. Conceptually, the protocols for the evaluation of the different farming approaches and their combinations can be seen as aggregated frameworks for the consideration of multiple dimensions of sustainability (in this case referring to farming) through linear additive models, as proposed e.g. by Paracchini et al. (2011). The general concept is illustrated by Figure 3 below, specific rules for each protocol are detailed in the next sections.

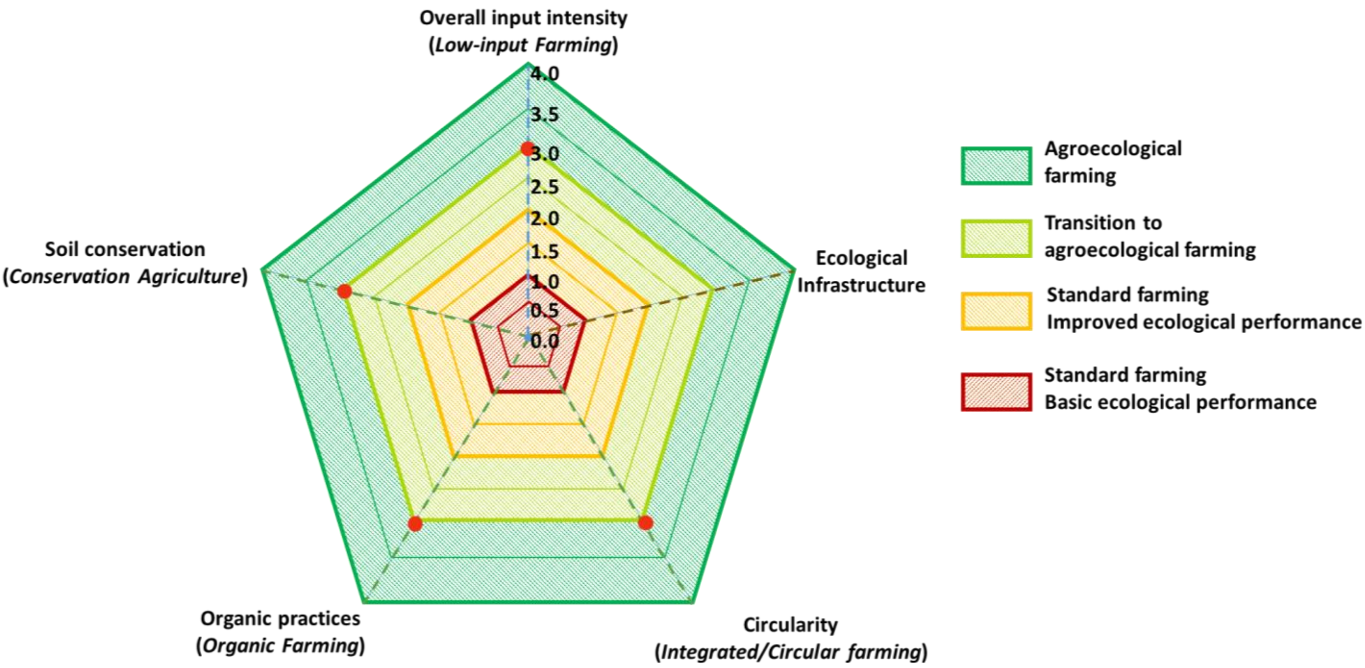

Figure 3: Schematic representation of the scoring system to evaluate the belonging of individual holdings to different farming approaches. Each axis represents an evaluated ecological dimension. The red dots indicate the threshold values for a farm to be classified into an individual farming approach (in italic in parenthesis).

In the following subsection, the FADN and LIFT survey protocols are described more in detail. The tables with the full scores and weights are provided in Annex 1.

4.4 FADN-based protocol: approach and implementation

The proposed FADN-based protocols take into consideration a selection of variables describing the level of inputs, expressed in monetary terms (value in Euros or national currency) purchased or produced by individual holdings, the underlying assumption being that the expenditure for a certain input is correlated and proportional to the usage of the same input during the agricultural production process. It is acknowledged that this assumption is prone to a certain level of error, as the purchase of some input does not automatically translate into usage, but it is maintained that these indicators provide nonetheless relevant information on the farming approach adopted by the farmer.

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. This is in line with the mentioned CAP context indicator C.33 and with the current scientific literature on methods and metrics to measure farming intensity (see e.g. Erb et al., 2013; van der Zanden et al., 2016; Levers et al., 2018; Rega et al., 2020b).

FADN data do 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.

4.4.1 FADN-based protocol for *Low-Input farming* approach

After screening and assessing the different variables included in the FADN dataset (microdata at farm level), the variables describing the following input types have been selected for the protocol on ***Low-Input farming***: fertilisers, plant protection products, seeds, water, fuels, electricity, use of machinery and equipment/tools (measured as annual upkeep cost) and level of total physical assets used in the production process, measured as annual depreciation of capital assets. For specialist livestock farms, feed value, stocking density and number of days grazed on common land have been considered in addition.

Whilst the general architecture of the protocol is the same for all farm types, some specific variables are considered only for some farm types for which they are relevant, as shown in **Erreur ! Source du renvoi introuvable.** below. The first column from the left lists the farming aspect considered, the second column describes the variable more in details, and the third column indicates the formula used to compute it, showing the name of the variables as coded in the FADN database. The column "Arable" comprises the following types of farm: Specialist COP (TF 14 = 15), Specialist horticulture (TF14 = 20), Specialist other field crops (TF14 = 60). The column "Permanent" comprises Specialist vineyards (TF 14 = 35), Specialist orchards/fruits (TF 14 = 36), Specialist olives (TF 14 = 37) and permanent crops combined (TF 14 = 38). The column "Livestock" includes Specialist milk (TF 14 = 45), Specialist sheep and goats (TF 14 = 48), Specialist cattle (TF 14 = 49) and Specialist granivores (TF 14 = 50). The column "Mixed" comprises Mixed crops (TF 14 = 60), Mixed livestock (TF 14 = 70) and Mixed crops and livestock (TF 14 = 80).

For most considered variables, FADN reports total expenditures or values for the entire farm for one accounting year, thus to obtain a measure of intensity, the absolute figures have been divided by the relevant unit of reference, namely ha of UAA for inputs that are specific for crop area (fertilisers, pesticides, seeds) and LU for livestock-specific inputs (feed). In some cases, the variables refer to general inputs not univocally linkable to crops or livestock production, such as use of fuel, electricity, equipment. In these cases, the absolute value has been divided by ha of UAA for specialist crop farms (where, if present, livestock represent a relatively minor production) and by LU for livestock specialist farms as in this case LU is considered to be the main unit of reference for production (moreover, UAA may be = 0 in these farms). For mixed farms, UAA was used for normalisation. As a general rule, variables are considered in the calculation of the score of individual farms only when they can be mathematically computed. For example, fertilisation, seeds, and pesticides per ha UAA are considered only if the holding to be assessed has UAA > 0.

Concerning farms specialised in grazing livestock, the variable on stocking density is considered as a key descriptor of the intensity of management but it has to be pointed out that the denominator, i.e. foraging area, does not include common land used for pasture. This may lead to an overestimation of the indicator, particularly in some areas where grazing on common land is still practiced, e.g. certain alpine regions. Consequently, variable *"no. of grazing days on common land*" was added as a corrective factor. This variable acts as a "bonus" as it can have only a score of 3 or 4 for farms that have this practice, whilst the variable is discarded (i.e. does not contribute to the average score) if the farm does not have it.

As for machinery and building (FADN variable SE340), it is known that the figure may underestimate the actual usage of machinery in case when the farmer rents the equipment or outsources the work. The plurality of variables included in the calculation of the aggregated score precisely aims to offset the possible inaccuracies that may be associated to individual variables.

Table 2: Variables considered in the FADN-based protocol for the Low-Input farming approach for different types of farms (TF)

Farming aspect	Description	FADN code and formula	Arable TF	Permanent crops TF	Livestock TF	Mixed TF
Fertilisation	Value of purchased fertilisers and soil improvers per ha of UAA	SE295/SE025	**X**	**X**	**X**	**X**
Pest control	Value of plant protection products, (including traps and baits, bird scarers, anti-hail shells, frost protection) per ha of UAA	SE300/SE025	**X**	**X**	**X**	**X**
Water use	Water value per ha of UAA	IWATR_V/SE025	**X**	**X**	**X**	**X**
Energy use - fuels and lubricants	Value of heating fuels and motor fuels and lubricant expenditure per ha of UAA	(IHFULS_V+IFULS_V)/SE025	**X**	**X**	**X**	**X**
Seeds	Value of seeds and seedlings (purchased and home produced) per ha of UAA	SE285/SE025	**X**		**X**	
Energy use - electricity	Value of consumed electricity per ha of UAA	IELE_V/SE025	**X**	**X**	**X**	**X**
Machinery & building	Costs of current upkeep of equipment (and purchase of minor equipment), car expenses, current upkeep of buildings and land improvements, insurance of buildings, per ha of UAA. Major repairs are excluded	SE340/SE025	**X**	**X**	**X**	**X**
Total physical assets (depreciation)	Depreciation of capital assets entry in the accounts of depreciation of capital assets over the accounting year, per ha of UAA	SE360/SE025	**X**	**X**	**X**	**X**
Stocking density	Total grazing livestock standard units LU per ha of forage area	(SE085 + SE090 + SE095) /(SE71)			**X**	**X**
Grazing on common land	Total number of LU grazing days by farm animals on common land used by the holding /total grazing livestock (LU)				**X** (only grazing livestock)	**X**
Feed for livestock	Value of feed for the predominant farm livestock, including concentrated feedingstuffs and coarse fodder/total grazing livestock (LU)	SE310/(SE085 + SE090 + SE095)			**X**	**X**

The assignation of scores to each variable followed a series of steps to calculate statistics and make variables' values comparable across time and space. In particular:

1. Data from five accounting years (2011-2015 period) were considered. 2015 is the most recent year available in LIFT, and the choice of 2011 was made to achieve a balance between the need to have a pool of data large enough to derive robust statistics on the one hand and the need to keep the entire dataset manageable and possibly representative of the current status of EU agriculture.

2. Data cleaning: selected variables were checked to find and remove missing values or entries considered as errors, such as livestock specialist farms with total LU = 0. We also removed crop specialist farms with UAA = 0, though we recognise for horticulture farms this is not unusual, we decided they were to be treated as outliers.

3. Adjustment of monetary values to take into account inflation. This and the following represented two key steps of the whole data processing. Since the expenditure on different inputs is used here as a proxy for their actual usage, differences in costs deriving from changes in prices due to inflation/deflation must be taken into account to allow pooling data from different years. To this end, all values were converted in 2010 prices using official inflation figures from Eurostat[5]. The latter provides inflation coefficients specific for countries and different agricultural inputs, including fertilisers, feed, fuel, seeds, machinery, and electricity.

4. Adjustment of monetary values to take into account price differences across countries. Similar to what was done for inflation, differences in purchasing power across EU countries were considered to make data comparable. In this case, data from single countries were adjusted, for each year, using official Eurostat figures of price level index, defined as the price level of a given country relative to the EU average obtained by dividing the purchasing power parities by the current nominal exchange rate. This adjustment was made for each country and for each year using a specific coefficient for electricity/fuel and water. For the remaining variables, a more aggregate coefficient for agricultural machinery/equipment was used.

5. Calculation of the percentiles of the distribution of variables' values. Once original values are adjusted following the procedure described in steps 3 and 4 above, they can be pooled together, and the statistical distribution of each variable can be calculated. This was done to be able to transform original values into discrete scores. To this purpose, the adopted method was to calculate the 20%, 40%, 60% and 80% percentiles of the (adjusted) variables' distribution to obtain 5 value ranges for each variable. Subsequently, values from 0 to 4 were assigned accordingly, i.e. a score of 0 to values belonging to the 80-100% percentile range, 1 to values belonging to the 60-80% range and so on (considering that generally, the higher the value, the higher the usage of the related input so the lower the assigned score). Percentiles were used also because they are less sensitive to the presence of possible outliers. Percentile calculations were made with and without outliers (defined as any value > 99.5% percentile), and differences were negligible given the size of the database.

6. The use of different inputs is obviously not homogeneous across farm types, so to account for this variability, the statistical distribution was determined for each combination of variables and farm type, i.e. pooling together each time only farms belonging to the same farm type TF14.

7. Consideration of geographic-specific values. The general approach adopted for the protocol is to derive percentiles values using the entire dataset, so that scores reflect, as far as possible, the

[5] In particular, the table "Price indices of the means of agricultural production, input (2010 = 100) - annual data (apri_pi10_ina)" available here: https://ec.europa.eu/Eurostat/web/agriculture/data/database

relative level of input use of an individual farm compared to all holdings of the same farm type *across the entire EU* (including UK, as data from the 2011-2015 period were used). For some variables, however, it was considered that geographic conditions had to be taken into account as well. In particular, value ranges to assign scores to the variable *water use* and *grazing density* were calculated separately not for farm types alone, but for different combinations of farm types and *biogeographic regions*. For the latter, we referred to the delineation used in the Habitat Directive 1992/43/EC provided by European Environmental Agency[6]. The following main regions were considered: Mediterranean, Continental, Atlantic, Alpine, Boreal, and Pannonian. Water use is, in fact, higher for example, in the Mediterranean region compared to Continental or Atlantic zones. Similarly, stocking density level shall be considered taking into account the carrying capacity of grasslands in different climatic zones (again, e.g. lower in the Mediterranean compared to Atlantic or Continental). Therefore, each individual holding in the FADN database was associated with one of the main biogeographical regions using overlaying techniques in a GIS environment. Available FADN data did not contain information on the exact location of the holding for privacy reasons, but did report the NUTS3[7] region to which the farm belongs. Many NUTS3 regions are entirely comprised within a single biogeographical regions, so in this case the assignation was straightforward. When NUTS3 regions crossed two or more biogeographical regions, of which one was the Alpine region, we used information on the altitude at which the farm is located (provided by FADN data) to assign farms at altitude > 600 m to the Alpine region. In all the remaining cases, the holding was considered to belong to the biogeographical region with the largest intersection with the NUTS3 region it belonged to.

8. Assignation of weights to different variables. Weights were assigned to the considered variables based on an assessment of the accuracy of the data, their reliability and the degree to which they represent good proxies of overall input intensity. It is known a priori that some FADN data are inherently less reliable than others, for example water costs do not always reflect with precision actual water usage due to a variety of reasons (sometimes water is paid with forfeit prices, in other situations, farmers do not pay at all for water or meters are not present). Conversely, fertiliser prices can be considered a more direct proxy of fertiliser use as they are by definition purchased on the market (although as said purchase does not equal use). Three level of weights were assigned (corresponding to low, medium and high accuracy), numerically corresponding to 1, 1.5 and 2. The assignation of the final values followed an iterative process taking into account feedback from pilot applications from different partners.

The following Table 3 and

[6] Available here: https://www.eea.europa.eu/data-and-maps/data/biogeographical-regions-europe-3

[7] The Nomenclature of territorial units for statistics, NUTS is a geographical nomenclature subdividing the territory of the EU into regions at three different levels (NUTS 1, 2 and 3 respectively, moving from larger to smaller territorial units). (https://ec.europa.eu/Eurostat/statistics-explained/index.php?title=Glossary:Nomenclature_of_territorial_units_for_statistics_(NUTS))

Table 4 illustrate the final outcome of the described process by showing two examples of Low-Input farming protocol, one referring to specialist COP and one to specialist cattle in the Continental biogeographic region, with actual value ranges for each variable and related scores. The entire set of tables is included in the Annex. When a user applies the protocol to one or more farms using FADN microdata, he/she has, therefore, to extract the relevant variables, adjust them using the inflation and price index coefficients (provided in the Annex for each Member State) and compare the obtained adjusted value with the ranges shown in the table to assign a score. Then, a weighted average of the obtained score is calculated and if the result is ≥3 the farm is classified as *Low-Input farming*.

*Table 3: Example of FADN-based protocol for the evaluation of the Low-Input farming approach for Specialist COP farms. Water use values refer to the Continental biogeographic region. Variable SE025 is total Utilised Agricultural Area. The * means that the original value has to be adjusted considering inflation and price level indexes.*

Low-Input farming – Specialist COP				
Farming aspect	**Variable Formula**	**Value Ranges**	**Score**	**Weight**
Fertilisation	Total fertilisation costs per ha of UAA SE295*/SE025	48	4	2
		92	3	
		147	2	
		240	1	
		> 240	0	
Pest control	Total expenditure for pest control products per ha of UAA SE300*/SE025	25	4	2
		66	3	
		125	2	
		245	1	
		> 245	0	
Water use	Total expenditure in water per ha of UAA IWATR_V*/SE025	0	4	1
		2	3	
		5	2	
		14	1	
		>14	0	
Energy use - fuels and lubricants	Total expenditure in fuels per ha of UAA (IHFULS_V*+IFULS_V*)/SE025	54	4	1.5
		94	3	
		143	2	
		252	1	
		> 252	0	
Seeds	Total cost for seeds and plantlets for ha of UAA SE285*/SE025	28	4	1.5
		56	3	
		94	2	
		196	1	
		> 196	0	
Energy use - electricity	Total expenditure in electricity per ha of UAA IELE_V*/SE025	0.0	4	1
		8.6	3	
		24	2	
		71	1	
		> 71	0	
Machinery & building (maintenance costs)	Costs of current upkeep of equipment and purchase of minor equipment per ha of UAA	17	4	1
		45	3	
		92	2	
		198	1	
		> 198	0	

	SE340*/SE025			
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per ha of UAA SE360*/SE025	68	4	1.5
		192	3	
		359	2	
		688	1	
		> 688	0	

*Table 4: Example of FADN-based protocol for the evaluation of the Low-Input farming approach for Specialist cattle farms. Stocking density and water use values refer to the Continental biogeographic region. Variable SE080 is total Livestock Units (LU). The * means that the original value has to be adjusted considering inflation and price level indexes.*

Low-Input farming – Specialist Cattle				
Farming aspect and definition	**Variable description and formula**	**Value Range**	**Score**	**Weight**
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE71)	0.78	4	1.5
		1.13	3	
		1.53	2	
		2.27	1	
		>2.27	0	
Grazing on common land (applies only if "GRAZDAYS">0, otherwise discard the variable)	Average Number of days spent grazing on common land per grazing LU GRAZDAYS/(SE085 + SE090 + SE095)	>130	4	1.5
		5.6-130	3	
Fertilisation (applies only if SE025>0, otherwise discard the variable**)**	Total fertilisation costs per ha of UAA SE295*/SE025	0	4	1
		22	3	
		59	2	
		110	1	
		> 110	0	
Livestock feed	Cost of purchased feed for grazing livestock per grazing LU (SE310*/(SE085 + SE090 + SE095)	117	4	2
		207	3	
		306	2	
		459	1	
		> 459	0	
Pest control (applies only if SE025>0, otherwise discard the variable)	Total expenditure for pest control products per ha of UAA SE300*/SE025	0	4	1
		1.2	3	
		11	2	
		36	1	
		> 36	0	
Energy use - fuels and lubricants	Total expenditure in fuels per LU (IHFULS_V*+IFULS_V*)/SE080	30	4	1.5
		50	3	
		74	2	
		121	1	
		> 121	0	
Energy use - electricity	Total expenditure in electricity per LU IELE_V*/SE080	3.8	4	1
		8.9	3	
		17	2	
		32	1	
		> 32	0	
Machinery & building - upkeep	Costs of current upkeep of equipment and purchase of minor equipment per LU SE340*/SE080	29	4	1
		62	3	
		100	2	
		165	1	
		> 165	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per LU SE360*/SE080	68	4	1.5
		140	3	
		225	2	
		384	1	
		> 384	0	

4.4.2 FADN-based protocol for *Integrated/Circular farming*

The degree of internal integration is evaluated through the consideration of on-farm production of the following inputs: feed (for farms with livestock), seeds (for non-livestock farms), and electricity. FADN does not report information on the value or quantity of manure or compost used as fertilisers produced on farm, so the total value of purchased fertiliser is used here too, the assumption being that lower expenditure per ha is expected if part of the fertilisation needs is met with internally produced fertilisers (manure, compost, use of legumes or other cover crops as green manure). Similarly, stocking density is considered here too in farms with grazing livestock to complement and better capture the internal crop (grassland)/livestock integration as the indicator is expressed in physical unit (grazing LU/ha forage area) and account for all grazing area (including rough grazing), whilst the value of home-produced feed refers only to the value of marketable farm products.

Table 5 shows the variables considered in the protocol for Integrated/Circular farming approach for the different types of farms. Table 6 shows, as an example, the Integrated/Circular farming protocol for Specialist dairy (values for water use and stocking density refer to the Continental biogeographical region).

For all farm types, the production of electricity on farm acts as a “bonus” score, i.e. it can only take scores of 3 or 4, and it is applied only if the value is >0. The reason is that the value does not refer to the total amount of electric energy produced on farm, but only to the surplus sold on the market, thus not accounting for self-consumption. It is assumed that a farm with a surplus meets most of its electric energy needs with own-produced energy, so the scores account for this, but conversely, it cannot be assumed that a farm without surplus is not producing energy at all, so when its value = 0 the variable is simply not considered in the calculation of the weighted average. Similarly, scores referring to seeds’ own production and fertilisation are calculated only if the farm has UAA, otherwise these variables are discarded.

In all cases where variables represent ratios of homogeneous quantities, no value adjustments for inflation or price level indexes are needed. In these cases, the obtained value represents a physical quantity that has a straightforward meaning (i.e. the share of the own-produced input on the total amount of that kind of input used by the farm). When adjustments are required, the same procedure described for the Low-Input farming approach is applied, and the same thresholds and scores based on percentiles are used.

Table 5: Variables considered in the FADN-based protocol for the Integrated/Circular farming approach for different types of farms (TF)

Farming aspect	Description	FADN code and formula	Arable TF	Permanent crops TF	Livestock TF	Mixed TF
On farm feed production	Share of home grown feed on total used feed, expressed as ratio between marketable value of home-produced feed and total value of all feed used (range: 0 - 1)	(SE315+SE325/(SE310 +SE320)	**X**	**X**	**X**	**X**
Feed for livestock	Value of feed for farm livestock, including concentrated feeding stuffs and coarse fodder/total livestock (LU)	SE310/(SE085 + SE090 + SE095)			**X**	**X**
Fertilisation	Value of purchased fertilisers and soil improvers per ha of UAA	SE295/SE025	**X**	**X**	**X**	**X**
Energy - own production	Value of electricity produced on farm on total electricity consumed	ONRGPRD_SV/IELE_V	**X**	**X**	**X**	**X**
On farm seed production	Share of the value of home-produced seeds on total value of used seeds	SE290/SE285	**X**			**X**

*Table 6: Example of FADN-based protocol for the evaluation of the Integrated/Circular farming approach for Specialist dairy farms. Stocking density and water use values refer to the Continental biogeographic region. The * means that the original value has to be adjusted considering inflation and price level indexes.*

Integrated/circular farming – Specialist Dairy				
Farming aspects	**Variable Name**	**Value Ranges**	**Scores**	**Weight**
Own feed production	Value of own produced feed on total feed value SE315/SE310	>0.5	4	2
		0.5	3	
		0.3	2	
		0.1	1	
		0	0	
Livestock feed	Value of purchased feed per grazing LU (SE310*/ SE085 + SE090 + SE095)	258	4	1.5
		360	3	
		484	2	
		731	1	
		> 731	0	
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE071)	< 1.21	4	1.5
		1.62	3	
		2.04	2	
		2.68	1	
		>2.68	0	
Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)	Value of sold electricity produced on farm on total value of consumed electricity ONRGPRD_SV/IELE_V	>0.2	4	1
		0.2	3	
Fertilisation (applies only if SE025>0, otherwise discard the variable**)**	Total fertilisers cost per ha of UAA SE295*/SE025	14	4	1.5
		60	3	
		104	2	
		158	1	
		>158	0	
Seed - own ratio (applies only if SE290>0, otherwise discard the variable**)**	Value of seeds produced on farm on total value of used seeds SE290/SE285	>0.2	4	1
		0.2	3	

4.4.3 FADN-based protocol for the Organic farming approach

The belonging of a holding to the *Organic farming* approach can be established straightforwardly with FADN microdata as there is a specific variable "ORGANIC" which can assume the following values (Table 7):

Table 7: Values of the variable "ORGANIC" in FADN and corresponding scores in the protocol

FADN value variable "ORGANIC"	Description	Assigned score
1	The holding does not apply organic production methods	0
2	The holding applies only organic production methods	4
3	The holding applies both organic and other production methods	3
4	The holding is converting to organic production methods	3

In terms of belonging to the Organic farming approaches, all values >1 are considered valid, although with different scores to discriminate between case 2 and cases 3 and 4.

4.4.4 FADN-based protocol for the Agroecological farming approach

As explained in section 3, criteria for *Agroecological farming* comprises those already considered in the Low-Input farming, Integrated/Circular farming and Organic farming approaches, plus the presence of seminatural vegetation on farm and soil conservation practices. In particular, it is required that the farm gets a score ≥2 in each of the Low-Input and Integrated/Circular farming approaches and that the sum of the scores of the three approaches (the previous two and Organic farming) is ≥6. In practice, in the FADN protocol, the coexistence of any combination of two or more approaches among Low-Input, Integrated/circular and Organic farming is considered sufficient for the farm to be classified as Agroecological farming. These conditions are not however necessary, as the threshold of 6 can in theory be reached by farms sufficiently "close" to all the approaches at the time, without reaching any of them individually.

4.5 Survey-based protocol: approach and implementation

Similarly to the FADN-based one, the Survey-based protocol is a scoring system whereby individual farms are evaluated using selected items from the LIFT large-scale farmer survey, against the main ecological dimensions described in section 3: soil conservation, overall input use (including specific inputs relevant for organic production), degree of internal integration/circularity and presence of seminatural vegetation on farm. Each practice is assigned a score labelled *basic score*, representing the intrinsic potential of the practice in achieving the objectives of the farming approach under evaluation as described in section 3. The score presented here is the result of expert-based judgements involving the JRC team plus additional external experts (see section 8 Acknowledgements). Each expert was asked to assess individually the different practices based on their merit and relevance with regard to the aspects characterising soil conservation, intensity of inputs and the potential of landscape features to support biodiversity (in particular functional biodiversity as pollinators and pest predators). The scores assigned by experts were averaged and approximated to the closer integer or half score (2.5, 3.5 etc.). For practices that are area-based, the information provided by farmer respondents on the share of area on which the practice is applied is used as a weighting factor to calculate so-called *weighted scores* (WS). When this is the case, the upper limit of the interval is used, e.g. if a practice is applied on 25-50% of the area, the basic score of the practice is multiplied by 0.5, if applied on 50-75% the basic score is multiplied by 0.75 and so on. In the tables below, this area share is denoted with % Area (usually reported in columns C or E of the LIFT large-scale farmer survey questionnaire, see Tzouramani et al., 2019). Partial scores are calculated for practices referring to the same farming aspects as weighted averages of the individual WS. Partial scores are then added to calculate a final score. As in the case of the FADN-based protocol, individual holdings are classified into each of the farming approaches of the typology if a certain threshold score is reached. In what follows, the numbering of the survey questions refers to the questions in the LIFT large-scale farmer survey questionnaire (Tzouramani, et al. 2019).

4.5.1 Survey-based protocol - Conservation Agriculture

The following Table 8 shows the survey questions that are considered in the protocol for Conservation Agriculture, the basic scores assigned to each of them, and the formula to calculate the weighted scores. The protocol is applicable only to farms with UAA>0. Three partial scores are calculated for the three main dimensions evaluated for soil conservation – tillage management; crop rotation and diversification; and soil coverage. The share of area on which the practice is applied is used as scoring weight to calculate each partial score. The three obtained partial scores are then summed to derive the final score. In the following tables, the reference to the number of the relevant items in the questionnaire is reported in the leftmost column.

Table 8: Survey-based protocol for the Conservation Agriculture approach

Tillage management			
No.	**Practice name**	**Basic score** (column A = YES)	**Weighted score (WS)**
26.1	Conventional tillage	2	WS1 = 2 * % $Area_i$
26.2	Conservation tillage	3	WS2 = 3 * % $Area_i$
26.3	No tillage	3	WS3 = 3 * % $Area_i$
		Score tillage = ($\Sigma_{i=1-3}$ WS*i*/Σ % $Area_i$)	
Crop rotation and diversification			
29.1	Crop rotation	4	WS4 = 4 * % $Area_i$
29.2	Crop diversification	Between 2 and 4 (depending on n = no. of crops grown on farm; if n = 2 then score = 2; if n = 3 then score = 3; if n ≥4 then score = 4)	WS5 = n * % $Area_i$
29.4	Mixed cropping	2	WS6 = 2 * % $Area_i$
		Score diversity = ($\Sigma_{i=4-6}$ WS*i*/Σ % $Area_i$)	
Soil Cover			
26.10	Leaving crop residues on soil	4	WS5 = 4 * % $Area_i$
26.12	Planting of catch crop	2	WS6 = 2 * % $Area_i$
26.13	Planting of cover crops	2	WS7 =2 * % $Area_i$
26.11	Planting of Nitrogen fixing crops	4 if multiannual (e.g. alfalfa); 2 otherwise	WS8 = (Basic Score) * % $Area_i$
29.5	Leaving land fallow	2	WS9 = 2 * % $Area_i$
24.1	Mulching with organic/biodegradable material	3	WS10 = 3 * % $Area_i$
24.2	Mulching with an inorganic material	3	WS11 = 3 * % $Area_i$
		Score cover = ($\Sigma_{i=5-11}$ WS*i*/Σ % $Area_i$)	
	Final Score	**(Score tillage + Score diversity + Score cover)/3**	
	Threshold	**≥ 3**	

Note: % $Area_i$ indicates the share of the farm crop area on which the practice *i* is applied

4.5.2 Survey-based protocol – Low-Input farming

The Low-Input farming protocol takes into account the use of a variety of inputs and the adoption of farming practices; it can be applied to all farm types. The protocol is subdivided into the following sub-sections covering different farming aspects and related practices:

- Section 1: fertilisation of cropland. It applies all farms with UAA >0 (information derivable by survey question Q11)
- Section 2: Weeds, pests and plant disease management. It applies to farms with UAA >0
- Section 3: Grassland management. It applies to farms with either temporary or permanent grassland (information derivable by survey questions Q11_1a and Q11_2)

- Section 4: water and energy management. It applies to all farms, but some specific scores apply only to farms with UAA >0
- Section 5: Livestock feed. It applies to all farms with total LU > 0 (information derivable by survey question Q7_2)
- Section 6: Livestock management. It applies to all farms with total LU > 0. Some scores apply only to farms with grazing livestock.

Table 9 below shows section 1 of the protocol, based on survey questions 26.4 to 26.9 and 27.1 to 27.3. For the practices for which the application rate is reported, the information is used to differentiate the basic scores.

Table 9: Survey-based protocol for Low-Input farming approach. Section 1: fertilisation of cropland

Section 1: Fertilisation of cropland				
No.	**Practice name**	**Application rate (Kg N/ha/year)**	**Basic Score (BS*i*)**	**Weighted score (WS*i*)**
26.4	Application of inorganic fertilisers	No application	4	*BSi* * % Area$_i$
		<50	3	
		50-100	2	
		100-150	1	
		>150	0	
26.5	Application of animal manure	No application	4	*BSi* * % Area$_i$
		<50	4	
		50-100	3.5	
		100-150	2.5	
		>150	1	
26.6	Application of sewage sludge and other sludge	<50	3	*BSi* * % Area$_i$
		50-100	2	
		100-150	1	
		>150	0	
26.7	Application of compost	<50	4	*BSi* * % Area$_i$
		50-100	4	
		100-150	3	
		>150	1	
26.8	Application of soil amendments		NO = 4 YES =2	*BSi* * % Area$_i$
26.9	Green manuring		NO = 0 YES =3	*BSi* * % Area$_i$
27.1	Precision technologies to target application rate		NO = 0 YES = 2	*BSi* * % Area$_i$
27.2	Machine controlled application		NO = 0 YES = 2	*BSi* * % Area$_i$
27.3	Soil mapping		NO= 0 YES = 3	*BSi* * % Area$_i$
Score Section 1 = (Σ_i WS$_i$/Σ % Area$_i$)				

Note: % Area$_i$ indicates the share of the farm crop area on which the practice *i* is applied

The following Table 10 shows section 2 of the protocol, covering practices related to the management of weeds, pests and plant diseases (survey questions 20, 21, 22, 23, 24 and 25).

Table 10: Survey-based protocol for Low-Input farming approach. Section 2: weeds, pests and plant diseases management

Section 2: Weeds, pests and plant diseases management			
No.	**Practice name**	**Basic Score (BS*i*) if YES**	**Weighted score (WS*i*)**
20.1	Use of synthetic insecticides/fungicides at rate recommended by the manufacturer for that specific crop	1.5	BSi * % $Area_i$
	Use of synthetic insecticides/fungicides at lower rate than recommended by the manufacturer for that specific crop	2	BSi * % $Area_i$
20.2	Use of chemical products allowed by organic regulations for pests/fungi at rate recommended by the manufacturer for that specific crop	2.5	BSi * % $Area_i$
	Use of chemical products allowed by organic regulations for pests/fungi at lower rate than recommended by the manufacturer for that specific crop	3	BSi * % $Area_i$
21.1	Biological control	4	BSi * % $Area_i$
22.1	Adoption of Integrated Pest Management practices	3.5	BSi * % $Area_i$
22.2	Precision technologies to target application rate (variable rate application)	2	BSi * % $Area_i$
23.1	Use of synthetic chemical products (herbicides) at rate recommended by the manufacturer	1.5	BSi * % $Area_i$
23.1	Use of synthetic chemical products (herbicides) at lower rate than recommended by the manufacturer for that specific crop	2	BSi * % $Area_i$
23.2	Use of chemical products allowed by organic regulations for weed control at rate recommended by manufacturer	2.5	BSi * % $Area_i$
23.2	Use of chemical products allowed by organic regulations for weed control at lower rate than recommended by manufacturer	3	BSi * % $Area_i$
24.1	Mulching with organic/biodegradable material	3	BSi * % $Area_i$
24.2	Mulching with inorganic material	3	BSi * % $Area_i$
24.3	Machine weeding	3	BSi * % $Area_i$
24.4	Manual weeding	4	BSi * % $Area_i$
24.5	Thermal weed control	2	BSi * % $Area_i$
24.6	Use of varieties tolerant of weeds	4	BSi * % $Area_i$
25.1	Integrated weed management principles	4	BSi * % $Area_i$
25.2	Precision technologies to guide herbicide application	2	BSi * % $Area_i$
Score Section 2 = (Σ_i WS_i/Σ % $Area_i$)			

Note: % $Area_i$ indicates the share of the farm crop area on which the practice *i* is applied

Section 3 on the protocol covering grassland management practices (survey questions 30_1- 30_7) is shown in Table 11 below. Again, the information on application rates is used to determine different basic scores.

Table 11: Survey-based protocol for Low-Input farming approach. Section 3: grassland management

Section 3: Grassland management				
No.	**Practice name**	**Application rate (Kg N/ha/year)**	**Basic Score (BS*i*)**	**Weighted score (WS*i*)**
30.1	Application of inorganic fertilisers	No application	4	BSi * % $Area_i$
		<50	3	
		50-100	2	
		100-150	1	
		>150	0	
30.2	Application of animal manure	<50 (incl. no application)	4	BSi * % $Area_i$
		50-100	3	
		100-150	2	
		>150	1	
30.3	Application of sewage sludge and other sludge	No application	4	BSi * % $Area_i$
		<50	3.5	
		50-100	2.5	
		100-150	1.5	
		>150	0.5	
30.4	Application of compost	<50 (incl. no application)	4	BSi * % $Area_i$
		50-100	3	
		100-150	2	
		>150	1	
30.5	Application of soil amendments		NO = 4 YES = 2	BSi * % $Area_i$
30.7	Reseeding		NO = 4 YES = 1	BSi * % $Area_i$
	Score Section 3 = (Σ_i WS_i/Σ % $Area_i$)			

Note: % $Area_i$ indicates the share of the farm crop area on which the practice *i* is applied

Section 4 of the protocol (Table 12) covers aspects related to water and energy management/consumption, based on survey questions Q40, Q41 and Q43. For water, the information provided in columns C and D on the source of water used and the share of irrigated area is used in combination to determine the weighted scores. Fuel consumption is included in this section: here, a link with the FADN protocol is made, and fuel expenditure (after adjustments as explained in section 4.4.1) is used to determine the scores. Scores referring to questions 40 and 41 apply only to farms with arable or permanent crop area and pasture area, respectively (information derivable from survey question Q11).

Table 12: Survey-based protocol for Low-Input farming approach. Section 4: water and energy management and consumption

Section 4: Water and energy management/consumption				
No	**Practice name**			
		Source of water	**Basic Score (BS*i*)**	**Weighted score (WS*i*)**
40.1	Irrigation of arable and permanent crops area	No Irrigation	4	*BSi* * % $Area_i$
		Rainfall storage	4	
		Natural surface water courses	2	
		Artificial surface water courses	3	
		Ground water	0	
		Mains water supply	0	
40.2	Irrigation of pasture area	No Irrigation	4	*BSi* * % $Area_i$
		Rainfall storage	4	
		Natural surface water courses	2	
		Artificial surface water courses	3	
		Ground water	0	
		Mains water supply	0	
41.1	Soil mapping		NO = 2 YES = 2	*BSi* * % $Area_i$
41.2	Soil moisture sensing		NO = 0 YES = 3	*BSi* * % $Area_i$
41.3	Variable rate irrigation		NO = 0 YES = 3	*BSi* * % $Area_i$
Partial score water = (Σ_i WS_i/Σ % $Area_i$)				
42.3 b	Cost of total fuel consumed for machinery		0-4 Apply value from the FADN-based protocol for the relevant farm type	
Partial score fuel = [0-4]				
43.1	Improve energetic performance of specific buildings <u>with</u> recognised energetic certification		Yes =2 No = 0	
43.2	Improve energetic performance of specific buildings <u>without</u> recognised energetic certification		Yes = 1 No = 0	
43.3	Installation of Photovoltaic panels (electricity production)		Yes = 3.5 No = 0	
43.4	Installation of Solar panels (heat production)		Yes = 2.5 No = 0	
43.5	Installation of Wind turbines		Yes = 4 No = 0	

43.6	Production of energy/heat from geothermal sources		Yes = 4 No = 0
43.7	Biomass combustion		Yes = 2.5 No = 0
Partial score energy = Min (4, Σ*i* WS*i*)			
Score section 4 = (Partial score water + Partial score fuel + Partial score energy)/3			

Note: % $Area_i$ indicates the share of the farm crop area on which the practice *i* is applied

Section 5 (Table 13) deals with the type of livestock feed and is based on survey question Q34. In this case, the weights are represented by the product of the duration that the feed type was given (Nm = number of months, from column B in the survey questionnaire), by the LU*i* for each animal type to which the feed type was given. The latter is calculated by multiplying the number of animals provided in survey question Q31 by the specific coefficients used by Eurostat to calculate standard LU[8].

Table 13: Survey-based protocol for Low-Input farming approach. Section 5: livestock feed

Section 5: livestock feed				
No.	**Livestock type**	**Feed type**	**Basic Score (BS*i*)**	**Weighted score (WS*i*)**
Q34.1 to Q34.15	Grazing livestock (dairy cows, cull dairy cows, calves for fattening, suckler cows, goats, sheep, ewes)	Grazing on pasture	4	BS*i* * Nm*i* LU*j*
		Conserved forage: silage	3	BS*i* * Nm*i* * LU*j*
		Conserved forage: hay	4	BS*i* * Nm*i* * LU*j*
		Concentrates	0	BS*i* * Nm*i* * LU*j*
		Grains	2	BS*i* * Nm*i* * LU*j*
		Beets	3	BS*i* * Nm*i* * LU*j*
		Grazing on crop residues	4	BS*i* * Nm*i* * LU*j*
	Pigs and Poultry	Concentrated feed	0	BS*i* * Nm*i* * LU*j*
		Feed grain (wheat, barley, oats, triticale)	2	BS*i* * Nm*i* * LU*j*
		Mineral feed	2	BS*i* * Nm*i* * LU*j*
		Soy	1	BS*i* * Nm*i* * LU*j*
		Corn-cob-mix	3	BS*i* * Nm*i* * LU*j*
		Feed beans/peas	3	BS*i* * Nm*i* * LU*j*
		Potato protein	2	BS*i* * Nm*i* * LU*j*
		Supplements feeds	2	BS*i* * Nm*i* * LU*j*
		Grassfeed (like alfalfa, clover or other grass-pellets)	4	BS*i* * Nm*i* * LU*j*
		Grazing (pasture, forests, crop residues)	4	BS*i* * Nmi* LU*j*
		Whey	3	BS*i* * Nmi* LU*j*
		Feeding Lime (poultry only)	2	BS*i* * Nmi* LU*j*

[8] Available here: https://ec.europa.eu/Eurostat/statistics-explained/index.php?title=Glossary:Livestock_unit_(LSU)

		Expeller/cake from Soy, Linseed or Rapeseed (Poultry)	3	BS*i* * Nmi* LU*j*
		Oil (poultry)	3	BS*i* * Nmi* LU*j*
		"Grazing" on pasture (poultry)	4	BS*i* * Nmi* LU*j*
		"Grazing" on crop residues (poultry)	4	BS*i* * Nmi* LU*j*
Score Section 5 = (Σ_j Σ_i WS*i*/Σ Nm*i* *% LU*j*)				

Note: Nm*i* = number of months that feedtype *i* was given to livestock unit (LU) *j*

Section 6 (Table 14) covers other aspects of livestock management, namely total stocking density, livestock disease management (survey question Q35) and Livestock location (question Q36).

Table 14: Survey-based protocol for Low-Input farming approach. Section 6: Livestock management

	Section 6: Livestock management			
Farming aspect	**No.**	**Practice name**	**Basic Score (BS*i*)**	**Weighted score (WS*i*)**
Stocking density	Calculate as total grazing LU (Q31) over total foraging area (Q11_1a+ Q11_2)	Total stocking density = total LU/total foraging area	0-4. Apply score from the FADN-based protocol for the relevant farm type and biogeographical region	
Livestock disease management	35.1	Use of antibiotics for prevention, or for treatment and prevention	Yes = 0 No = 4	
	35.2	Use of antibiotics only for treatment	Yes = 2 No = 4 If 35.1 = yes, discard	
	35.3	Alternative remedies e.g. homeopathy or essential oils	Yes = 3 No = discard	
	35.4	Physical measures e.g. separation, aeration, minimum days outdoors	Yes = 4 No = 0	
	35.5	Trait selection	Yes = 3 No = discard	
Livestock location	36.1	Total no. of grazing days (Sum column C in survey questionnaire)	0-4. Apply score from the FADN-based protocol for the relevant farm type and biogeographical region	
	36.2			
Score section 6 = [Score stocking density + (Score disease management/n) + Score location]/3				

Note: In the partial score disease management, n indicates the number of not discarded answers

The final score for the Low-Input farming approach is calculated with the following equation 1:

$$\text{Low-Input score (Farm type j)} = \frac{\sum_{i=1}^{6} Score\ section_i * W_{i,j}}{\sum_{i=1}^{6} W_{i,j}} \quad (1)$$

where score section *i* refers to the score obtained by the farm in each section and W*ij* is a weighting factor representing the relative importance of that section for the *jth* farm type (TF8).Table 14 Table 15 shows the scores for each combination of section and TF8 farm type. Scores are expressed as percentages. Yellow cells indicate a section that may not be applied to the corresponding type of farm (e.g. sections 5 and 6 do not apply if the farm has no livestock). In these cases, the scores are simply not assigned and the final score is calculated using equation 1. In this case, too, the threshold for the holding to be classified as Low-Input farming is 3 over 4.

Table 15: Weights (in %) for the calculation of the final score for the Low-Input farming protocol, for different types of farm (TF8).

Type of Farm (TF8)	Section 1 Fertilisation of cropland	Section 2 Weed pest management	Section 3 Grassland management	Section 4 Water & energy	Section 5 Livestock Feed	Section 6 Livestock management
1 Fieldcrops	30	30	10	20	5	5
2 Horticulture	25	30	5	30	5	5
3 Wine	25	35	5	25	5	5
4 Other permanent crops	25	35	5	25	5	5
5 Milk	5	5	25	15	25	25
6 Other grazing livestock	5	5	25	15	25	25
7 Granivores	5	5	10	15	35	15
8 Mixed	20	20	10	10	20	20

4.5.3 Survey-based protocol – Integrated/Circular farming

The structure of the Survey-based protocol for the Integrated/Circular farming approach is similar to the Low-Input farming one, but here the focus is on the origin of inputs. The protocol is subdivided in 5 sections:

- Section 1: Origin of fertilisers (survey question Q26)
- Section 2: Origin of livestock feed
- Section 3: Origin of seeds, cuttings or plantlets
- Section 4: On-farm energy production
- Section 5: Integration with trees/livestock (agroforestry system)

Table 16 presents section 1 of the Integrated/circular farming protocol. This section is based on survey question Q26. In this case, the scores are calculating by combining the type of fertilisers and their origin. Origin from within the farm or from the neighbouring farm is considered equivalent following the reasoning expressed in section 3. It is assumed that by definition inorganic fertilisers can only come from outside the farm and that green manuring is always an on-farm practice. The share of cropland on which the fertilisation applies is also used in this case as a weighting factor to calculate the weighted scores. If the farm has UAA = 0, the score for this section = 0.

Table 16: Survey-based protocol for Integrated/Circular farming approach. Section 1: Origin of fertilisers

Section 1: Origin of fertilisers for cropland			
	Type of fertiliser	Origin of fertiliser: from within the farm or neighbouring farms/ from elsewhere	
No.		**Basic Score (BS*i*)**	**Weighted score (WS*i*)**
26.4	Application of inorganic fertilisers	NA/0	BSi * % $Area_i$
26.5	Application of animal manure	4/1	*BSi* * % Area
26.6	Application of sewage sludge and other sludge	3/2	*BSi* * % Area
26.7	Application of compost	3/2	*BSi* * % Area
26.9	Green manuring	4	*BSi* * % Area
Score Section 1 = (Σ_i WS*i*/Σ % Area)			

Note: % $Area_i$ indicates the share of the farm crop area on which the practice *i* is applied

Section 2 of the protocol is shown in Table 17 and evaluates the origin of livestock feed, if produced on farm, coming from neighbouring farms or from elsewhere. In general, origin from elsewhere is assigned a 0 score. A score >0 is assigned to grazing on pastures as "elsewhere" in this case would be most likely associated to the practice of transhumance, considered a traditional and ecological practice, especially in some countries (e.g. Alps and Pyrenees).

Table 17: Survey-based protocol for Integrated/Circular farming approach. Section 2: Origin of feed

Section 2: Origin of livestock feed			
Livestock type	**Feed type**	**Basic Score (BS*i*) (from within the farm or neighbouring farm/elsewhere)**	**Weighted score (WS*i*)**
Grazing livestock (dairy cows, cull dairy cows, calves for fattening, suckler cows, goats, sheep, ewes)	Grazing on pasture	4/3	BS*i* * Nmi* LU*i*
	Conserved forage: silage	3/0	BS*i* * Nmi* LU*i*
	Conserved forage: hay	4/0	BS*i* * Nmi* LU*i*
	Concentrates	0/0	BS*i* * Nmi* LU*i*
	Grains	2/0	BS*i* * Nmi* LU*i*
	Beets	3/0	BS*i* * Nmi* LU*i*
	Grazing on crop residues	4/2	BS*i* * Nmi* LU*i*
Pigs and Poultry	Concentrated feed	0 /0	BS*i* * Nmi* LU*i*
	Feed grain (wheat, barley, oats, triticale)	2/0	BS*i* * Nmi* LU*i*
	Mineral feed	0/0	BS*i* * Nmi* LU*i*

	Soy	1/0	BS*i* * Nmi* LU*i*
	Corn-cob-mix	3/0	BS*i* * Nmi* LU*i*
	Feed beans/peas	3/0	BS*i* * Nmi* LU*i*
	Potato protein	2/0	BS*i* * Nmi* LU*i*
	Supplements feeds	2/0	BS*i* * Nmi* LU*i*
	Grassfeed (like alfalfa, clover or other grass-pellets)	4/1	BS*i* * Nmi* LU*i*
	Grazing (pasture, forests, crop residues)	4/3	BS*i* * Nmi* LU*i*
	Whey	3/0	BS*i* * Nmi* LU*i*
	Feeding Lime (poultry only)	2/0	BS*i* * Nmi* LU*i*
	Expeller/cake from Soy, Linseed or Rapeseed (Poultry)	3/0	BS*i* * Nmi* LU*i*
	Oil (poultry)	3/0	BS*i* * Nmi* LU*i*
	"Grazing" on pasture (poultry)	4/2	BS*i* * Nmi* LU*i*
	"Grazing" on crop residues (poultry)	4/2	BS*i* * Nmi* LU*i*
Score Section 2 = (Σ_i WS*i*/Σ Nm*i* *% LU*i*)			

Note: Nm*i* = number of months that feedtype *i* was given to livestock unit (LU) *j*

Section 3 (Table 18) evaluates the origin of seeds, plantlets and cuttings (survey question 28). It applies to farms with arable land >0, if the farm has no arable area, this section is skipped and no score is calculated. Since multiple selections were allowed but no information on the relative share of seeds from different sources is provided, the final score is simply the average of the basic scores.

Table 18: Survey-based protocol for Integrated/Circular farming approach. Section 3: Origin of seed, cuttings or plantlets

Section 3: Origin of seed, cuttings or plantlet		
Q_28	**Origin**	**Basic Score (BS*i*)**
	Own production	Yes = 4 No = 0
	Other farmers / community seed banks	Yes = 3 No =0
	Purchased from commercial providers	Yes = No = 0
Score Section 3 = Σ_i BS*i*/i		

Section 4 accounts for the production of energy on farm (Table 19). Based on questions in section 2 of the survey questionnaire, no information on the amount of energy produced and the level of auto-consumption is provided, so similar to what is done in the Low-Input protocol, scores consider only the way in which energy is produced and not the total amount. In the case of biomass combustion, however, information on the origin of the biomass is present, so this is used to differentiate the scores.

Table 19: Survey-based protocol for Integrated/Circular farming approach. Section 4: on-farm production of energy

Section 4: On-farm energy production		
No	**Practice name**	**Basic Score BS*i***
43.1	Improve energetic performance of specific buildings with recognised energetic certification	Yes = 2
43.2	Improve energetic performance of specific buildings without recognised energetic certification	Yes = 1 No = 0
43.3	Installation of photovoltaic panels (electricity production)	Yes = 3.5 No = 0
43.4	Installation of solar panels (heat production)	Yes = 2.5 No = 0
43.5	Installation of wind turbines	Yes = 4 No = 0
43.6	Production of energy/heat from geothermal sources	Yes = 4 No = 0
43.7	Biomass combustion (from the farm or neighbouring farms)	Yes = 2.5 No = 0
	Biomass combustion (elsewhere)	Yes = 1.5 No = 0
Score Section 4 = Min (4, Σ*i* BS*i*)		

Finally, section 5 (Table 20) considers more specifically the integration of trees, livestock and crops in agroforestry systems, which are considered to be highly integrated and valuable from an ecological point of view (see e.g. Kay et al., 2019). Hence, a specific section is dedicated to such systems. Three main types of agroforestry are considered in the LIFT large-scale farmer survey questionnaire (question Q39), namely:

- Agroforestry on arable land, or silvoarable agroforestry, usually including the presence of hedgerow, windbreak and riparian buffer strips;
- Agroforestry on permanent grassland, including traditional silvopastoral systems such as *dehesas*, *montados*, wood pastures, with the presence of hedgerows, windbreaks, and riparian buffer strips;
- Agroforestry with perennial crops with grazing and intercropping of perennial crops.

The second and third types of agroforestry receive a higher score because they feature crop-livestock integration, which may not be present in the first one. If this section was not filled by the farmer respondent, no score is applied and the section is not considered in the calculation of the final score.

Table 20: Survey-based protocol for Integrated/Circular farming approach. Section 5: agroforestry systems

Section 5: Agroforestry systems		
No.	**Agroforestry type**	**Basic Score BS*i***
Q39.1	Agroforestry on arable land (silvoarable, hedgerow, windbreak and riparian buffer strips)	Yes = 3 No =0
Q39.2	Agroforestry on permanent grassland (silvopastoral practices such as dehesas, montados, wood pasture; and hedgerows, windbreaks, and riparian buffer strips)	Yes = 4 No =0
Q39.3	Agroforestry with permanent crops (grazing and intercropping of permanent crops)	Yes = 4 No =0
Score Section 5 = Min (4, Σ*i* BS*i*)		

The final score for the Integrated/Circular farming approach is calculated as the weighted average of the 5 scores received in the considered sections (equation 2). Weight ($W_{i,j}$) for the different TF8 are shown in Table 21.

$$\text{Integration/Circularity score (Farm type j)} = \frac{\sum_{i=1}^{5} Score\ section_i * W_{i,j}}{\sum_{i=1}^{5} W_{i,j}} \qquad (2)$$

The holding is classified as Integrated/Circular if the final score is ≥3.

Table 21: $W_{i,j}$ weights (in %) for the calculation of the final score for the Integrated/Circular farming protocol, for different types of farm (TF8).

Type of Farm (TF8)	Section 1 Origin of fertilisers	Section 2 Origin of livestock feed	Section 3 Origin of seeds, cuttings or plantlets	Section 4 On-farm energy production	Section 5 Agroforestry system
1 Fieldcrops	30	20	20	15	15
2 Horticulture	30	20	20	15	15
3 Wine	30	20	15	15	15
4 Other permanent crops	30	20	15	15	15
5 Milk	25	35	10	15	15
6 Other grazing livestock	25	35	10	15	15
7 Granivores	25	35	10	15	15
8 Mixed	20	20	15	15	15

4.5.4 Survey-based protocol – Organic farming approach

Using the survey, belonging of the holding to the Organic farming approach can be evaluated directly through either survey question Q8.1 or Q9.2 (in both cases, with reference to the year 2018, column A). If the reply to any of these two questions is YES, the farm is classified as organic and no other checks are necessary. However, in the approach presented here we are not focusing on organic farming in terms of official certification, also considering that some farmers may decide, for different reasons, not to apply for it even if they comply with all the requirements. Therefore, the protocol allows to evaluate also “organic-equivalent” approaches, i.e. if a farm complies with organic rules as established by Regulation 848/2008 regardless if it has the certification. The checks to perform with regard to the survey items are sown in Table 22 below; all conditions must be met in this case. For fertilisation, the criteria in the EU regulation is that the total amount of organic Nitrogen cannot exceed 170 kg N/ha per year. This is not precisely evaluable through the information provided in the survey, so in this case a threshold of 200 kg/ha in total (considering the sum of animal manure and compost, using the upper value of the intervals) is applied as a proxy. In principle, this would allow a farm exceeding the established limit to be still classified as organic, which can introduce a certain level of error. Nevertheless, as all other conditions must be met as well, this is considered less prone to inaccuracy than the establishment of a stricter threshold such as 150 kg N/ha.

Table 22: Survey-based protocol for Organic farming approach.

	No.	Criteria/practice	Check
Preliminary check (for any type of farm)	Q8.1 or Q9.2	Participation to Organic schemes and/or obtainment of the organic certification	Q8.1 = YES OR Q9.2=YES. If none =YES, check the following items
Criteria for crops area	20.1	Chemical products (insecticides/fungicides)	20.1 [A] = NO
	23.1	Chemical products (herbicides)	23.1 [A] = NO
	26.4 and 30.1	Application of inorganic fertilisers to cropland or grassland	26.4 [A] = NO 30.1 [A] = NO
	26.5, 26.7, 30.2, 3 0.4	Application of animal manure and application of compost	(Manure + compost) ≤ 200 kg N/ha in cropland (Manure + compost) ≤ 200 kg in grassland
	26.4; 30.3	Application of sewage sludge and other sludge	26.4 [A] = NO 30.3 [A] = NO
	29.1	Crop rotation (only for farms with arable land >0, otherwise, skip)	29.1 = YES
Criteria for livestock	Q11, Q33	Foraging area > 0 OR Grazing on common land	(Q11_1a + Q11_2 + arable area used to produce fodder) >0

			OR Q33 = YES
	Q11, Q31	Total livestock density	(LU_tot/Q11) ≤ 2
	Q31 column [C]	Access to outdoor grazing	For each animal type present on farm, column C = YES
	Q35.2	Use of antibiotics for prevention of diseases	Q35.2 = NO

4.5.5 Survey-based protocol – Agroecological farming approach

The protocol for the Agroecological farming approach is based on the combination of the scores obtained from the application of the protocols for the previous approaches, plus additional information on the presence and abundance of ecological infrastructure on farm, derived from survey question Q38. In this case, the share of the area covered by the different features acts as basic scores (the median point of the range interval is considered), and the expert scores are used as weights (Table 23). The partial score obtained from the weighted average is normalised to the 0-4 range using the formula shown in the last row of Table 23.

Table 23: Scoring system for the evaluation of the Ecological Infrastructure Dimension in the protocol for the Agroecological farming approach

Type of element	**Basic score *BSi* (column C, share of UAA covered)**	**Weight (*Wi*)**
Hedgerows	≤5% = 2.5 5% - 10% = 7.5 10% - 15% = 12.5 15% - 20% = 17.5 ≥ 20% = 20	4
Bushes		2
Wet areas		3
Tree lines		3
Woodland on UAA (coppice, afforested areas, woodlots, etc.)		4
Isolated trees		2.5
Field margins		4
Buffer strips		3
Flower strips		3.5
Terraces		2.5
EI = Partial score Ecological Infrastructure = (Σ_i*BSi***Wi*/Σ_i *Wi*)**		
Final Score Ecological Infrastructure = Max (4, EI/4)		

Belonging to the *Agroecological farming* approach is assessed through the following equation. In addition, the farm must have a score ≥2 for each of the Conservation Agriculture, Low-Input farming and Integrated/Circular farming approaches

Total agroecological score = (Score Conservation Agriculture + Score Low-Input farming + Score Integrated/Circular farming + Score Ecological Infrastructure)/4

5 Application of the protocols in selected case study areas

In this section we present the results from the application of the protocols to real farms from different case study areas: for the FADN-based protocol, application to specialist dairy and cattle farms in Austria and France is shown; for the Survey-based protocol, we show the application to specialist olive and vineyards farms in Greece.

5.1 Application of the FADN-based protocol to dairy farms in Austria (BOKU)

In WP3 of LIFT, specifically in Tasks 3.2 and 3.4, the BOKU team of LIFT implemented the LIFT farm typology using the FADN-based protocol on a set of specialised Austrian dairy farms in order to differentiate farms according to the degree of ecological approaches adopted by farms. Several specifications of the protocol were tested in order to assess how different assumptions would affect the results of the LIFT farm typology. Specifically, the allocation of farms to the groups of the LIFT farm typology was calculated in four different ways. On the one hand, threshold values for the score assignment were calculated based on all farms in the EU FADN dataset as defined in the EU-wide FADN protocol (as in this deliverable). On the other hand, calculations only for all Austrian farms in the EU FADN dataset were carried out. Namely, first a subset was created, comprised of only Austrian FADN farms and, then, threshold values for the scores based on this reduced dataset were derived, using the software developed by Thompson et al. (2021). However, in that process none of the calculation rules for the scores have been changed. In order to assess the effect of the weights on the overall scores, these calculations were carried out for unweighted and weighted sub-indicator scores for the calculation of overall (weighted) average scores for Low-Input and Integrated/Circular farming approaches.

Results of the implementation of the LIFT farm typology to a dataset of Austrian specialised dairy farms in the FADN data, when pooling the years 2011-2015 (n = 4,073 observations) are shown in the four Venn diagrams below (the size of the sets is not proportional to the number of farms in that set, though). The results of this exercise show how the composition of the different farming approaches varies depending on the underlying dataset. If the thresholds derived from the whole EU-FADN dataset are used (Figure 4 and Figure 6), a larger number of farms is classified in the Integrated/Circular approach or a mixture of Integrated/Circular and Organic. At the same time, few farms are classified as Low-Input or any combination of Low-Input with other farming systems. In turn, if the Austrian sub-sample of the FADN data is used to calculate thresholds for the scores (Figure 5 and

), the number of Integrated/Circular farms or combinations of Integrated/Circular farms with other farming systems decreases significantly, while the number of farms classified as Low-Input or a combination of Low-Input with other farming approaches increases. These differences do not indicate that one of the two approaches is worse or better than the other, they simply reflect the different regional focus of the underlying threshold calculations for the individual indicators.

With respect to weighting, a tendency is that with weighted scores, more farms are classified Standard and more farms are classified Organic only, compared to the unweighted scores, regardless of whether the full FADN dataset or the Austrian subsample is used for calculations. The weights thus make it more difficult for farms to be classified as one of the score-based farming systems, (Low-Input, Integrated/Circular or a combination of these farming approaches or with other farming approaches), which reflects that not all sub-scores are equally important for the categorisation.

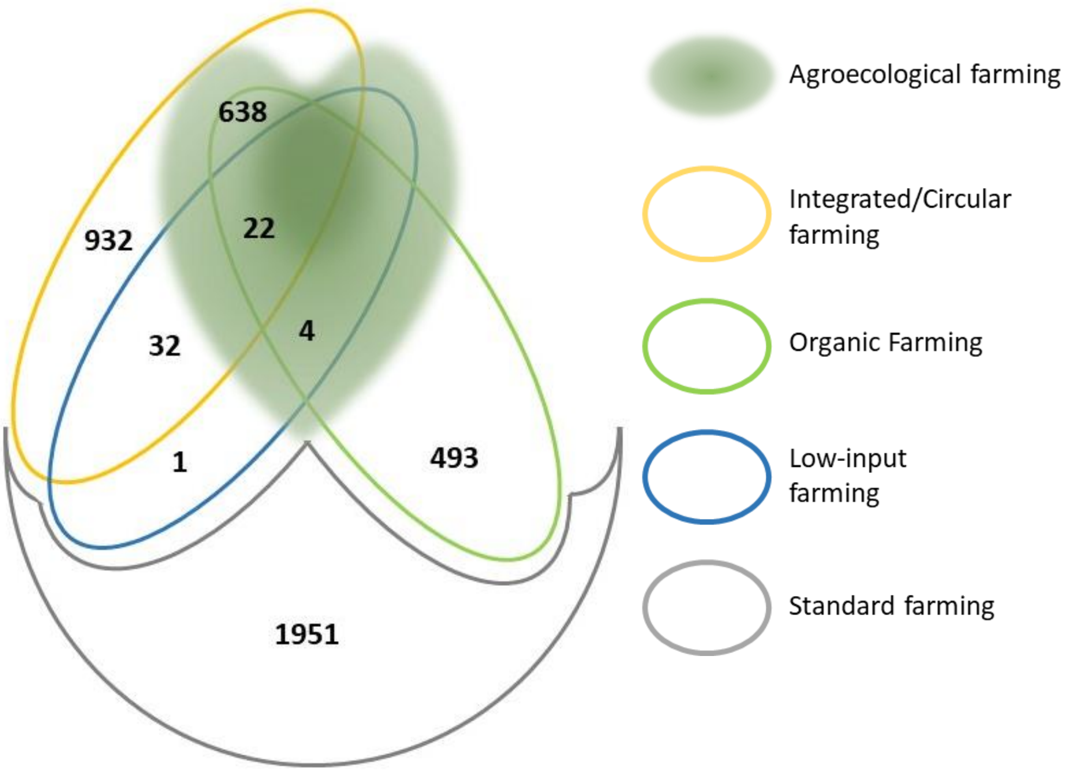

Figure 4: LIFT farm typology results of Austrian specialised dairy farms (t = 2011-2015, n = 4,073 observations), based on thresholds derived from the full EU-FADN dataset (unweighted)

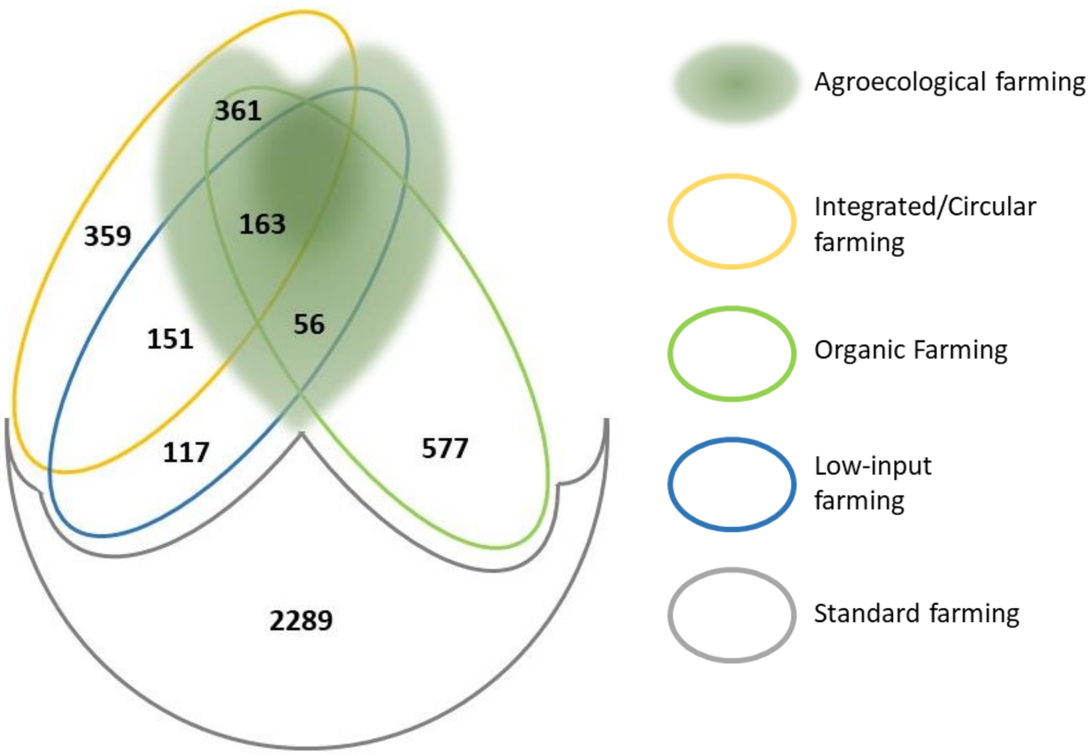

Figure 5: LIFT farm typology results of Austrian specialised dairy farms (t = 2011-2015, n = 4,073 observations), based on thresholds derived from the EU-FADN dataset, containing only Austrian farms (unweighted)

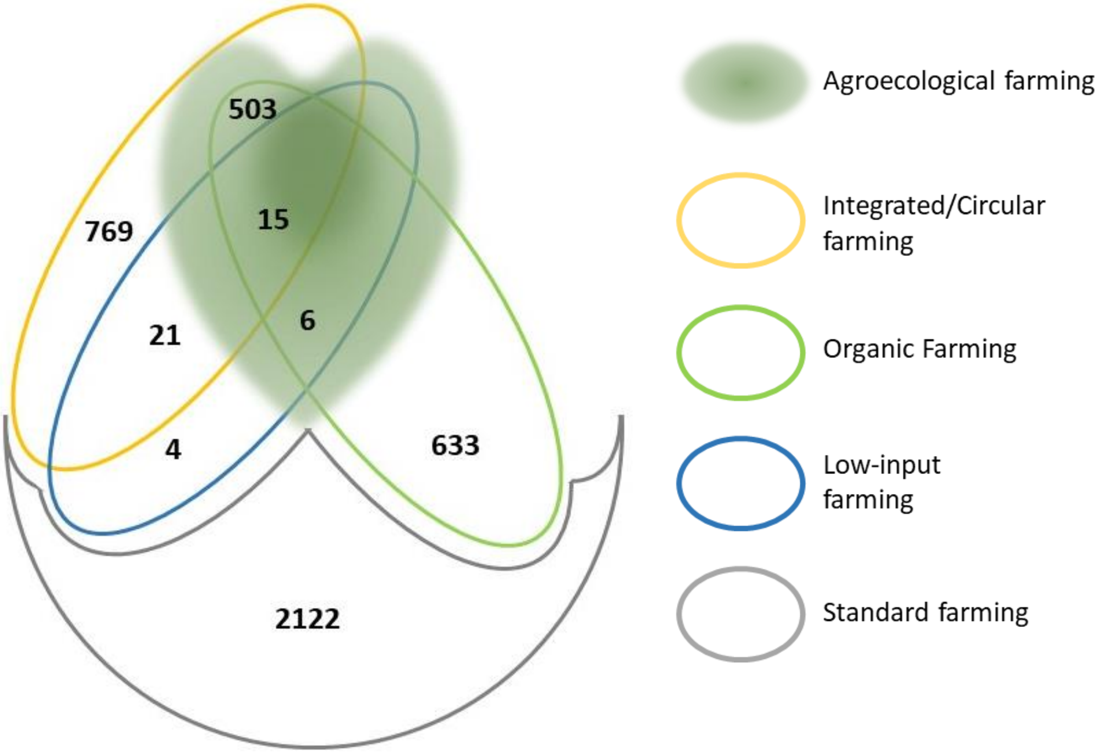

Figure 6: LIFT farm typology results of Austrian specialised dairy farms (t = 2011-2015, n = 4,073 observations), based on thresholds derived from the full EU-FADN dataset (weighted)

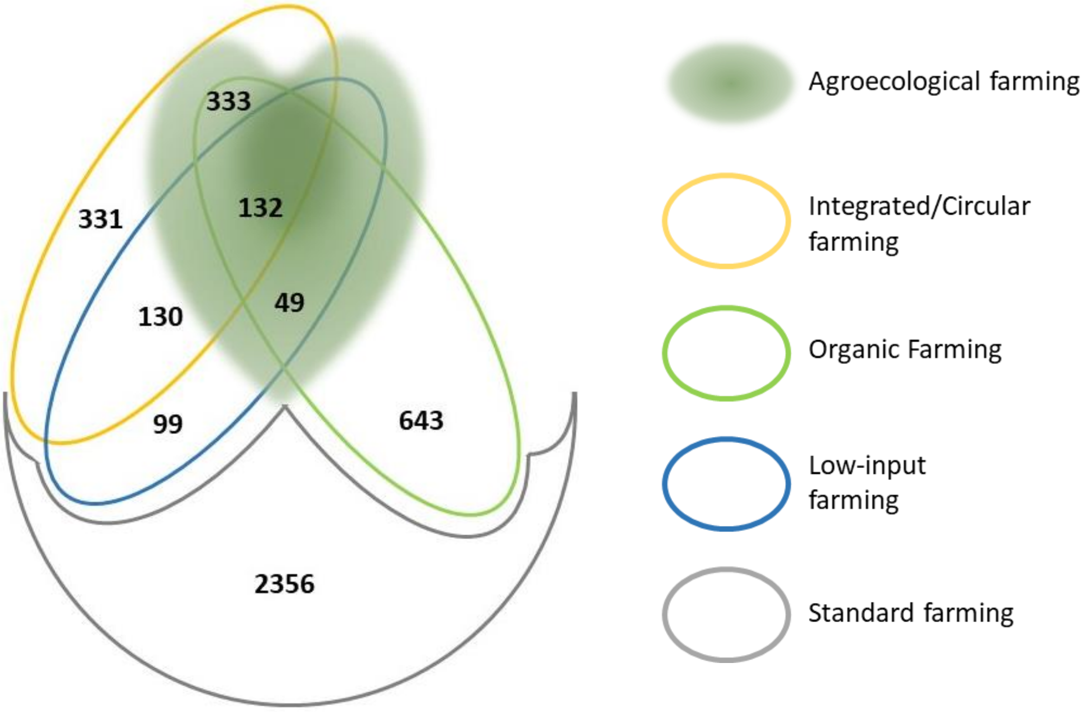

Figure 7 LIFT farm typology results of Austrian specialised dairy farms (t = 2011-2015, n = 4,073 observations), based on thresholds derived from the EU-FADN dataset, containing only Austrian farms (weighted)

5.2 Application of the FADN-based protocol to specialist dairy and beef cattle farms in France (INRAE and VetAgro Sup)

In this section, we describe the application of the FADN protocol (section 4.2) to EU FADN data for France and specifically for dairy farms and beef cattle farms (TF14 = 45 and 49 in FADN, see Table 1 in section 3) by the INRAE-VetAgro Sup team of LIFT.

5.2.1 The FADN samples

The FADN samples used here consist in 5,280 and 4,685 observations (pooled years), respectively for the dairy farms and beef cattle farms, over the period studied 2011-2015. Table 24 shows the descriptive statistics of the two samples for main characteristics and for the variables used in the typology protocol.

Table 24: Averages and standard deviations of describing variables over 2011-2015 for the French FADN dairy and beef cattle farm samples

		Dairy farms			Beef cattle farms		
Name of the variable	**FADN code**	**Average**	**Std dev**	**Valid obs.**	**Average**	**Std dev**	**Valid obs.**
Utilised agricultural area (ha)	SE025	99.1	55.9	5,280	126.8	70.3	4,685
Number of livestock units	SE080	108.4	59.4	5,280	142.8	85.0	4,685
Total farm labour (AWU)	SE010	1.96	0.98	5,280	1.64	0.83	4,685
Variables used in the protocol							
Stocking density	(SE085 + SE090 + SE095) / (SE71)	1.5	0.6	5,278	1.5	5.2	4,669
Grazing on common land	GRAZDAYS / (SE085 + SE090 + SE095)	14.3	16.5	63	22.5	27.5	57
Fertilisation	SE295/SE025	96.4	58.2	5,278	61.3	46.4	4,677
Livestock feed	(SE310 + SE320) / SE080	344.5	148.8	5,280	169.6	127.9	4,685
Pest control	SE300/ SE025	48.8	41.1	5,278	22.5	26.6	4,677
Water use	IWATR_V/ SE080	14.6	14.5	5,280	7.9	8.4	4,685
Energy use - fuels and lubricants	(IHFULS_V+IFULS_V) / SE080	78.5	34.1	5,280	56.8	25.2	4,685
Energy use - electricity	IELE_V*/SE080	32.1	16.8	5,280	10.8	9.5	4,685
Machinery & building - upkeep	SE340*/SE080	155.9	80.2	5,280	101.1	53.0	4,685
Total physical assets (depreciation)	SE360*/SE080	382.1	183.8	5,280	226.0	123.9	4,685
Own feed production	(SE315+SE325) / (SE310+SE320)	0.14	0.16	5,280	0.20	0.21	4,641
Electricity - own production	ONRGPRD_SV / IELE_V	6.9	4.3	22	12.0	7.35	19
Seed - own ratio	SE290 / SE285	0.11	0.13	1,238	0.18	0.20	1,355

5.2.2 Distribution of farms per ecological type over the full period 2011-2015

Figure 8 and Figure 9 show the distribution of farms in each type of farming approaches, in percentages for the whole period 2011-2015, and Table 25 provides a summary of five types, recalling that the types are not exclusive except for Standard farming. The percentages for both samples are within the same range for Standard farms (about 80-82% of the samples), Integrated/Circular farms (about 10-11%) Low-input farms (about 6-8%), and Organic farms (about 5-6%).

Table 25: Percentages of the FADN French dairy farms in types of farming approaches (2011-2015)

Farming approaches	% of farms of the dairy sample	% of farms of the beef sample
Standard farming	80.2	82.7
Low-Input farming	7.7	5.7
Integrated/Circular farming	11.8	9.9
Organic farming	6.2	4.9
Low-Input farming and Integrated/Circular farming and Organic farming	0.8 that is to say 43 farms out of 5,280 or about 8 farms per year	0.2 that is to say 11 farms out of 4,685 or about 2 farms per year

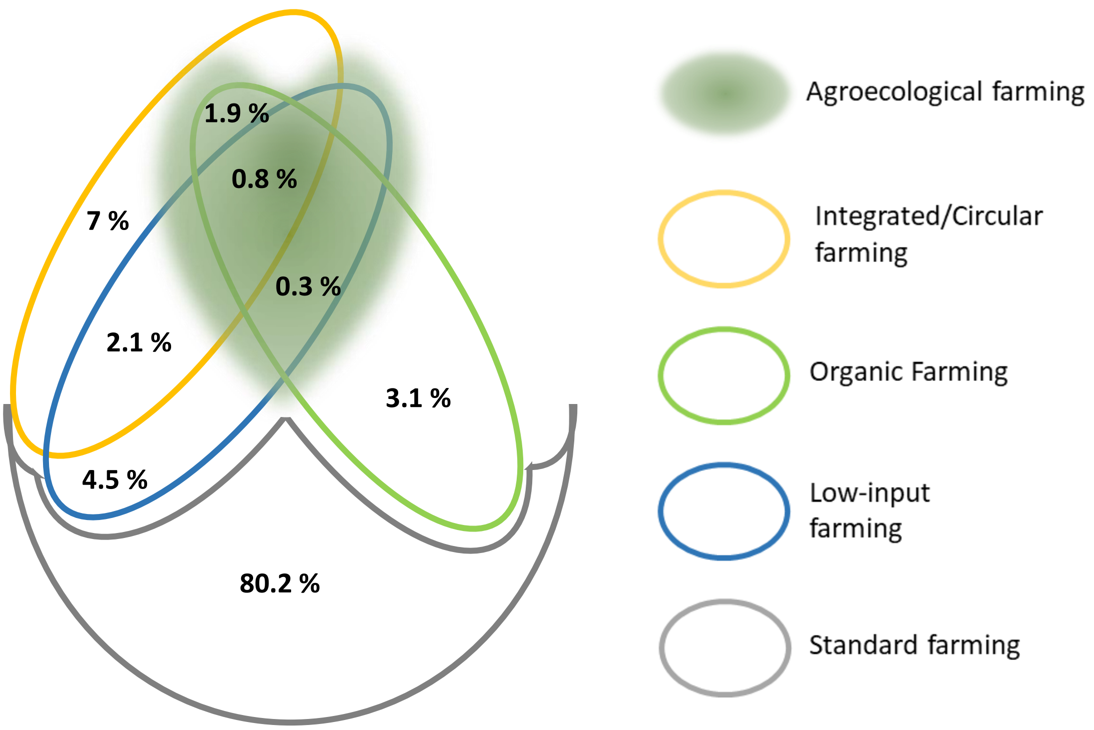

Figure 8: Distribution of the FADN French dairy farms in the types of farming approaches (2011-2015)

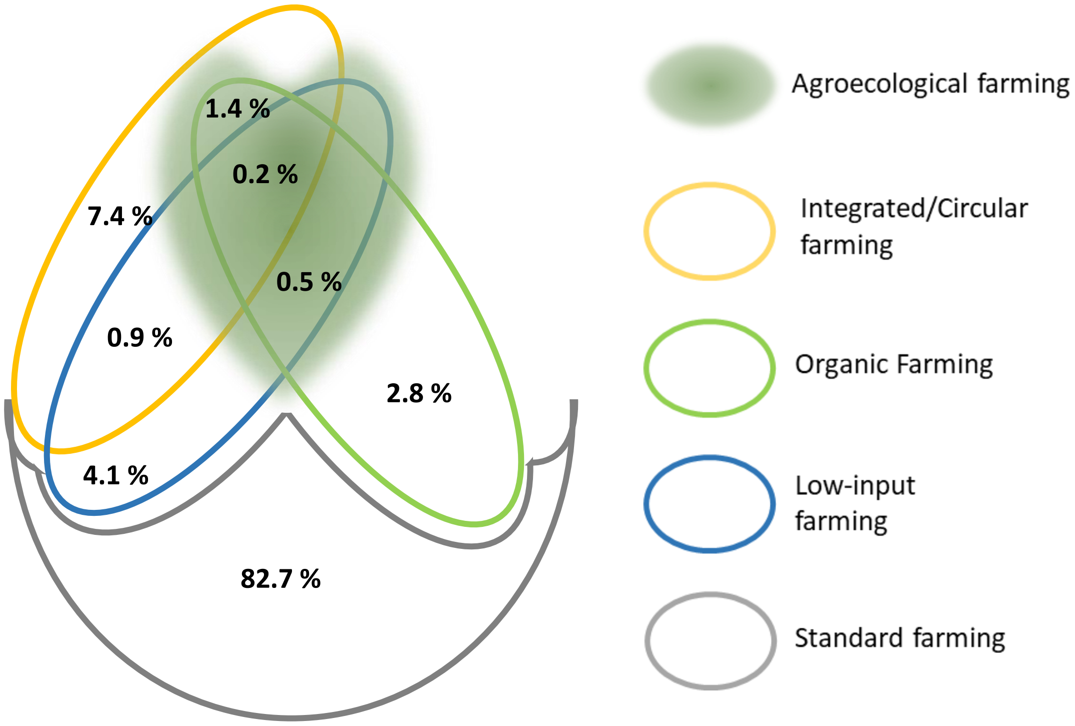

Figure 9: Distribution of the FADN French beef cattle farms in the types of farming approaches (2011-2015)

5.2.3 Yearly distribution of farms across farming approaches

Erreur ! Source du renvoi introuvable. shows the evolution of the distribution of farms in the e cological types Low-Input, Integrated/Circular and Organic, while **Erreur ! Source du renvoi introuvable.** is for farms in the ecological types Organic only, Low-Input-Organic, Integrated/Circular-Organic, and Low-Input-Integrated-Organic. In both figures, the evolution for dairy farms is shown in the left panel, while the evolution for beef farms is shown in the right panel.

Erreur ! Source du renvoi introuvable. shows that although the percentage of Organic farms is low, it h as been continuously increasing slightly over the period. By contrast, the percentages of Low-Input farms and Integrated/Circular farms have been decreasing, in particular Low-Input farms since 2013, although the percentage of Integrated/Circular farms has been increasing since 2013. Looking at the evolution of Organic farms (**Erreur ! Source du renvoi introuvable.**), the percentage of Organic farms only (no Integrated/Circular, no Low-Input) has increased, as well as the percentage of farms Integrated/Circular-Organic. But the percentages of Low-Input Organic and Low-Input-Integrated/Circular-Organic farms have decreased in the last years.

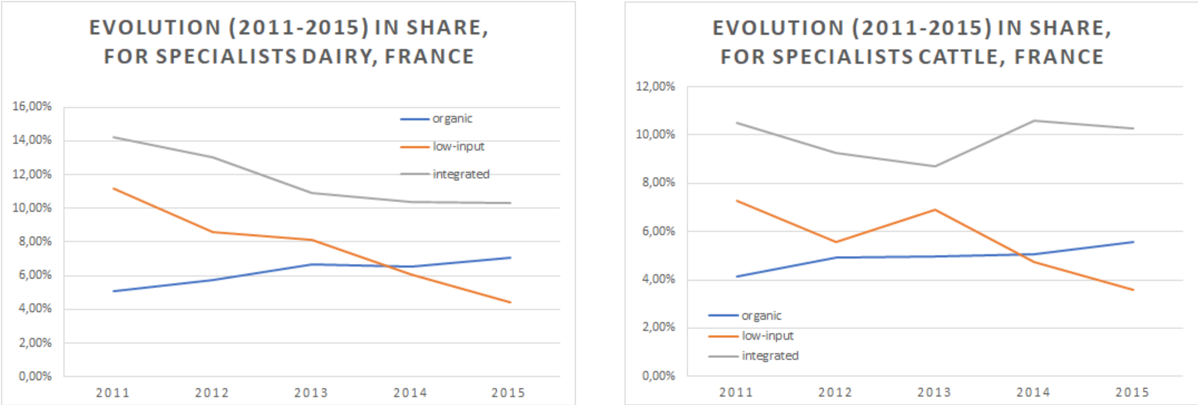

Figure 10: Evolution of the proportion of Low-input, Integrated/Circular and Organic farms in the FADN French dairy farms (left panel) and beef cattle farms (right panel) (2011-2015)

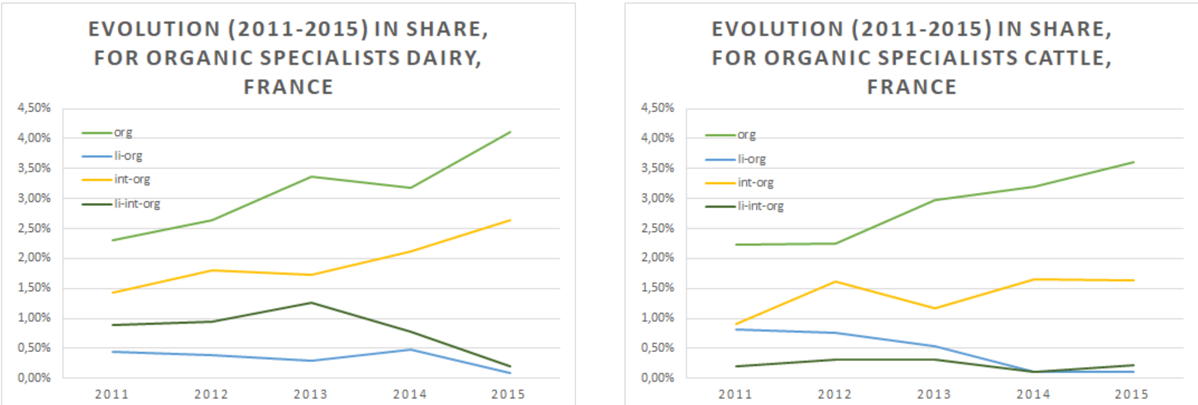

Figure 11: Evolution of the proportion of Organic only farms (org), Low-Input-Organic farms (li-org), Integrated/Circular-Organic farms (int-org), and Low-Input-Integrated/Circular-Organic farms (li-int-org) in the FADN French dairy and beef cattle farms (2011-2015)

We contrast the distribution evolutions with the evolution of variables that are used in the typology protocol. The evolution of these variables as averages for the sample per year is shown for dairy farms on Figure 12. The figure clearly shows an increase in the use of livestock feed and pest control over the whole period, which could explain the decrease in the share of Low-Input farms. Fertilisation has been increasing up to 2013, and then decreasing.

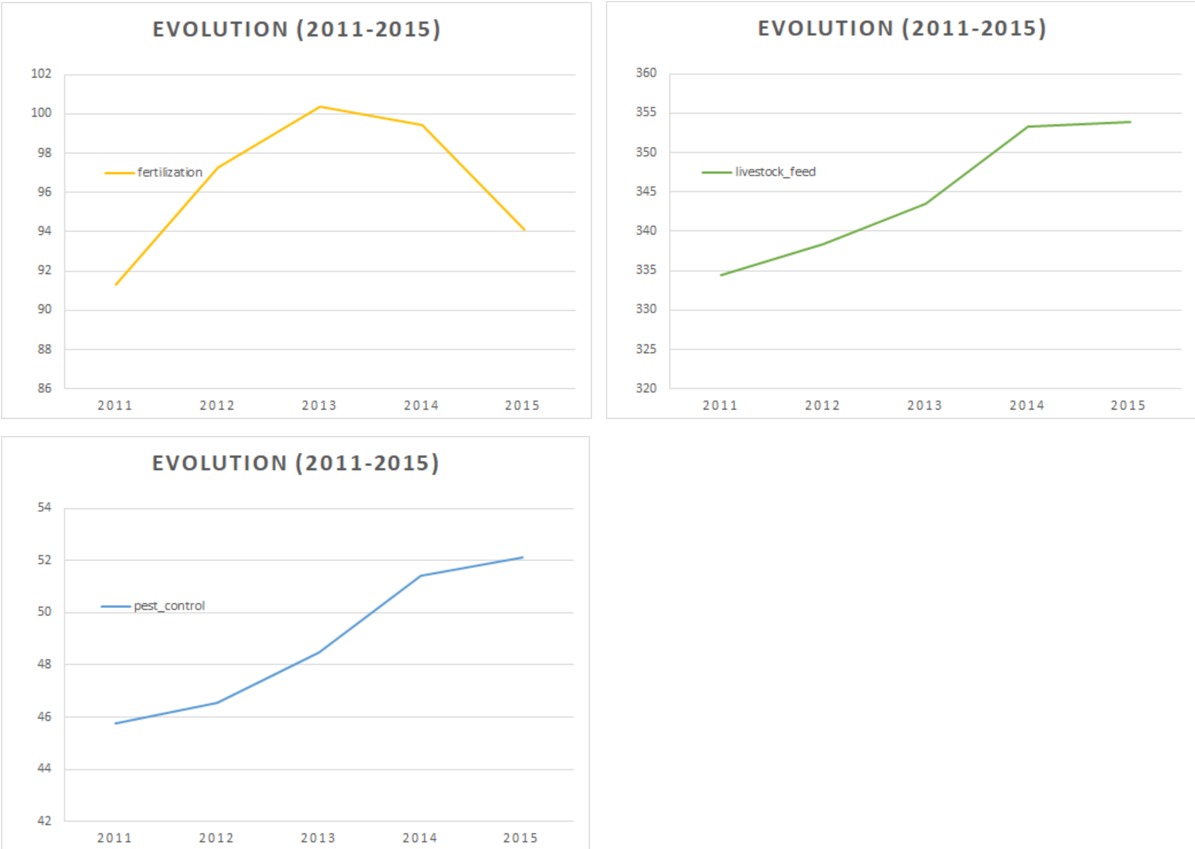

Figure 12: Evolution of the protocol variables of fertilisation, livestock feed and pest control for the FADN French dairy farms

5.2.4 Discussion

Compared to other EU countries, there are not many organic farms in France. This widely known fact is reflected in the small percentages of organic dairy farms and beef cattle farms in the typology above. The above results however give new information, in relation to Low-Input farms and Integrated/Circular farms. There are more Low-Input farms and more Integrated/Circular farms than Organic farms, and there are very few farms that have the highest degree of ecological uptake, namely Low-Input and Integrated/Circular and Organic farming simultaneously: 0.8% over 2011-2015 for dairy farms, 0.2% for beef cattle farms. Another piece of information revealed with this application is the unfavourable evolution of the ecological farms, as the percentages of Low-Input farms and Integrated/Circular farms have been largely decreasing over the period.

From a methodological point of view, one issue relates to the way water is integrated in the protocol. According to the protocol, a highest (most favourable) score is assigned to a farm if it has zero water use for livestock farms. However, this does not make sense for livestock farms where the watering of animal is a bare necessity. One possibility could be to decide on the minimal quantity and to score farms based on the excess quantity. Another (simpler and quicker) solution would be to ignore water and to discard it from the protocol. This latter solution has been applied to the French dairy farms for illustration, and the distribution of farms per ecological type over the period is shown in the right panel of Figure 13. The left panel of Figure 13 is exactly Figure 8 above and recalls the distribution of farms when water is included in the protocol. The percentages in each type of farming approaches are very similar in the left and right panel. This suggests that the simple solution to ignore water in the protocol for grazing livestock farms, may be appropriate, but it would have to be confirmed for other samples.

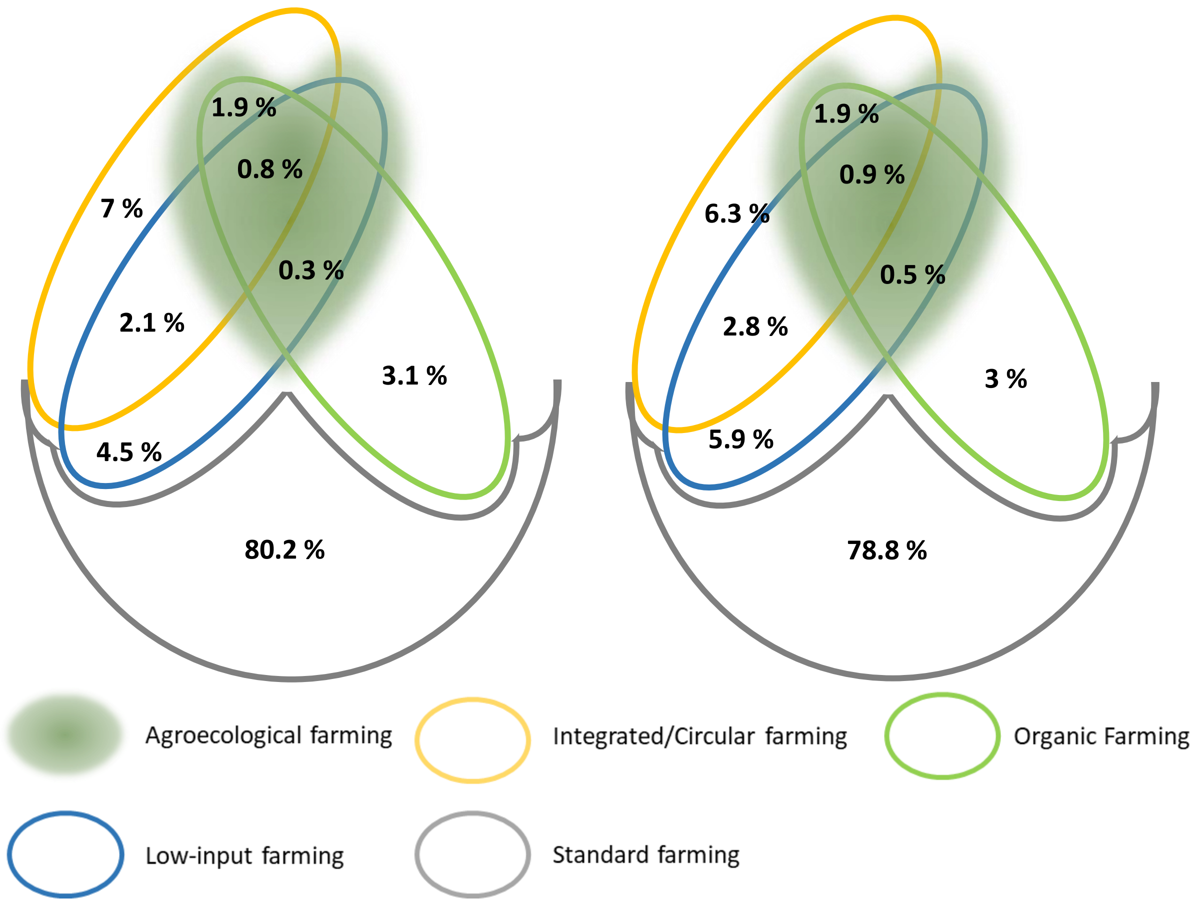

Figure 13: Distribution of the FADN French dairy farms in the types of farming approaches (2011-2015), accounting for water (left panel) and not accounting for water in the protocol (right panel)

5.3 Application of the FADN-based protocol to specialist olives and vineyards farms in Greece (DEMETER)

In this application, carried out by the DEMETER team of LIFT, FADN data covering the period 2004-2015 were used. As an initial step, farms whose ID was used for the entire time-period of interest were isolated. This process was deemed necessary, given that FADN has an annual renewal rate of 20-25% in the farm IDs used. Therefore, for the period 2004-2015, the sample size was 1,162 farms. A preliminary check was conducted, to examine how many of the Greek farms were Organic (Table 26Table 7). It is evident from Table 26 below that most Greek farms do not apply any organic methods.

Table 26: Number of farms in different "ORGANIC" classifications.

	Years											
Classification	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***
Not organic	1,139	1,140	1,122	1,094	1,095	1,086	1,090	1,088	1,088	1,082	1,078	1,071
Fully organic	8	6	21	29	31	38	28	33	37	39	42	5

Partially organic	15	16	19	39	36	38	44	41	37	41	42	86
In conversion	0	0	0	0	0	0	0	0	0	0	0	0
Total	***1,162***	***1,162***	***1,162***	***1,162***	***1,162***	***1,162***	***1,162***	***1,162***	***1,162***	***1,162***	***1,162***	***1,162***

Following the protocol, fully organic farms and partially organic ones, ranging between 1.9% and 7.8% of the sample, were classified in the Organic farming approach. We thus focused on not organic farms for the application of the protocol. This preliminary check indicated that the number of organic farms in Greece has been increasing in the considered period (Figure 14).

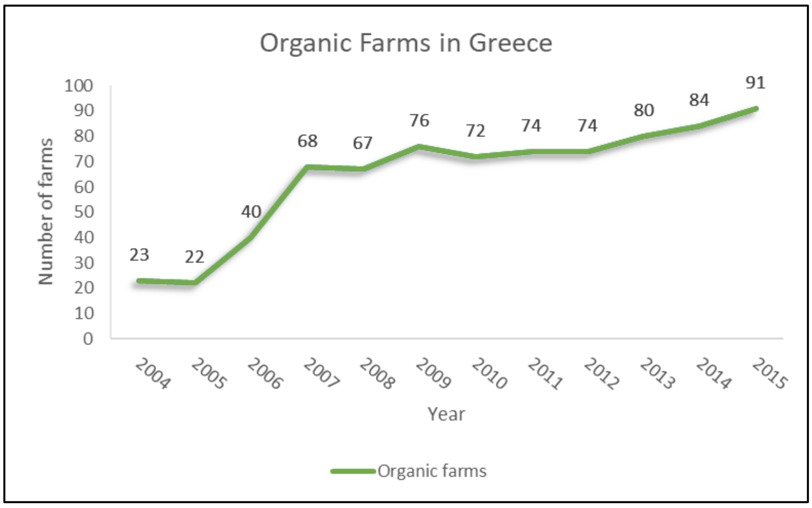

Figure 14: Organic farms in FADN Greek sample.

To be more precise, in 2015, most Organic farms in Greece were specialist olives, while the rest specialised in the cultivation of combined permanent crops, orchards and fruits, and lastly, wine grapes (Figure 15).

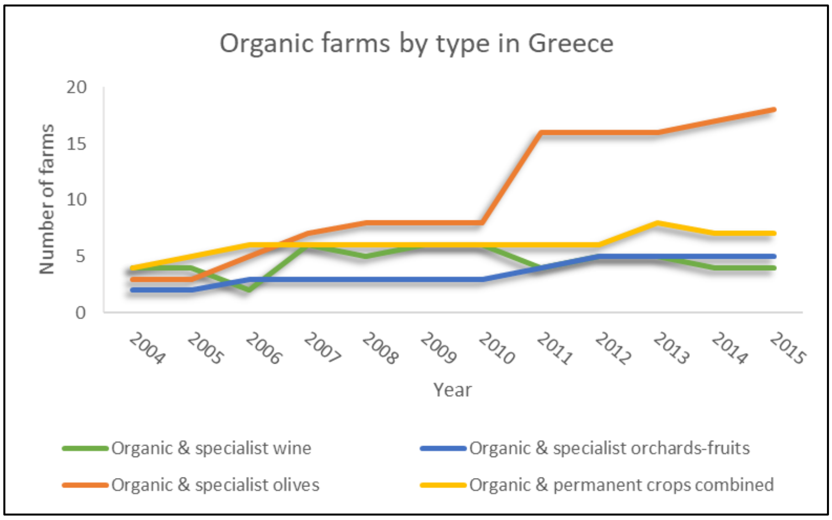

Figure 15: Organic farms in FADN Greek sample, by type (TF14)

To test the Low-Input and the Integrated/Circular farming approaches, we considered the time period between 2010 and 2015 and since some farms transitioned from non-organic, to organic during that period, only farms that were registered as non-organic for the entire time period were kept in the sample. Thus, the final sample size consisted of 291 farms.

Next, the variables of interest were isolated and adjusted for inflation and prices, as described in section 4.2. More specifically, the Low-Input and Integrated/Circular protocols were applied on the following types of farm: specialist olives, specialist vineyards, specialist orchards and fruits, and permanent crops combined farms.

What is evident from the results is that before applying the typology protocol, most of the farms in the sample were not considered to be Organic. However, after the application of the typology protocol, it is evident that there are several farms that can be classified into a different farming approach than Standard farming. To be more precise, on average, 10% of farms are Organic; while out of the 90% of farms that are not Organic, approximately 31% are Low-Input and 60% have not been classified otherwise (Table 27).

Table 27: Results of the application of the FADN-based protocol to Greek farms (permanent crops).

	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Total farms	291	291	291	291	291	291
Organic	19	25	27	29	29	30
Not organic farms	272	266	264	262	262	261
Of which						
Low-Input	79	78	73	78	63	100
Integrated/Circular	0	0	0	0	0	0
Standard Farming	193	188	191	184	199	161

It is interesting to note that no overlaps between the different farming systems exist. That is, in the Greek case, there are no farms that are Low-Input and Integrated/Circular simultaneously, as can be seen from the figures below (Figure 16, Figure 17 and Figure 18).

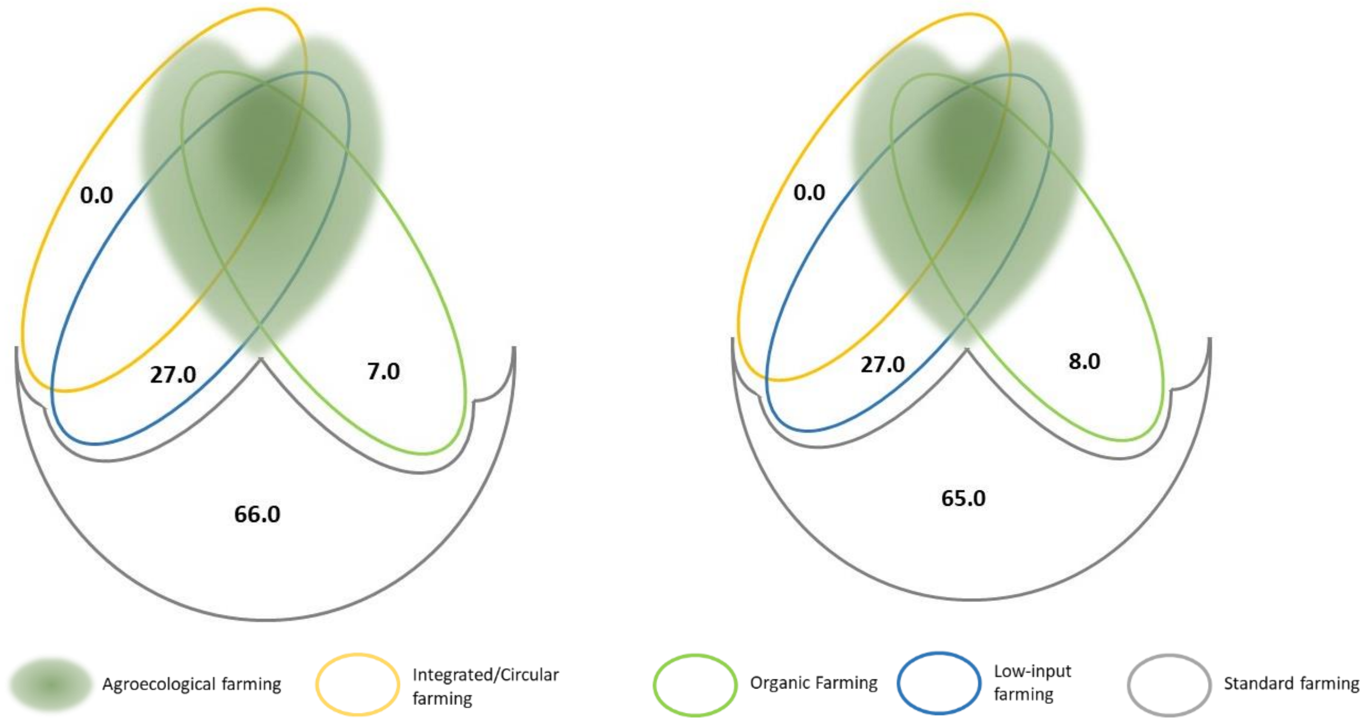

Figure 16: Results of the application of the FADN-based protocol on Greek case study in 2010 (left) and 2011 (right). Figures indicate percentages. (n = 291 observations)

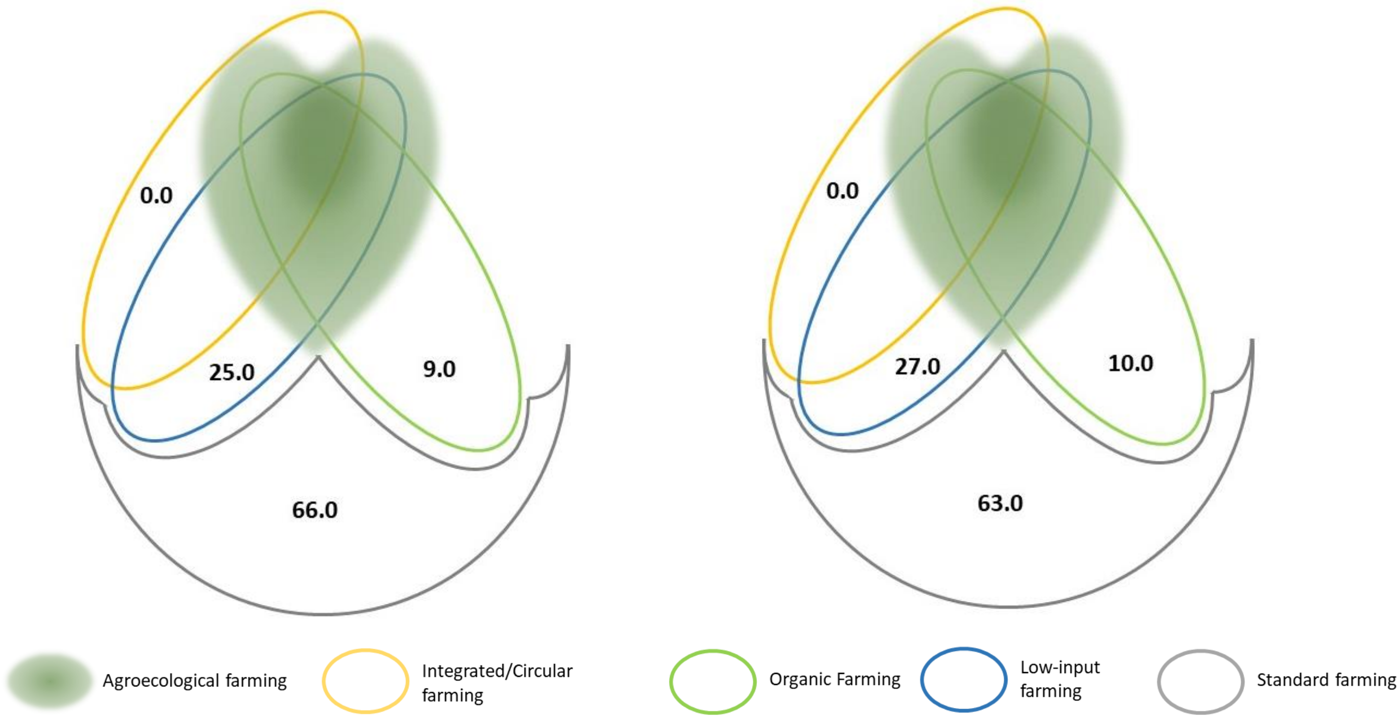

Figure 17: Results of the application of the FADN-based protocol on Greek case study in 2012 (left) and 2013 (right) Figures indicate percentages. (n = 291 observations).

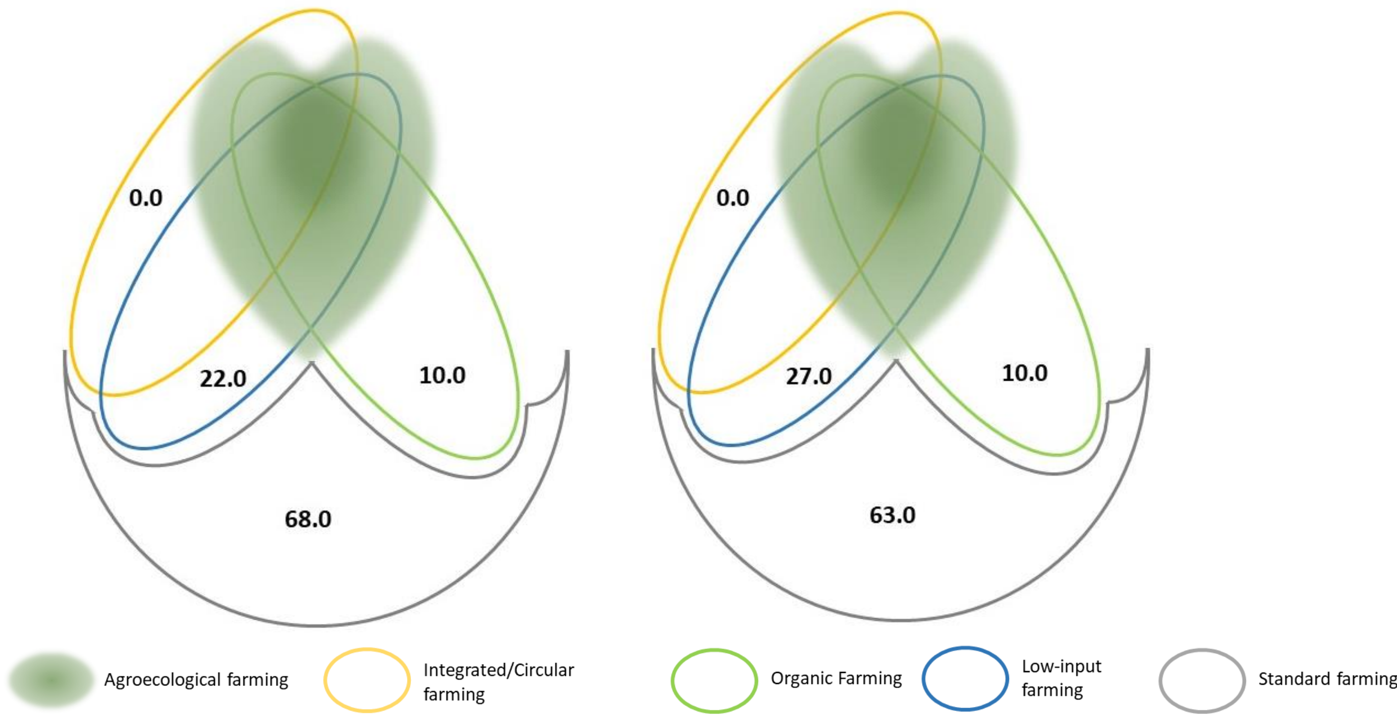

Figure 18: Results of the application of the FADN-based protocol on Greek case study in 2014 (left) and 2015 (right). Figures indicate percentages. (n = 291 observations).

5.4 Application of a pilot version of the Survey-based protocol to permanent crops farms in Greece (DEMETER)

In this section, we report on the testing of an earlier version of the Survey-based protocol on Greek farms (specialist olives). Also, in this case, the exercise is used to illustrate the iterative process and interactions that took place between the JRC team in LIFT (Task leader) and other LIFT partners, whose feedback was used to incrementally refine the methodology and the architecture of the protocol.

Initially, an early version of the Survey-based protocol, grounded in a combination of pre-defined conditions and "IF, AND, OR" operators (see also section 5.1 on the Austrian application), was examined by the DEMETER team for its compatibility with respect to the olive cultivation for the Greek case study area. More specifically, the examination focused on the following issues:

- The validity of the existing conditions concerning the Greek case study, as well as the possibility of adjusting these conditions to meet the requirements for the specific case study.
- The need for creating new and/or additional conditions based on critical factors for the Greek case study agricultural practices for each farming system, that were not originally included.
- The availability of data from the LIFT large-scale farmer survey, that in some cases were required as inputs for the conditions of the protocol.

To this end, the DEMETER team explored and combined information from various different sources; that is, the conditions from the preliminary version of Survey-based protocol; the practices applied in each farming system for olive cultivation, according to regulations and relevant literature (e.g., Balafoutis et al., 2014; Berg et al., 2018; European Commission, 2007; Pleguezuelo et al., 2018); the practices from the LIFT large-scale farmer survey questionnaire and the available data collected for the Greek case study; information regarding the protocol's key features and links with data sources from LIFT's Milestone MS3 (Rega et al., 2020a).

One of the main identified issues was the lack of data regarding nitrogen (N) quantities from inorganic fertilisers and compost, as Greek farmers were unable to answer this question of the LIFT large-scale farmer survey, and thus, application of the relevant conditions mentioned in the preliminary protocol was not possible. On the other hand, the aforementioned exploratory research revealed the need to further examine whether conditions regarding landscape features and habitats, density and irrigation of olive groves - a particularly important practice in the Greek case - should also be taken into account. Finally, another important issue that arose was the need to establish thresholds to classify a farm as Low-Input or Integrated/Circular. Next, all relevant feedback was communicated to the JRC team, and a dynamic, continuous process of collaboration was initiated between JRC and DEMETER; information and ideas as regards possible solutions to all the challenges that occurred during the development of the protocol, turned into an iterative process of testing and adjustments.

One significant outcome of the initial discussions was that the preliminary protocol based on "IF, AND, OR" conditions proved too restrictive and difficult to apply. This was consistent with the feedback received from test applications in Austria (section 5.1). Hence, the choice was to adopt a more flexible scoring system for the development of the final protocol. As a next step, a new version of the protocol using a weighted scoring model was developed by the JRC team. Based on this, a dynamic excel model was set up by the DEMETER team, that allowed breaking down each condition and simultaneously gave the ability to test various scores and weights. The main issue revealed during testing was the difficulty to find objective ways to define threshold values for the sub-protocols of Conservation Agriculture, Low-Input and Integrated/Circular farming approaches[9]. To address this issue, an exercise was sent to selected Greek experts who were asked to assign a score to selected farming practices according to their significance for olive cultivation (see section 8 Acknowledgements). To that end, the exercise along with guidelines was prepared by the DEMETER team and emailed to seven experts (researchers and university professors) with a strong background in the cultivation of olives and ecological practices. From the data collected, three responses were identified as outliers, as their scores showed an abnormal distance from the corresponding values observed in the other four responses. The final scores for each farming practice were thus calculated as the averages of the scores given in the four responses. The result of this exercise is shown in

[9] This issue did not occur in the protocol for Organic farming, as the criteria used there, concerned only the non-use of certain practices (i.e., chemical products and inorganic fertilisers) and a quantity threshold on application of animal manure (i.e., ≤ 150 N kg/ha).

Table 28 below. Selected practices cover the key aspects of soil conservation and overall input intensity. For Integrated/Circular farming, the same scores assigned in the Low-Input protocol were used, adjusted by combining them with the information on the origin of the input (from within the farm, from neighbouring farm or from elsewhere).

Table 28: Criteria, farming practices and scores used for each farming approach in the Survey-based protocol.

Farming Approaches	Criteria	Farming practices	Scores if YES (NO=0)
Conservation Agriculture	*Main criterion 1: Soil tillage intensity*	Conventional tillage	0
		Conservation tillage	8.5
		No tillage	10
	Main criterion 2: Soil cover	Planting of cover crops	7.25
	Additional criterion 1: Fertilisation	Leaving crop residues on soil	9.5
		Planting of catch crops	6.25
		Crop rotation	6.25
		Mixed cropping	6.75
Low-Input farming	*Main criterion 1: Fertilisation*	Inorganic fertilisers	1.75
		Animal manure	9.25
		Compost	8.75
		Soil amendments	7.5
	Main criterion 2: Weed, pest and plant disease management	Chemical products (insecticides/fungicides)	1.25
		Chemical products allowed by organic regulations (insecticides/fungicides)	6.75
		Chemical products (herbicides)	1.25
		Chemical products allowed by organic regulations (herbicides)	6.75
		Quantity of chemical products applied, lower than what was recommended by the manufacturer	2

For the criteria regarding fuels, tree density and water, scores were not derived from experts' judgement but were derived from the range of values of the variables themselves. The range of values was computed based on the minimum, maximum and mean values and divided into 8 classes[10]. Next, the score applied was made proportional across the ranges and lied between 0 and 1.75 (Table 29). Lastly, in both Low-Input and Integrated/Circular farming approaches, the higher the variable range, the smaller the score given to the farm.

[10] Water (% of UAA applied) is broken down into 6 different ranges, as is in the LIFT large-scale farmer survey questionnaire.

Table 29: Scores assigned to fuel, tree density and water usage in Greek farms, based on values ranges[11]

Farming practice	Ranges	Scores
Fuel (litres)	0-1000	1.75
	1000-2000	1.5
	2000-3000	1.25
	3000-4000	1
	4000-5000	0.75
	5000-6000	0.5
	6000-7000	0.25
	>7000	0
Fuel (cost)	0-500	1.75
	500-1000	1.5
	1000-2000	1.25
	2000-4000	1
	4000-6000	0.75
	6000-10000	0.5
	10000-15000	0.25
	>15000	0
Tree density: Orchards excluding olives No. trees/ha	0-1000	1.75
	1000-2000	1.5
	2000-3000	1.25
	3000-4000	1
	4000-5000	0.75
	5000-6000	0.5
	6000-7000	0.25
	>7000	0
Tree density: Olive groves No. trees/ha	0-80	1.75
	80-150	1.5
	150-200	1.25
	200-250	1
	250-300	0.75
	300-350	0.5
	350-400	0.25

[11] The scores and ranges are the same for both Low-Input and Integrated/Circular farming approaches.

	>400	0
Tree density: vineyards No. plants/ha	0-1000	1.75
	1000-2000	1.5
	2000-3000	1.25
	3000-4000	1
	4000-5000	0.75
	5000-6000	0.5
	6000-7000	0.25
	>7000	0
Water (quantity in litres)	0-100000	1.75
	100000-300000	1.5
	300000-600000	1.25
	600000-1000000	1
	1000000-3000000	0.75
	3000000-6000000	0.5
	6000000-10000000	0.25
	>10000000	0
Water (% of UAA irrigated)	*less than 5%*	1.75
	between 5 and 25%	1.5
	between 25 and 50%	1.25
	between 50 and 75%	1
	between 75 and 100%	0.75
	100%	0.15

As in the FADN-based protocol, the value of UAA in which each farming practice was applied, was also utilised in this case, to obtain a level of intensity. More specifically, for each practice, a score was calculated as the product of the average score assigned by the experts and the weight assigned based on the percentage of UAA in which the farming practice was applied. The latter differed between the farming approach, as practices considered in Conservation Agriculture are beneficial for the environment, hence the larger the UAA on which they are applied, the higher the score, whilst in the Low-Input and Integrated/Circular ones they represent production input, hence the opposite is true. The weights used can be seen in Table 30 below.

Table 30: Scores assigned according to the UAA range a farming practice was applied on, for different farming approaches

Ranges of the UAA a farm practice was applied on	Conservation Agriculture	Low-Input farming and Integrated/Circular farming
less than 5%	*0.025*	*1*
between 5 and 25%	*0.15*	*0.8*
between 25 and 50%	*0.375*	*0.6*
between 50 and 75%	*0.625*	*0.4*
between 75 and 100%	*0.875*	*0.2*

Next, the calculated score averages were applied in the model and after performing a sensitivity analysis, the values of the weights for each of the criteria were finalised (see Table 31 below). The score for each farming practice was then calculated as the quotient of the weighted sum of scores of the criteria, divided by an area weight. The area weights were computed using information on the percentage of UAA where the farming practice was applied, in accordance with Table 30 above.

Table 31: Values of the weights for each of the criteria used in the Survey-based protocol, by farming approach.

Criterion	Conservation agriculture	Low-Input farming	Integrated/Circular farming
Main criterion 1	5	3	3
Main criterion 2	3	2.5	2.5
Main criterion 3	-	2	2
Additional criterion 1	2	1.25	1.25
Additional criterion 2	-	1.25	1.25

Lastly, the final score that considered information for all farming practices, was calculated as the weighted sum of each criterion and was in turn normalised in a scale of 0 to 10, according to the following formula (3):

$$Normalised\ score = (max - min) * \left[\frac{(score_i - min)}{(score_{max} - score_{min})}\right] + min \qquad (3)$$

where,

$\max = 10, which\ is\ the\ max\ value\ of\ the\ range\ in\ which\ the\ normalised\ values\ should\ belong$

$min = 0, which\ is\ the\ min\ value\ of\ the\ range\ in\ which\ the\ normalised\ values\ should\ belong$

$score_i = the\ value\ of\ the\ final\ score\ for\ farm\ i,$

$score_{max} = the\ maximum\ value\ of\ all\ farm\ scores$ and

$score_{min} = the\ minimum\ value\ of\ all\ farm\ scores.$

The final typology results can be seen in Figure 19 below, for the sample of the Greek case study (n = 108 farms).

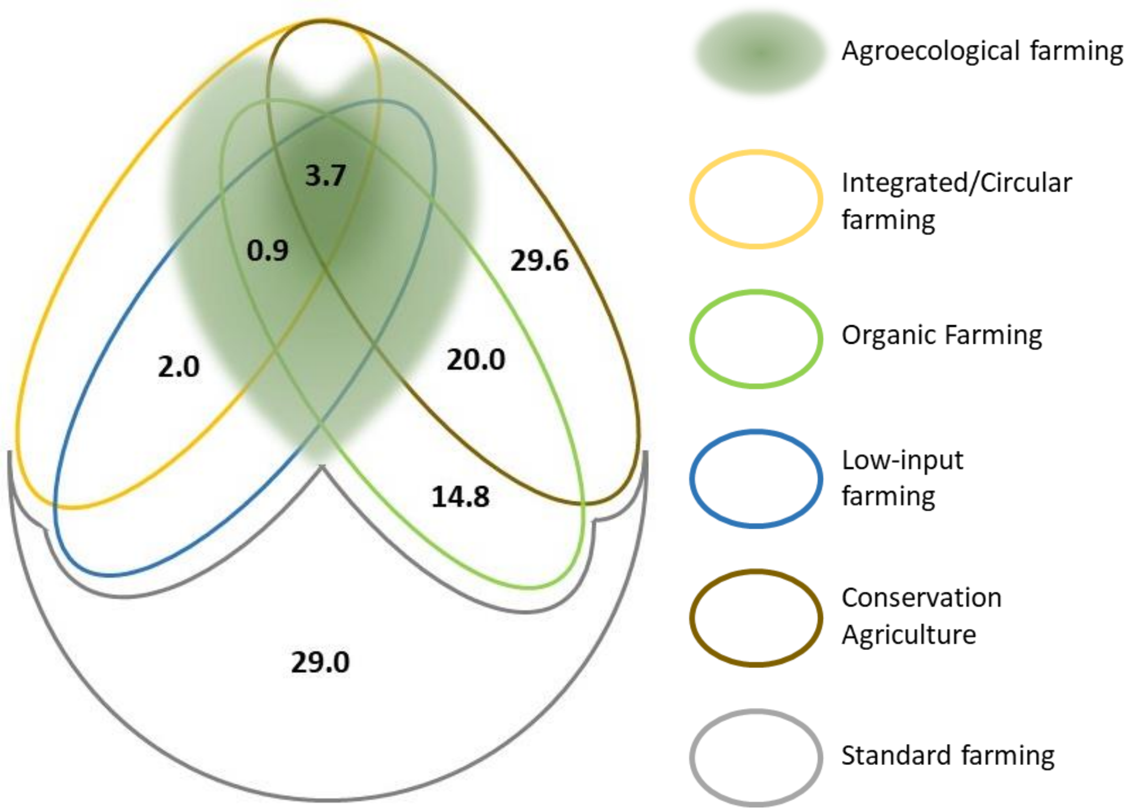

Figure 19: LIFT farm typology results of the Greek case study (t = 2018,), based on LIFT large-scale farmer survey dataset. Figures indicate percentages (n = 108 observations)

6 Discussion and Conclusions

6.1 Potentialities, limitations and further development of the protocols

As shown in the previous section, the development of the protocols has been an iterative and interactive process, whereby feedback from test applications was used to incrementally refine the protocols architecture. The Austrian and Greek case study farms were used to test preliminary versions of both the FADN- and the Survey-based protocols, through intense exchange between the respective teams. Starting from the farm typology of D1.1 (Rega et al., 2018), several versions of the protocol were tested, each time intensively discussing the selected indicators and making several adjustments in an iterative process. Additionally, the overall methodological approach of the protocols was discussed. The first version of the protocol consisted of a set of pre-defined conditions, combined by "AND" / "OR" Boolean operators. When applying this approach to Austrian and Greek data from the LIFT large-scale farmer survey data, it became clear that it was associated with two major drawbacks: firstly, thresholds for indicators were pre-defined and could thus become out-of-date rather quickly. Secondly, the allocation to farming systems was rather restrictive. For example, if a farm did not comply with only one condition defined for a farming system, it did not qualify as such.

This led to the choice of a more flexible scoring system as the final architecture of the protocols, as described in the previous section. Another advantage of the selected method is that it is a multi-scale approach and allows users to adjust the implementation of the LIFT farm typology to different needs. Firstly, the thresholds for scores can be updated if new data become available and/or can be adjusted for datasets with different spatial coverage. For example, if the aim of an analysis is to identify groups of the LIFT farm typology at the European level, the thresholds for scores, derived from the full EU FADN dataset are most suitable, whereas when groups of the LIFT farm typology in a specific country/region need to be identified, the threshold values can be recalculated based on farm data from that country/region. Secondly, the weights proposed for the individual sub-indicators which are used to calculate overall scores for different farming approaches, can also be adapted to different regional conditions.

The involvement of experts to assign scores to practices in the Survey-based protocol also emerged as the preferred strategy for this protocol. A 0-4 score range was chosen for this protocol as well as to keep consistency with the FADN-based scores, and final scores presented in section 4.5 reflect a more general evaluation compared to the more specific ones presented in section 5.3 on Greek olive farms. However, the exercise carried out in the Greek case study proved very useful to test this approach and results informed the choice of the final scores.

The definition of the thresholds is crucial for assigning a farm to one (or more) of the LIFT farming approaches. At this regard, it is important to notice that: 1. the thresholds can be fine-tuned as more data and information become available, but once considered final, they should not be changed any longer, to allow for monitoring to take place; 2. the definition of what is agroecological or not is based on a concept and a statistical data analysis, and not on absolute thresholds fixed a priori. Some in-depth analysis should be carried out on farms classified by the protocols as agroecological, to cross-check if the thresholds need further adjustments (e.g. if they are too wide or too restrictive) and eventually derive absolute thresholds.

Both protocols described in this deliverable present potentialities and limitations, mainly derived from the underlying dataset used to elaborate them. A general consideration is that the protocols, as all systems combining scores and weights, encompass a certain level of subjectivity. This includes the values assigned to weights, but also the range of scores (0-4 in this case) and their granularity. The final proposal reflects the effort of finding a balance among limiting the possibilities for subjective decisions, maximising the accuracy and easing the application. The main limitation of the FADN-based protocol, as said, is that in the current version it is not able to evaluate two of the identified ecological dimensions of farming constituting the typology, i.e. soil conservation and presence of ecological infrastructure. Potential inaccuracies may also stem from the price adjustment procedure described in section 4.2. Potential improvements to this regard include the use of more detailed data on price level differences of selected inputs across EU countries. It is considered, however, that any potential error resulting from the current adjustment procedure is comparatively lower than the error that no adjustment procedure at all would imply. More generally, the thorough analysis carried out on FADN data also led to the identification of current knowledge gaps in this database with respect to the evaluation of farm environmental characteristics, on which we specifically report in next section 6.2.

As for the Survey-based protocol, it is foreseen to widen the pool of experts to be consulted to assign scores, with the aim to include as much as possible expert knowledge on different types of farm from a variety of geographical contexts in Europe. In general, whilst this deliverable presents an operational version of the protocols, they should be considered as a first version to be further adjusted and improved as application advances and additional feedback is collected.

In terms of potential application, the main advantage of the FADN-based protocol is that it can be used by whoever has access to FADN microdata. Application within and outside the project will be also facilitated by the LIFT digital tool (the LIFT typology-tool) planned in WP1 task 1.4. The tool is intended to be used not only by scholars but also by farmers, advisory systems and regional administrations. It is devised as a generic, free software type, complying with General Data Protection Regulation (GDPR) rules and easily modifiable as new data become available. Application of the FADN-based protocol through the tool is also foreseen as part of the training in the LIFT Massive Open Online Course (MOOC) under development.

6.2 Identification of knowledge gaps in the current FADN and recommendations for the transition to the Farm Sustainability Data Network

As mentioned, one of the results of the work carried out in task 1.3 and specifically in the analysis of the FADN was the identification of knowledge gaps in the current structure of this database with regard to its potential use to evaluate farms' environmental performances. FADN has already been identified as a potentially usable dataset for this purpose in previous research projects (notably FLINT - Farm Level Indicators for New Topics in policy evaluation,[12] see Poppe and Vrolijk, 2016) and literature (e.g. Uthes and Herrera, 2019; Dabkiene et al., 2021). Accordingly, the extension of its scope to cover farm practices with significant environmental implications has been widely advocated by field scholars (e.g. Kelly et al., 2018; Vrolijk et al., 2016). In the new policy framework set by the EU Green Deal, the '*proposal for a revision of the Farm Accountancy Data Network Regulation to transform it into a Farm Sustainability Data Network with a view to contribute to a wide uptake of sustainable farming practices'* is indeed one of the key actions included in the Farm to Fork Strategy (European Commission, 2020). Along these lines, we report here on the main data gaps identified in FADN from the point of view of the application of the LIFT typology.

Firstly, current data allow evaluating only one of the three main aspects of soil conservation, i.e. crop diversity. FADN in fact provides detailed information on the acreage of each crop cultivated on farm, so this would easily allow deriving a synthetic diversity indicator at the farm level. Conversely, information on the other two aspects (tillage management and soil coverage) is scarce or absent.

[12] https://www.flint-fp7.eu/

Currently, no information on tillage management is available; as regards cover crops, there is one variable (M_AI_10318_0_0_N) reporting the number of areas with catch crops greening subsidy, which is far from being sufficient to derive any meaningful indicator on this aspect.

Concerning the degree of internal integration, FADN already provides valuable information on feed and seeds own-production and use, but no information on the use of own-produced manure as source of fertiliser. This additional data would be very valuable to provide a more detailed assessment of the degree of circularity of the farm. This type of information seems to be very much sensible with regard to the objectives of reducing fertilisers use by 20% established by the Farm to Fork Strategy.

More generally, echoing previous research (e.g. Vrolijk et al., 2016) it is argued that environmental sustainability assessment through FADN data would greatly benefit from the collection of more physical data complementing financial/monetary figures. Improvements in this direction have already been implemented, for instance starting from 2014 information on the quantity of Nitrogen (N), Phosphorus (P_2O_5) and Potassium (K_2O) in kilograms is available. These variables were not used in the current version of the protocols due to the limited time series available (2 years) and the identification of discrepancies between these figures and costs incurred for fertilisers is some cases; nonetheless, this represents a promising source of information for future application, once data collection methods are harmonised and longer time-series are available. Along similar lines, quantitative information on plant protection products and water use would greatly improve the ability of FADN to provide a fuller picture of the environmental performance of individual holdings. For the water use, well-known technical difficulties arising from the lack of meters or other reliable measurement sources should be addressed. Conversely, information on quantities of purchased plant protection products is most likely available in the majority of the cases from the same invoice used to obtain costs (Vrolijk et al., 2016). In general, it has been shown how this type of information is currently already being collected in some Member States – which shows possibilities for practical implementation – and therefore that existing data collection methods and networks can be used to this purpose in a cost-effective way (*ibid.*).

A final specific recommendation stemming from the elaboration of the protocol is the usefulness of data on the presence and area of landscape features present on farms. From the ecological point of view, the presence of seminatural habitats on farm is essential for halting and reversing biodiversity loss in agricultural areas. This is explicitly acknowledged by the Biodiversity Strategy for 2030, which proposes a target of 10% of the agricultural area to be devoted to high-diversity landscape features including, *inter alia*, buffer strips, rotational or non-rotational fallow land, hedges, non-productive trees, terrace walls, and ponds. How and to which extent translating this aspirational target into legally binding regulations in the new CAP (for instance, in GAECs) is currently being negotiated between the European Commission, the EU Parliament and the European Council. In the LIFT typology, this is a key component for the identification of the agroecological farming approach.

7 Deviations or delays

None

8 Acknowledgements

We are grateful to the experts who were involved in the assignation of the scores in the Survey-based protocol: Ernesto Tabacco - Department of Agriculture, Forest and Food Sciences, University of Turin, Italy; Dr. Alexandra Solomou - Researcher, Hellenic Agricultural Organisation "Demeter" (HAO – DEMETER), Institute of Mediterranean & Forest Ecosystems, Athens, Greece; Dr. Vassilis D. Gkisakis - CEO & founder, Agroecologiki SP, Research & Development for Sustainability Solutions in Agriculture, Archanes, Crete, Greece; Dr. Georgios Koubouris - Researcher, Hellenic Agricultural Organisation "Demeter" (HAO – DEMETER), Institute of Olive Tree, Subtropical Crops and Viticulture, Chania, Crete, Greece; Dr. Georgios Psarras – Researcher, Hellenic Agricultural Organisation "Demeter" (HAO – DEMETER), Institute of Olive Tree, Subtropical Crops and Viticulture, Chania, Crete, Greece; Dr. Nektarios Kourgialas - Researcher, Hellenic Agricultural Organisation "Demeter" (HAO – DEMETER), Institute of Olive Tree, Subtropical Crops and Viticulture, Chania, Crete, Greece; Dr. Athanassios Sfougaris - Professor, University of Thessaly, Department of Agriculture, Crop Production and Rural Environment, Laboratory of Ecosystem and Biodiversity Management, Volos, Greece; Dr. Andreas Mamolos - Professor, Laboratory of Ecology and Environmental Protection, Faculty of Agriculture, Forestry and Natural Environment, School of Agriculture, Aristotle University of Thessaloniki, Thessaloniki, Greece.

9 References

Andersen E. (2017). The farming system component of European agricultural landscapes. *European Journal of Agronomy*, 82; 282–291. https://doi.org/10.1016/j.eja.2016.09.011.

Balafoutis A, Baptista F, Briassoulis D, Silva LL, Panagakis P, Murcho D. (2014). Comparative studies on energy efficiency and GHG emissions between conventional and organic olive groves in Greece and Portugal. Proceedings of the International Conference on Agricultural Engineering – AgEng2014, C0344, 8 p., Zurich, Switzerland. Online: http://dspace.uevora.pt/rdpc/handle/10174/11312

Berg H, Maneas G, Salguero Engström A. (2018). A Comparison between Organic and Conventional Olive Farming in Messenia, Greece. *Horticulturae*, 4(3):15. https://doi.org/10.3390/horticulturae4030015

Bigot G, Duclos A, Nowak B, Pérochon L, Rega C, Rusu M, Hansson H, Zavalloni M, Paracchini ML. (2019). Interactions with stakeholders on farm typology. LIFT project deliverable D1.2. Online: https://www.lift-h2020.eu/deliverables/

Dabkiene V, Balezentis T, Streimikiene D. (2021). Development of agri-environmental footprint indicator using the FADN data: Tracking development of sustainable agricultural development in Eastern Europe. *Sustainable Production and Consumption*, 27; 2121-2133.

Darnhofer I, Lindenthal T, Bartel-Kratochvil R, Zollitsch W (2010) Conventionalisation of organic farming practices: from structural criteria towards an assessment based on organic principles. A review. *Agronomy for Sustainable Development,* 30(1); 67–81

Erb K-H, Haberl H, Jepsen MR, Kuemmerle T, Lindner M, Müller D, Verburg PH, Reenberg A (2013). A conceptual framework for analysing and measuring land-use intensity. *Current Opinion in Environmental Sustainability*, 5(5); 464–470. https://doi.org/10.1016/j.cosust.2013.07.010.

European Commission 2007. Council Regulation No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. Official Journal of the European Union L189 (1), 1–23.

European Commission (2020). A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. COM(2020) 381 final

Eurostat (2017) Archive: Agri-environmental indicator - intensification – extensification. Online: https://ec.europa.eu/Eurostat/statistics-explained/index.php?oldid=356785 (last accessed May 11th, 2021)

FAO (2019). TAPE Tool for Agroecology Performance Evaluation 2019 – Process of development and guidelines for application. Test version. Rome, Italy.

HLPE (2019). Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome, Italy.

Kay S, Rega C, Moreno G, den Herder M, Palma JH, Borek R, Crous-Duran J, Freese D, Giannitsopoulos M, Graves A, Jäger M, Lamersdorf N, Memedemin D, Mosquera-Losada R , Pantera A Paracchini ML , Paris P , Roces-Díaz JV, Rolo V, Rosati A, Sandor M, Smith J, ,Szerencsits E, Vargat A , Viaud V, Wawer R, Burgess PJ, and Herzog, F. (2019). Agroforestry creates carbon sinks whilst enhancing the environment in agricultural landscapes in Europe. *Land Use Policy*, 83; 581-593.

Kelly E, Latruffe L, Desjeux Y, Ryan M, Uthes S, Diazabakana A, Dillon E and Finn J. (2018). Sustainability indicators for improved assessment of the effects of agricultural policy across the EU: Is FADN the answer? *Ecological Indicators*, 89; 903-911.

Kertész Á, Madarász B. (2014). Conservation agriculture in Europe. International Soil and Water *Conservation Research*, 2(1), 91-96.

Levers C, Müller D, Erb K-H, Haberl H, Jepsen MR, Metzger MJ, Meyfroidt P, Plieninger T, Plutzar C, Stürck J, Verburg PH, Verkerk PJ, and Kuemmerle T. (2018). Archetypical patterns and trajectories of land systems in Europe. *Regional Environmental Change*, 18(3); 715–732. https://doi.org/10.1007/s10113-015-0907-x.

Meredith S, Schefer G, Hart K. (2021) Using the CAP to upscale sustainable agriculture and forestry management practices. European Network of Rural Development thematic Group on the European Green Deal and Rural Areas. Available at: https://enrd.ec.europa.eu/publications/using-cap-upscale-sustainable-agriculture-and-forestry-management-practices_en

Meul M, Van Passel S, Nevens F, Dessein J, Rogge E, Mulier A, Van Hauwermeiren A. (2008) MOTIFS: a monitoring tool for integrated farm sustainability. *Agronomy for Sustainable Development*, 28; 321-332

Navarrete M. (2009) How do farming systems cope with marketing channel requirements in organic horticulture? the case of market-gardening in Southeastern France. *Journal of Sustainable Agriculture*, 33; 552-565

Paracchini ML, Pacini C, Jones MLM, and Pérez-Soba, M. (2011). An aggregation framework to link indicators associated with multifunctional land use to the stakeholder evaluation of policy options. *Ecological indicators*, 11(1), 71-80.

Paracchini ML, Bulgheroni C, Borreani G, Tabacco E, Banterle A, Bertoni D, Rossi G, Parolo G, Origgi R, De Paola C (2015). A diagnostic system to assess sustainability at a farm level: The SOSTARE model. *Agricultural Systems*, 133; 35-53.

Petit C, Aubry C. (2016). Typology of organic management styles in a cash-crop region using a multi-criteria method. *Organic Agriculture*, 6(3); 155-169.

Pleguezuelo CRR, ZuazoVHD, Martínez JFR, Martín Peinado FJ, Moreno Martín F García Tejero IF (2018) Organic olive farming in Andalusia, Spain. A review. *Agronomy for Sustainable Development* 38, 20. https://doi.org/10.1007/s13593-018-0498-2

Poppe K, Vrolijk H. (eds.) (2016) Farm sustainability data for better policy evaluation with FADN. FLINT final report. Doi: 10.18174/414173.

Rega C, Short C, Pérez-Soba M and Paracchini ML. (2020b). A classification of European agricultural land using an energy-based intensity indicator and detailed crop description. *Landscape and Urban Planning*, 198; 103793

Rega C, Paracchini ML (2019). Identification of existing and additional data sources. LIFT project Milestone MS2.

Rega C, Paracchini ML, McCraken D, Saba A, Zavalloni M, Raggi M, Viaggi D, Britz W, Frappier L (2018). Review of the definitions of the existing ecological approaches. LIFT project deliverable D1.1. Online: https://www.lift-h2020.eu/deliverables/

Rega C, Paracchini ML, Desjeux Y, Latruffe L, Ferreira J, Manevska-Tasevska G, Hansson H, Heinrichs J, Bareille F, Zavalloni M, Rusu M, Luca L. (2019). First version of the LIFT farm typology towards the protocol to assign farms to LIFT farm typology: linking farming systems with existing EU databases and farming practices. LIFT project deliverable D1.3. Online: https://www.lift-h2020.eu/deliverables/

Rega C, Paracchini ML, Britz W, Zavalloni M, Manevska-Tasevska M, Latruffe L, Desjeux Y, Rusu M, Ferreira J. (2020a) Protocol to assign farms to the typology. LIFT project Milestone MS3.

Thompson, B., Rega, C., D'Alberto, R., 2021. Typology of Ecological Farms in the EU. Zenodo

Tzouramani I, Latruffe L, Konstantidelli V, Desjeux Y, Bailey A, Bardounioti M, Barnes A, Bigot G, Dakpo H, Davidova S, Duval J, Eichhorn T, Gerner L, Henderson S, Hostiou N, Jeanneaux P, Kantelhardt J, Larmet V, Legras S, Niedermayr A, Paracchini ML, Polge E, Rega C, Schaller L, Solomou A, Thompson B, Toma L, Treguer S, Tzanopoulos J, Vedrine L, Walder P. (2019). LIFT large-scale farmer survey questionnaire. LIFT project deliverable D2.2. Online: https://www.lift-h2020.eu/deliverables/

Uthes S, Herrera B. (2019) Farm-Level Input Intensity, Efficiency and Sustainability: A Case Study Based on FADN Farms (No. 2240-2019-3061). https://ageconsearch.umn.edu/record/292342/files/P1-149-Uthes-Farm-Level_Input_Intensity%2C_Efficiency_and_Sustainability_c.pdf

Van der Zanden EH, Levers C, Verburg PH, Kuemmerle T. (2016). Representing composition, spatial structure and management intensity of European agricultural landscapes: A new typology. *Landscape and Urban Planning*, 150; 36–49.

Vrolijk H, Poppe K, Keszthelyi S. (2016). Collecting sustainability data in different organisational settings of the European Farm Accountancy Data Network. *Studies in Agricultural Economics*, 118(3); 138-144.

Zahm F, Viaux P, Vilain L, Girardin P, Mouchet C. (2008). Assessing farm sustainability with the IDEA method–from the concept of agriculture sustainability to case studies on farms. *Sustainable Development*, 16(4); 271-281.

10 Annex 1 – Full list of FADN-based protocols

In the two following sections the full list of tables comprising the FADN-based protocol for Low-Input farming (section 10.1) and Integrated/Circular farming (section 10.2) for different types of farm is provided, as well as biogeographic region specific values for water use (for crop farms), grazing density and number of grazing days on common land for livestock farms, where relevant.

10.1 FADN-based Low-Input farming approach

Table 32: FADN-based protocol for Low-Input farming approach – Specialist Cattle farms

Low-Input farming – Specialist Cattle				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE71)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Grazing on common land (applies only if "GRAZDAYS">0, otherwise discard the variable)	Average Number of days spent grazing on common land per grazing LU GRAZDAYS/(SE085 + SE090 + SE095)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
Fertilisation (applies only if SE025>0, otherwise discard the variable)	Total fertilisation costs per ha of UAA SE295*/SE025	0	4	1
		22	3	
		59	2	
		110	1	
		> 110	0	
Livestock feed (Purchased feed for grazing livestock */Grazing_LU)	Cost of purchased feed for grazing livestock per grazing LU (SE310*/(SE085 + SE090 + SE095)	117	4	2
		207	3	
		306	2	
		459	1	
		> 459	0	
Pest control (applies only if SE025>0, otherwise discard the variable)	Total expenditure for pest control products per ha of UAA SE300*/SE025	0	4	1
		1.2	3	
		11	2	
		36	1	
		> 36	0	
Energy use - fuels and lubricants	Total expenditure in fuels per LU (IHFULS_V*+IFULS_V*)/SE080	30	4	1.5
		50	3	
		74	2	
		121	1	
		> 121	0	
Energy use - electricity	Total expenditure in electricity per LU IELE_V*/SE080	3.8	4	1
		8.9	3	
		17	2	
		32	1	
		> 32	0	
Machinery & building - upkeep	Costs of current upkeep of equipment and purchase of minor equipment per LU SE340*/SE080	29	4	1
		62	3	
		100	2	
		165	1	
		> 165	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per LU SE360*/SE080	68	4	1.5
		140	3	
		225	2	
		384	1	
		> 384	0	

Table 33: FADN-based protocol for Low-Input farming approach – Specialist Dairy/Milk farms

Low-Input farming – Specialist Dairy				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE71)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Grazing on common land (applies only if "GRAZDAYS">0). Does not apply in the Boreal Bioregion	Average Number of days spent grazing on common land per grazing LU GRAZDAYS/(SE085 + SE090 + SE095)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Fertilisation (applies only if SE025>0, otherwise discard the variable)	Total fertilisation costs per ha of UAA SE295*/SE025	14	4	1
		60	3	
		104	2	
		158	1	
		>158	0	
Livestock feed (Purchased feed for grazing livestock */Grazing_LU)	Cost of purchased feed for grazing livestock per grazing LU (SE310*/(SE085 + SE090 + SE095)	258	4	2
		360	3	
		484	2	
		731	1	
		> 731	0	
Pest control (applies only if SE025>0, otherwise discard the variable)	Total expenditure for pest control products per ha of UAA SE300*/SE025	0	4	1
		10	3	
		25	2	
		52	1	
		> 52	0	
Energy use - fuels and lubricants	Total expenditure in fuels per LU (IHFULS_V*+IFULS_V*)/SE080	46	4	1.5
		71	3	
		98	2	
		141	1	
		> 141	0	
Energy use - electricity	Total expenditure in electricity per LU IELE_V*/SE080	22	4	1
		32	3	
		42	2	
		59	1	
		>59	0	
Machinery & building - upkeep	Costs of current upkeep of equipment and purchase of minor equipment per LU SE340*/SE080	49	4	1
		91	3	
		138	2	
		207	1	
		> 207	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per LU SE360*/SE080	121	4	1.5
		211	3	
		307	2	
		456	1	
		> 456	0	

Table 34: FADN-based protocol for Low-Input farming approach – Specialist Sheep and Goats farms

Low-Input farming– Specialist Sheep and Goats				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE71)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Grazing on common land (applies only if "GRAZDAYS">0). Does not apply in the Boreal Bioregion	Average Number of days spent grazing on common land per grazing LU GRAZDAYS/(SE085 + SE090 + SE095)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
Fertilisation (applies only if SE025>0, otherwise discard the variable)	Total fertilisation costs per ha of UAA SE295*/SE025	0	4	1
		11	3	
		35	2	
		73	1	
		> 73	0	
Livestock feed (Purchased feed for grazing livestock */Grazing_LU)	Cost of purchased feed for grazing livestock per grazing LU (SE310*/(SE085 + SE090 + SE095)	173	4	2
		259	3	
		359	2	
		534	1	
		> 534	0	
Pest control (applies only if SE025>0, otherwise discard the variable)	Total expenditure for pest control products per ha of UAA SE300*/SE025	0	4	1
		2	3	
		4	2	
		18	1	
		> 18	0	
Energy use - fuels and lubricants	Total expenditure in fuels per LU (IHFULS_V*+IFULS_V*)/SE080	15	4	1.5
		34	3	
		55	2	
		94	1	
		> 94	0	
Energy use - electricity	Total expenditure in electricity per LU IELE_V*/SE080	1.7	4	1
		6	3	
		14	2	
		31	1	
		> 31	0	
Machinery & building - upkeep	Costs of current upkeep of equipment and purchase of minor equipment per LU SE340*/SE080	8	4	1
		22	3	
		49	2	
		102	1	
		> 102	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per LU SE360*/SE080	24	4	1.5
		66	3	
		129	2	
		259	1	
		> 259	0	

Table 35: FADN-based protocol for Low-Input farming approach – Specialist Granivores

Low-Input farming - Specialist Granivores				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation (applies only if SE025>0, otherwise discard the variable)	Total fertilisation costs per ha of UAA SE295*/SE025	31	4	1
		74	3	
		113	2	
		162	1	
		> 162	0	
Livestock feed	Purchased feed for pigs and poultry/ pigs and poultry LU SE320* / (SE100 + SE105)	277	4	2
		467	3	
		581	2	
		761	1	
		> 761	0	
Pest control (applies only if SE025>0, otherwise discard the variable)	Total expenditure for pest control products per ha of UAA SE300*/SE025	19	4	1
		55	3	
		93	2	
		146	1	
		> 146	0	
Energy use - fuels and lubricants	Total expenditure in fuels per LU (IHFULS_V*+IFULS_V*)/SE080	12	4	1.5
		25	3	
		41	2	
		69	1	
		> 69	0	
Energy use - electricity	Total expenditure in electricity per LU IELE_V*/SE080	9	4	1
		17	3	
		25	2	
		40	1	
		> 40	0	
Machinery & building - upkeep	Costs of current upkeep of equipment and purchase of minor equipment per LU SE340*/SE080	12	4	1
		28	3	
		47	2	
		77	1	
		> 77	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per LU SE360*/SE080	36	4	1.5
		75	3	
		115	2	
		184	1	
		> 184	0	

Table 36: FADN-based protocol for Low-Input farming approach – Mixed Livestock farms

Low-Input farming – Mixed Livestock				
Theme	**Variable Name**	**Value Ranges**	**Scores**	**Weight**
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE71)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Grazing on common land (applies only if "GRAZDAYS">0). Discard the variable if in Boreal Bioregion	Average Number of days spent grazing on common land per grazing LU GRAZDAYS/(SE085 + SE090 + SE095)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
Fertilisation (applies only if SE025>0, otherwise discard the variable**)**	Total fertilisation costs per ha of UAA SE295*/SE025	37	4	1
		70	3	
		103	2	
		144	1	
		> 144	0	
Livestock feed	(SE310* + SE320*)/SE080	185	4	2
		282	3	
		379	2	
		538	1	
		> 538	0	
Pest control (applies only if SE025>0, otherwise discard the variable)	Total expenditure for pest control products per ha of UAA SE300*/SE025	11	4	1
		27	3	
		48	2	
		84	1	
		> 84	0	
Energy use - fuels and lubricants	Total expenditure in fuels per LU (IHFULS_V*+IFULS_V*)/SE080	36	4	1.5
		60	3	
		88	2	
		133	1	
		> 133	0	
Energy use - electricity	Total expenditure in electricity per LU IELE_V*/SE080	13	4	1
		20	3	
		29	2	
		44	1	
		> 44	0	
Machinery & building - upkeep	Costs of current upkeep of equipment and purchase of minor equipment per LU SE340*/SE080	30	4	1
		51	3	
		77	2	
		124	1	
		>124	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per LU SE360*/SE080	82	4	1.5
		136	3	
		195	2	
		296	1	
		> 296	0	

Table 37: FADN-based protocol for Low-Input farming approach – Mixed Crop-Livestock farms

Low-Input farming – Mixed Crop-Livestock				
Theme	**Variable Name**	**Value Ranges**	**Scores**	**Weight**
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE71)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Grazing on common land (applies only if "GRAZDAYS">0). Does not apply in the Boreal Bioregion	Average Number of days spent grazing on common land per grazing LUGRAZDAYS/(SE085 + SE090 + SE095)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
Fertilisation (applies only if SE025>0, otherwise discard the variable**)**	Total fertilisation costs per ha of UAA SE295*/SE025	44	4	2
		82	3	
		122	2	
		174	1	
		> 174	0	
Livestock feed	Cost of purchased feed for livestock per LU (SE310* + SE320*)/SE080	242	4	2
		366	3	
		486	2	
		646	1	
		> 646	0	
Pest control (applies only if SE025>0, otherwise discard the variable)	SE300*/SE025	16	4	1
		39	3	
		70	2	
		117	1	
		> 117	0	
Energy use - fuels and lubricants	(IHFULS_V*+IFULS_V*)/SE080	82	4	1.5
		131	3	
		190	2	
		293	1	
		> 293	0	
Energy use - electricity	IELE_V*/SE080	13	4	1
		25	3	
		40	2	
		69	1	
		> 69	0	
Machinery & building - upkeep	Costs of current upkeep of equipment and purchase of minor equipment per LU SE340*/SE080	51	4	1
		94	3	
		151	2	
		254	1	
		> 254	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per LU SE360*/SE080	148	4	1.5
		254	3	
		384	2	
		611	1	
		> 611	0	

Table 38: Biogeographic region specific threshold values for variable SE120 (grazing density) in different livestock types of farm

Specialist cattle						
Scores	**Alpine**	**Atlantic**	**Boreal**	**Continental**	**Mediterranean**	**Pannonian**
4	0.47	0.97	0.46	0.78	0.39	0.28
3	0.77	1.33	0.62	1.13	0.65	0.46
2	1.06	1.75	0.84	1.53	0.98	0.81
1	1.71	2.52	1.21	2.27	1.83	1.68
0	> 1.71	> 2.52	> 1.21	> 2.27	> 1.83	> 1.68
Specialist dairy						
Scores	**Alpine**	**Atlantic**	**Boreal**	**Continental**	**Mediterranean**	**Pannonian**
4	0.74	1.62	0.59	1.21	1.22	0.68
3	1.17	1.99	0.82	1.62	2.52	1.16
2	1.54	2.38	1.06	2.04	4.16	1.65
1	2.07	3.08	1.42	2.68	8.14	2.59
0	> 2.07	> 3.08	> 1.42	> 2.68	> 8.14	> 2.59
Specialist sheep and goats						
Scores	**Alpine**	**Atlantic**	**Boreal**	**Continental**	**Mediterranean**	**Pannonian**
4	0.38	0.58	0.27	0.32	0.26	0.52
3	0.66	0.95	0.39	0.73	0.66	1.05
2	1.03	1.28	0.55	1.20	1.29	1.57
1	1.93	1.74	0.82	2.66	3.51	2.66
0	> 1.93	> 1.74	> 0.82	> 2.66	> 3.51	> 2.66
Mixed crop-livestock						
Scores	**Alpine**	**Atlantic**	**Boreal**	**Continental**	**Mediterranean**	**Pannonian**
4	0.18	0	0.22	0.00	0.00	0.00
3	0.59	1.22	0.49	0.70	0.51	0.45
2	1.04	1.79	0.72	1.35	1.02	0.99
1	1.94	2.49	1.06	2.28	2.68	1.86
0	> 1.94	> 2.49	> 1.06	> 2.28	> 2.68	> 1.86
Mixed livestock						
Scores	**Alpine**	**Atlantic**	**Boreal**	**Continental**	**Mediterranean**	**Pannonian**
4	0.51	1.43	0.3	0.88	0.31	0.00
3	0.89	1.87	0.5	1.46	0.51	0.66
2	1.31	2.32	0.63	2.11	0.85	1.51
1	2.24	3.01	0.9	3.12	1.98	3.81
0	> 2.24	> 3.01	> 0.9	> 3.12	> 1.98	> 3.81

Table 39: FADN-based protocol for Low-Input farming approach – Specialist COP farms

Low-Input farming – Specialist COP				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	Total fertilisation costs per ha of UAA SE295*/SE025	67	4	2
		106	3	
		153	2	
		215	1	
		> 215	0	
Pest control	Total expenditure for pest control products per ha of UAA SE300*/SE025	31	4	2
		57	3	
		91	2	
		147	1	
		> 147	0	
Water use	Total expenditure in water per ha of UAA IWATR_V*/SE025	Insert biogeographic region specific values here	4	1
			3	
			2	
			1	
			0	
Energy use - fuels and lubricants	Total expenditure in fuels per ha of UAA (IHFULS_V*+IFULS_V*)/SE025	52	4	1.5
		84	3	
		113	2	
		154	1	
		> 154	0	
Seeds	Total cost for seeds and plantlets for ha of UAA SE285*/SE025	41	4	1.5
		58	3	
		76	2	
		102	1	
		> 102	0	
Energy use - electricity	Total expenditure in electricity per ha of UAA IELE_V*/SE025	0.5	4	1
		3.3	3	
		7	2	
		15	1	
		> 15	0	
Machinery & building	Costs of current upkeep of equipment and purchase of minor equipment per ha of UAA SE340*/SE025	15	4	1
		35	3	
		61	2	
		110	1	
		> 110	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per ha of UAA SE360*/SE025	35	4	1.5
		97	3	
		166	2	
		272	1	
		> 272	0	

Table 40: FADN-based protocol for Low-Input farming approach – Specialist Horticulture farms

Low-Input farming – Specialist Horticulture				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	Total fertilisation costs per ha of UAA SE295*/SE025	177	4	2
		480	3	
		1314	2	
		4772	1	
		> 4772	0	
Pest control	Total expenditure for pest control products per ha of UAA SE300*/SE025	123	4	2
		392	3	
		1043	2	
		2719	1	
		> 2719	0	
Water use	Total expenditure in water per ha of UAA IWATR_V*/SE025	Insert biogeographic region specific values here	4	1.5
			3	
			2	
			1	
			0	
Energy use - fuels and lubricants	Total expenditure in fuels per ha of UAA (IHFULS_V*+IFULS_V*)/SE025	190	4	1.5
		527	3	
		1690	2	
		12950	1	
		> 12950	0	
Seeds	Total cost for seeds and plantlets for ha of UAA SE285*/SE025	41	4	1.5
		58	3	
		76	2	
		102	1	
		> 102	0	
Energy use - electricity	Total expenditure in electricity per ha of UAA IELE_V*/SE025	48	4	1
		235	3	
		747	2	
		3104	1	
		> 3104	0	
Machinery & building	Costs of current upkeep of equipment and purchase of minor equipment per ha of UAA SE340*/SE025	118	4	1
		480	3	
		1603	2	
		7310	1	
		> 7310	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per ha of UAA SE360*/SE025	373	4	1.5
		1373	3	
		4348	2	
		15942	1	
		> 15942	0	

Table 41: FADN-based protocol for Low-Input farming approach – Specialist other fieldcrops farms

Low-Input farming – Specialist other fieldcrops				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	Total fertilisation costs per ha of UAA SE295*/SE025	74	4	2
		131	3	
		190	2	
		268	1	
		> 268	0	
Pest control	Total expenditure for pest control products per ha of UAA SE300*/SE025	36	4	2
		84	3	
		147	2	
		240	1	
		> 240	0	
Water use	Total expenditure in water per ha of UAA IWATR_V*/SE025	Insert biogeographic region specific values here	4	1
			3	
			2	
			1	
			0	
Energy use - fuels and lubricants	Total expenditure in fuels per ha of UAA (IHFULS_V*+IFULS_V*)/SE025	65	4	1.5
		106	3	
		152	2	
		241	1	
		> 241	0	
Seeds	Total cost for seeds and plantlets for ha of UAA SE285*/SE025	52	4	1.5
		89	3	
		135	2	
		271	1	
		>271	0	
Energy use - electricity	Total expenditure in electricity per ha of UAA UAA IELE_V*/SE025	1	4	1
		8	3	
		20	2	
		55	1	
		> 55	0	
Machinery & building	Costs of current upkeep of equipment and purchase of minor equipment per ha of UAA SE340*/SE025	25	4	1
		57	3	
		105	2	
		193	1	
		> 193	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per ha of UAA SE360*/SE025	83	4	1.5
		179	3	
		290	2	
		496	1	
		> 496	0	

Table 42: FADN-based protocol for Low-Input farming approach – Mixed crops farms

<table>
<tr><th colspan="5">Low-Input farming – Mixed crops</th></tr>
<tr><th>Theme</th><th>Variable Name</th><th>Value Ranges</th><th>Score</th><th>Weight</th></tr>
<tr><td rowspan="5">Fertilisation</td><td rowspan="5">Total fertilisation costs per ha of UAA
SE295*/SE025</td><td>48</td><td>4</td><td rowspan="5">2</td></tr>
<tr><td>92</td><td>3</td></tr>
<tr><td>147</td><td>2</td></tr>
<tr><td>240</td><td>1</td></tr>
<tr><td>> 240</td><td>0</td></tr>
<tr><td rowspan="5">Pest control</td><td rowspan="5">Total expenditure for pest control products per ha of UAA
SE300*/SE025</td><td>25</td><td>4</td><td rowspan="5">2</td></tr>
<tr><td>66</td><td>3</td></tr>
<tr><td>125</td><td>2</td></tr>
<tr><td>245</td><td>1</td></tr>
<tr><td>> 245</td><td>0</td></tr>
<tr><td rowspan="5">Water use</td><td rowspan="5">Total expenditure in water per ha of UAA
IWATR_V*/SE025</td><td rowspan="5">Insert biogeographic region specific values here</td><td>4</td><td rowspan="5">1</td></tr>
<tr><td>3</td></tr>
<tr><td>2</td></tr>
<tr><td>1</td></tr>
<tr><td>0</td></tr>
<tr><td rowspan="5">Energy use - fuels and lubricants</td><td rowspan="5">Total expenditure in fuels per ha of UAA
(IHFULS_V*+IFULS_V*)/SE025</td><td>54</td><td>4</td><td rowspan="5">1.5</td></tr>
<tr><td>94</td><td>3</td></tr>
<tr><td>143</td><td>2</td></tr>
<tr><td>252</td><td>1</td></tr>
<tr><td>> 252</td><td>0</td></tr>
<tr><td rowspan="5">Seeds</td><td rowspan="5">Total cost for seeds and plantlets for ha of UAA
SE285*/SE025</td><td>28</td><td>4</td><td rowspan="5">1.5</td></tr>
<tr><td>56</td><td>3</td></tr>
<tr><td>94</td><td>2</td></tr>
<tr><td>196</td><td>1</td></tr>
<tr><td>> 196</td><td>0</td></tr>
<tr><td rowspan="5">Energy use - electricity</td><td rowspan="5">Total expenditure in electricity per ha of UAA
IELE_V*/SE025</td><td>0.0</td><td>4</td><td rowspan="5">1</td></tr>
<tr><td>8.6</td><td>3</td></tr>
<tr><td>24</td><td>2</td></tr>
<tr><td>71</td><td>1</td></tr>
<tr><td>> 71</td><td>0</td></tr>
<tr><td rowspan="5">Machinery & building</td><td rowspan="5">Costs of current upkeep of equipment and purchase of minor equipment per ha of UAA
SE340*/SE025</td><td>17</td><td>4</td><td rowspan="5">1</td></tr>
<tr><td>45</td><td>3</td></tr>
<tr><td>92</td><td>2</td></tr>
<tr><td>198</td><td>1</td></tr>
<tr><td>> 198</td><td>0</td></tr>
<tr><td rowspan="5">Total physical assets (depreciation)</td><td rowspan="5">Depreciation of capital assets over the accounting year per ha of UAA
SE360*/SE025</td><td>68</td><td>4</td><td rowspan="5">1.5</td></tr>
<tr><td>192</td><td>3</td></tr>
<tr><td>359</td><td>2</td></tr>
<tr><td>688</td><td>1</td></tr>
<tr><td>688</td><td>0</td></tr>
</table>

Table 43: FADN-based protocol for Low-Input farming approach – Specialist Olives farms

Low-Input farming – Specialist Olives				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	Total fertilisation costs per ha of UAA SE295*/SE025	35	4	2
		76	3	
		125	2	
		200	1	
		> 200	0	
Pest control	Total expenditure for pest control products per ha of UAA SE300*/SE025	16	4	2
		42	3	
		74	2	
		131	1	
		> 131	0	
Water use	Total expenditure in water per ha of UAA IWATR_V*/SE025	Insert biogeographic region specific values here	4	1
			3	
			2	
			1	
			0	
Energy use - fuels and lubricants	Total expenditure in fuels per ha of UAA (IHFULS_V*+IFULS_V*)/SE025	45	4	1.5
		80	3	
		127	2	
		196	1	
		> 196	0	
Energy use - electricity	Total expenditure in electricity per ha of UAA IELE_V*/SE025	0	4	1
		7	3	
		14	2	
		36	1	
		> 36	0	
Machinery & building	Costs of current upkeep of equipment and purchase of minor equipment per ha of UAA SE340*/SE025	15	4	1
		35	3	
		66	2	
		128	1	
		> 128	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per ha of UAA SE360*/SE025	87	4	1.5
		204	3	
		360	2	
		628	1	
		>628	0	

Table 44: FADN-based protocol for Low-Input farming approach – Specialist Vineyards farms

Low-Input farming – Specialist Vineyards				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	Total fertilisation costs per ha of UAA SE295*/SE025	24	4	2
		77	3	
		133	2	
		219	1	
		> 219	0	
Pest control	Total expenditure for pest control products per ha of UAA SE300*/SE025	104	4	2
		229	3	
		388	2	
		636	1	
		> 636	0	
Water use	Total expenditure in water per ha of UAA IWATR_V*/SE025	Insert biogeographic region specific values here	4	1
			3	
			2	
			1	
			0	
Energy use - fuels and lubricants	Total expenditure in fuels per ha of UAA (IHFULS_V*+IFULS_V*)/SE025	71	4	1.5
		128	3	
		203	2	
		329	1	
		> 329	0	
Energy use - electricity	Total expenditure in electricity per ha of UAA IELE_V*/SE025	0	4	1
		14	3	
		42	2	
		114	1	
		> 114	0	
Machinery & building	Costs of current upkeep of equipment and purchase of minor equipment per ha of UAA SE340*/SE025	36	4	1
		117	3	
		288	2	
		741	1	
		> 741	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per ha of UAA SE360*/SE025	209	4	1.5
		510	3	
		940	2	
		1889	1	
		> 1889	0	

Table 45: FADN-based protocol for Low-Input farming approach – Specialist Orchard/Fruit farms

Low-Input farming- Specialist Orchards/Fruit				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	Total fertilisation costs per ha of UAA SE295*/SE025	53	4	2
		127	3	
		210	2	
		329	1	
		> 329	0	
Pest control	Total expenditure for pest control products per ha of UAA SE300*/SE025	83	4	2
		225	3	
		449	2	
		824	1	
		> 824	0	
Water use	Total expenditure in water per ha of UAA IWATR_V*/SE025	Insert biogeographic region specific values here	4	1
			3	
			2	
			1	
			0	
Energy use - fuels and lubricants	Total expenditure in fuels per ha of UAA (IHFULS_V*+IFULS_V*)/SE025	69	4	1.5
		146	3	
		227	2	
		348	1	
		> 348	0	
Energy use - electricity	Total expenditure in electricity per ha of UAA IELE_V*/SE025	0	4	1
		17	3	
		55	2	
		149	1	
		> 149	0	
Machinery & building	Costs of current upkeep of equipment and purchase of minor equipment per ha of UAA SE340*/SE025	33	4	1
		85	3	
		178	2	
		442	1	
		> 442	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per ha of UAA SE360*/SE025	160	4	1.5
		428	3	
		814	2	
		1554	1	
		> 1554	0	

Table 46: FADN-based protocol for Low-Input farming approach – Permanent Crops Combined farms

Low-Input farming – Permanent Crops Combined				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	Total fertilisation costs per ha of UAA SE295*/SE025	31	4	2
		71	3	
		129	2	
		225	1	
		> 225	0	
Pest control	Total expenditure for pest control products per ha of UAA SE300*/SE025	23	4	2
		60	3	
		129	2	
		323	1	
		> 323	0	
Water use	Total expenditure in water per ha of UAA IWATR_V*/SE025	Insert biogeographic region specific values here	4	1
			3	
			2	
			1	
			0	
Energy use - fuels and lubricants	Total expenditure in fuels per ha of UAA (IHFULS_V*+IFULS_V*)/SE025	49	4	1.5
		94	3	
		158	2	
		258	1	
		> 258	0	
Energy use - electricity	Total expenditure in electricity per ha of UAA IELE_V*/SE025	0	4	1
		4	3	
		20	2	
		60	1	
		> 60	0	
Machinery & building	Costs of current upkeep of equipment and purchase of minor equipment per ha of UAA SE340*/SE025	16	4	1
		45	3	
		103	2	
		237	1	
		> 237	0	
Total physical assets (depreciation)	Depreciation of capital assets over the accounting year per ha of UAA SE360*/SE025	96	4	1.5
		261	3	
		496	2	
		952	1	
		> 952	0	

Table 47: Biogeographic region specific values for the variable "Water use" in crop farms – FADN-based protocol for Low-Input farming approach

Specialist Fieldcrops (TF 8 = 1, TF14 = 15, 16, 60 and 80 - Specialist COP, Specialist other fieldcrops and mixed crops and mixed crop-livestock)						
Score	**Alpine**	**Atlantic**	**Boreal**	**Continental**	**Mediterranean**	**Pannonian**
4	0	0	0	0	0	0
3	6	1.5	1	2	17	1.6
2	25	3.2	2	5	65	4.1
1	88	6.9	4	14	164	11
0	> 88	> 6.9	>4	>14	> 164	> 11
Specialist Horticulture (TF8 = 2; TF14 = 20)						
Score	**Alpine**	**Atlantic**	**Boreal**	**Continental**	**Mediterranean**	**Pannonian**
4	0	0	0	0	0	0
3	97	26	40	57	139	11
2	432	94	744	254	382	54
1	1597	350	3996	936	899	267
0	> 1597	> 350	> 3996	> 936	> 899	> 267

Specialist Wine/Vineyards (TF8 = 3; TF14 = 35)						
Score	**Alpine**	**Atlantic**	**Boreal**	**Continental**	**Mediterranean**	**Pannonian**
4	0	0		0	0	0
3	24	5		18	11	21
2	57	10		48	33	47
1	123	21		108	95	98
0	> 123	> 21		> 108	> 95	> 98
Specialist TF8 = 4; TF14 = 36 (Specialist Orchard/fruits), 37 (Specialist Olives), 38 (permanent crops combined)						
Score	**Alpine**	**Atlantic**	**Boreal**	**Continental**	**Mediterranean**	**Pannonian**
4	0	0	0	0	0	0
3	44	9	2.4	10	28	7
2	96	19	4	26	101	18
1	197	39	11	61	233	47
0	> 197	> 39	> 11	> 61	> 233	> 47

Table 48: Biogeographic region specific threshold values for Grazing on common land (GRAZDAYS/ SE085 + SE090 + SE095). Apply the score only if the value is >= the lower threshold corresponding to score 3. If the value is < the threshold, just discard this variable when computing the final score. The score associated to this variable can be only 3 and 4.

Specialist Cattle and Specialist Dairy	**Score**	**Alpine**	**Atlantic**	**Continental**	**Mediterranean**	**Pannonian**
	4	> 21.8	> 20.8	> 130	> 135	> 58
	3	5.4 - 21.8	5.5 - 20.8	5.6 -130	2.7 - 135	27 -58
Specialist Sheep and Goats	**Score**	**Alpine**	**Atlantic**	**Continental**	**Mediterranean**	**Pannonian**
	4	> 105.7	> 31.9	> 193	> 230	> 19
	3	6.4 -105.7	12.4 - 31.9	4.22-193	117 - 230	3 -19

10.2 FADN-based Integrated/Circular farming approach

Table 49: FADN-based protocol for Integrated/Circular farming approach – Specialist Cattle farms

Integrated/Circular farming – Specialist Cattle				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Own feed production	Value of own produced feed on total feed value SE315/SE310	>0.5	4	2
		0.5	3	
		0.3	2	
		0.1	1	
		0	0	
Livestock feed	Value of purchased feed per grazing LU (SE310*/ SE085 + SE090 + SE095)	117	4	1.5
		207	3	
		306	2	
		459	1	
		> 459	0	
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE071)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)	Value of sold electricity produced on farm on total value of consumed electricity ONRGPRD_SV/IELE_V	>0.2	4	1
		0.2	3	
Fertilisation (applies only if SE025>0, otherwise discard the variable**)**	Total fertilisers cost per ha of UAA SE295*/SE025	0	4	1.5
		22	3	
		59	2	
		110	1	
		> 110	0	
Seed - own ratio (applies only if SE290>0, otherwise discard the variable**)**	Value of seeds produced on farm on total value of used seeds SE290/SE285	>0.2	4	1
		0.2	3	

Table 50: FADN-based protocol for Integrated/Circular farming approach – Specialist Dairy farms

Integrated/Circular farming – Specialist Dairy farms				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Own feed production	Value of own produced feed on total feed value SE315/SE310	>0.5	4	2
		0.5	3	
		0.3	2	
		0.1	1	
		0	0	
Livestock feed	Value of purchased feed per grazing LU (SE310*/ SE085 + SE090 + SE095)	258	4	1.5
		360	3	
		484	2	
		731	1	
		> 731	0	
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE071)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)	Value of sold electricity produced on farm on total value of consumed electricity ONRGPRD_SV/IELE_V	>0.2	4	1
		0.2	3	
Fertilisation (applies only if SE025>0, otherwise discard the variable**)**	Total fertilisers cost per ha of UAA SE295*/SE025	14	4	1.5
		60	3	
		104	2	
		158	1	
		>158	0	
Seed - own ratio (applies only if SE290>0, otherwise discard the variable**)**	Value of seeds produced on farm on total value of used seeds SE290/SE285	>0.2	4	1
		0.2	3	

Table 51: FADN-based protocol for Integrated/Circular farming approach – Specialist Sheep and Goats farms

Integrated/Circular farming – Specialist Sheep and Goats				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Own feed production	Value of own produced feed on total feed value SE315/SE310	>0.5	4	2
		0.5	3	
		0.3	2	
		0.1	1	
		0	0	
Livestock feed	Value of purchased feed per grazing LU (SE310*/ SE085 + SE090 + SE095)	173	4	1.5
		259	3	
		359	2	
		534	1	
		> 534	0	
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE071)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)	Value of sold electricity produced on farm on total value of consumed electricity ONRGPRD_SV/IELE_V	>0.2	4	1
		0.2	3	
Fertilisation (applies only if SE025>0, otherwise discard the variable**)**	Total fertilisers cost per ha of UAA SE295*/SE025	0	4	1.5
		11	3	
		35	2	
		73	1	
		> 73	0	
Seed - own ratio (applies only if SE290>0, otherwise discard the variable**)**	Value of seeds produced on farm on total value of used seeds SE290/SE285	>0.2	4	1
		0.2	3	

Table 52: FADN-based protocol for Integrated/Circular farming approach – Specialist Granivores farms

<table>
<tr><th colspan="5">Integrated/Circular farming – Specialist Granivores</th></tr>
<tr><th>Theme</th><th>Variable Name</th><th>Value Ranges</th><th>Score</th><th>Weight</th></tr>
<tr><td rowspan="5">Own feed production</td><td rowspan="5">Value of own produced feed on total feed value
SE315/SE310</td><td>>0.5</td><td>4</td><td rowspan="5">2</td></tr>
<tr><td>0.5</td><td>3</td></tr>
<tr><td>0.3</td><td>2</td></tr>
<tr><td>0.1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
<tr><td rowspan="5">Livestock feed (Purchased feed for pigs and poultry/ pigs and poultry LU)</td><td rowspan="5">Value of purchased feed per grazing LU
(SE310*/ SE085 + SE090 + SE095)</td><td>277</td><td>4</td><td rowspan="5">1.5</td></tr>
<tr><td>467</td><td>3</td></tr>
<tr><td>581</td><td>2</td></tr>
<tr><td>761</td><td>1</td></tr>
<tr><td>> 761</td><td>0</td></tr>
<tr><td rowspan="2">Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)</td><td rowspan="2">Value of sold electricity produced on farm on total value of consumed electricity
ONRGPRD_SV/IELE_V</td><td>>0.2</td><td>4</td><td rowspan="2">1</td></tr>
<tr><td>0.2</td><td>3</td></tr>
<tr><td rowspan="5">Fertilisation (applies only if SE025>0, otherwise discard the variable)</td><td rowspan="5">Total fertilisers cost per ha of UAA
SE295*/SE025</td><td>31</td><td>4</td><td rowspan="5">1</td></tr>
<tr><td>74</td><td>3</td></tr>
<tr><td>113</td><td>2</td></tr>
<tr><td>162</td><td>1</td></tr>
<tr><td>> 162</td><td>0</td></tr>
<tr><td rowspan="2">Seed - own ratio (applies only if SE290>0, otherwise discard the variable)</td><td rowspan="2">Value of seeds produced on farm on total value of used seeds
SE290/SE285</td><td>>0.2</td><td>4</td><td rowspan="2">1</td></tr>
<tr><td>0.2</td><td>3</td></tr>
</table>

Table 53: FADN-based protocol for Integrated/Circular farming approach – Mixed Livestock farms

Integrated/Circular farming – Mixed Livestock				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Own feed production	Value of own produced feed on total feed value SE315/SE310	>0.5	4	2
		0.5	3	
		0.3	2	
		0.1	1	
		0	0	
Livestock feed	Value of purchased feed per grazing LU (SE310*/ SE085 + SE090 + SE095)	185	4	1.5
		282	3	
		379	2	
		538	1	
		> 538	0	
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE071)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)	Value of sold electricity produced on farm on total value of consumed electricity ONRGPRD_SV/IELE_V	>0.2	4	1
		0.2	3	
Fertilisation (applies only if SE025>0, otherwise discard the variable**)**	Total fertilisers cost per ha of UAA SE295*/SE025	37	4	1.5
		70	3	
		103	2	
		144	1	
		> 144	0	
Seed - own ratio (applies only if SE290>0, otherwise discard the variable**)**	Value of seeds produced on farm on total value of used seeds SE290/SE285	>0.2	4	1
		0.2	3	

Table 54: FADN-based protocol for Integrated/Circular farming approach – Mixed Crop-Livestock farms

Integrated/Circular farming – Mixed Crop-Livestock				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Own feed production	Value of own produced feed on total feed value SE315/SE310	>0.5	4	2
		0.5	3	
		0.3	2	
		0.1	1	
		0	0	
Livestock feed	Value of purchased feed per grazing LU (SE310*/ SE085 + SE090 + SE095)	242	4	1.5
		366	3	
		486	2	
		646	1	
		> 646	0	
Stocking density	Total grazing LU/total forage area (SE085 + SE090 + SE095) /(SE071)	Insert biogeographic region specific values from the "Grazing" sheet	4	1.5
			3	
			2	
			1	
			0	
Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)	Value of sold electricity produced on farm on total value of consumed electricity ONRGPRD_SV/IELE_V	>0.2	4	1
		0.2	3	
Fertilisation (applies only if SE025>0, otherwise discard the variable**)**	Total fertilisers cost per ha of UAA SE295*/SE025	44	4	1.5
		82	3	
		122	2	
		174	1	
		> 174	0	
Seed - own ratio (applies only if SE290>0, otherwise discard the variable**)**	Value of seeds produced on farm on total value of used seeds SE290/SE285	>0.2	4	1
		0.2	3	

Table 55: FADN-based protocol for Integrated/Circular farming approach – Specialist COP farms

Integrated/Circular farming – Specialist COP				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	Total fertilisers cost per ha of UAA SE295*/SE025	67	4	2
		106	3	
		153	2	
		215	1	
		> 215	0	
Own feed production	Value of own produced feed on total feed value (SE315+SE325)/(SE310+SE320)	>0.5	4	1.5
		0.5	3	
		0.25	2	
		0 AND SE080 >0	1	
		0 AND SE080 =0	0	
Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)	Value of sold electricity produced on farm on total value of consumed electricity ONRGPRD_SV/IELE_V	> 0.2	4	1
		0.2	3	
		0	No score applied	
Energy use - electricity	IELE_V*/SE025	0.5	4	1
		3.3	3	
		7	2	
		15	1	
		> 15	0	
Seed - own ratio (applies only if SE290>0, otherwise discard the variable**)**	Value of seeds produced on farm on total value of used seeds SE290/SE285	> 0.5	4	1.5
		0.50	3	
		0.25	2	
		0.10	1	
		0.00	0	

Table 56: FADN-based protocol for Integrated/Circular farming approach – Specialist Horticulture farms

Integrated/Circular farming – Specialist Horticulture				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	Total fertilisers cost per ha of UAA SE295*/SE025	177	4	2
		480	3	
		1314	2	
		4772	1	
		> 4772	0	
Share of own-produced Feed	Value of own produced feed on total feed value (SE315+SE325)/(SE310+SE320)	>0.5	4	1.5
		0.5	3	
		0.25	2	
		0 AND SE080 >0	1	
		0 AND SE080 =0	0	
Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)	Value of sold electricity produced on farm on total value of consumed electricity ONRGPRD_SV/IELE_V	> 0.2	4	1
		0.2	3	
		0	No score applied	
Energy use - electricity	IELE_V*/SE025	48	4	1
		235	3	
		747	2	
		3104	1	
		> 3104	0	
Seed - own ratio (applies only if SE290>0, otherwise discard the variable**)**	Value of seeds produced on farm on total value of used seeds SE290/SE285	> 0.5	4	1.5
		0.50	3	
		0.25	2	
		0.10	1	
		0.00	0	

Table 57: FADN-based protocol for Integrated/Circular farming approach – Specialist Other Fieldcrops farms

Integrated/Circular farming – Specialist Other Fieldcrops				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	SE295*/SE025	74	4	2
		131	3	
		190	2	
		268	1	
		> 268	0	
Share of own-produced Feed	(SE315+SE325)/(SE310+SE320)	>0.5	4	1.5
		0.5	3	
		0.25	2	
		0 AND SE080 >0	1	
		0 AND SE080 =0	0	
Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)	ONRGPRD_SV/IELE_V	>0.2	4	1
		0.2	3	
		0	No score applied	
Energy use - electricity	IELE_V*/SE025	1	4	1
		8	3	
		20	2	
		55	1	
		> 55	0	
Seed - own ratio (applies only if SE290>0, otherwise discard the variable**)**	SE290/SE285	> 0.5	4	1.5
		0.50	3	
		0.25	2	
		0.10	1	
		0.00	0	

Table 58: FADN-based protocol for Integrated/Circular farming approach – Mixed crop farms

Integrated/Circular farming – Mixed crops				
Theme	**Variable Name**	**Value Ranges**	**Score**	**Weight**
Fertilisation	SE295*/SE025	48	4	2
		92	3	
		147	2	
		240	1	
		> 240	0	
Share of own-produced Feed	(SE315+SE325)/(SE310+SE320)	>0.5	4	1.5
		0.5	3	
		0.25	2	
		0 AND SE080 >0	1	
		0 AND SE080 =0	0	
Electricity - own production (applies only if ONRGPRD_SV >0, otherwise discard it)	ONRGPRD_SV/IELE_V	> 0.2	4	1
		0.2	3	
		0	No score applied	
Energy use - electricity	IELE_V*/SE025	54	4	1
		94	3	
		143	2	
		252	1	
		> 252	0	
Seed - own ratio (applies only if SE290>0, otherwise discard the variable**)**	SE290/SE285	> 0.5	4	1.5
		0.50	3	
		0.25	2	
		0.10	1	
		0.00	0	