UNISECO

UNDERSTANDING & IMPROVING THE SUSTAINABILITY OFAGRO-ECOLOGICAL FARMING SYSTEMS IN THE EU

Deliverable Report D3.5

Assessment of sustainability trade-offs and synergies among agro-ecological practices at farm level

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ACRONYMS

AEFS	Agro-ecological farming system
AEP	Agro-ecological practice
AUA	Agricultural University Athens
AWU	Annual Working Unit
BEF-LT	Baltijos Aplinkos Forumas VSI, LT
BEF-LV	Baltijas Vides Forums, LV
BOKU	University of Natural Resources and Life Sciences, Vienna
CFT	Cool Farm Tool
COMPAS	Comparative Agriculture System Model
CREA	Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria
DST	Decision support tools
FiBL	Research Institute of Organic Agriculture
FYM	Farmyard manure
GAN	Gestion Ambiental de Navarra, S.A.
GEO	Geonardo Environmental Technologies LTD
GHG	Greenhouse Gas
HUT	The James Hutton Institute
ISARA	Institut Superieur D'Agriculture Rhone Alpes
LUKE	Luonnonvarakeskus
NA	Not applicable
RDP	Rural Development Programmes
SAFA	Sustainability Assessment of Food and Agriculture systems
SLU	Sveriges Lantbruksuniversitet
SMART	Sustainability Monitoring and Assessment RouTine
TI	Johann Heinrich von Thünen Institut
UNIABN	The University Court of the University of Aberdeen
UZEI	Ustav Zemedelske Ekonomiky a Informaci
WWF	Asociatia WWF Programul Dunare Carpati Romania

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EXECUTIVE SUMMARY

Agro-ecological approaches are fundamental for sustainable food production in the future, and the overarching objective of UNISECO is to co-develop improved and practice-validated strategies and incentives for the promotion of improved agro-ecological approaches. The key dilemma is how to produce public goods whilst maintaining viable production of private goods, securing economic and social sustainability at a farm level. In this context, it is important to identify the farm management changes and innovative agro-ecological practices with win-win relationships and those with fewer trade-offs between social, ecological and economic dimensions.

In this Task, we investigate this question by exploring, in thirteen European case studies, the sustainability implications of implementing a range of different agro-ecological practices (AEPs) as part of different transitions strategies towards more sustainable agriculture. We implemented an analytical framework including the use of decision support tools (DSTs) to convey process-based information on the performance of 28 different AEPs, co-developed with local stakeholders, that are expected to improve the resilience and sustainability of farms. In particular, through the DSTs we identified and analysed 17 sustainability indicators that convey information on the potential environmental and socio-economic synergies and trade-offs, arising from the implementation of different AEPs at farm level. We classified different AEPs across three different categories: i) Efficiency increase, ii) Substitution practices, and iii) Farm re-design.

The category "Efficiency increase" included technological AEPs such as the installation of weather stations to integrate real time pest monitoring with fast prevention activities in vineyards, or improvement of mineral balance in ruminant diets through the provision of enriched boluses, or the re-configuration of canopies in tree orchards to enhance their productivity and resilience. Overall, these AEPs showed only win-win situations generated from livestock and crop health and yield provision.

The category "substitution practices" included the simulation of distinct AEPs, such as soil organic fertilization, use of biofertilizers and biofuels, as well as more complex strategies such as organic agriculture. Overall, this category emphasised the centrality for agro-ecological practices in reducing the use of external inputs and the simultaneous improvement in the quality and use-efficiency of input at farm level. Depending on the approach applied in the simulation of the AEPs, the transition from mineral to organic fertilization generated trade-offs between the increase of biodiversity benefits and the provision of yield, and between the carbon footprint and yield at farm level.

Finally, the "re-design" category includes single or bundle of AEPs, which are aimed at soil conservation and biodiversity benefits and increasing the diversification of farming systems. These included conservation agriculture practices, such as reduced tillage, permanent soil cover through cover crops or mulching, and intercropping with nitrogen fixing crops, the extensification of mixed crop-livestock systems, and more complex farm re-design driven by the reorganization of the resources in the farms and the reshuffling of arrangements 'downstream' of farms. Given the heterogeneity of this category, the environmental and socio-economic sustainability of the above agro-ecological strategies depended on several external factors such as farm type and size, initial farm infrastructure, as well as the dilemmas

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and objectives characterising the agricultural decision context in each case study. In this report, we outline the effect on the relationships between different farm-level sustainability indicators, as a result from the implementation of agro-ecological practices.

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1. INTRODUCTION

The adoption of more sustainable farming systems entails the need for agro-ecology experts, practitioners and researchers to analyse and support transition strategies that identify innovative agro-ecological practices, and changes in the governance of the farming systems that can improve the sustainability performance of the farms. This means that the transition towards sustainable agriculture requires innovation of the agricultural systems, including all the actors, infrastructures, processes and activities related to the production, transport, processing, distribution, and consumption of agricultural products (Timmermans et al., 2014). Agro-ecology has been conceptualized by three dimensions (i.e. scientific discipline, social movement, and a set of practices) which need to be implemented in an integrated way in order to change current agricultural paradigms and support the socio-technical transition towards more sustainable agricultural systems van der Ploeg et al., 2019). There is a wide-ranging debate in the literature on the best pathways toward sustainable agriculture (Ramankutty et al., 2019). To date, a number of studies defined transition strategies between incremental innovations, which are partial adaptations of existing practice/farm management and governance dimensions within the farming systems, and radical innovations, which are developed and tested in niches created by outsider networks, driven by alternative value chains and/or new performance criteria (Ramankutty et al., 2019, Schott, 1998).

The development and adoption of agro-ecological practices, however, has been reported to follow a variety of different, often unexpected and even contrasting trajectories (Smith, 2006, Cayre et al., 2018). The common view among researchers is that the transition towards sustainable agriculture should be assessed with regard to inherent trade-offs and synergies between site-specific farm requirements, maintaining the long-term ecosystem services for agroecosystem (Deng and Gibson, 2016). In that respect, to convey information in a clear manner and provide decision-making framework about potential sustainable pathways across geographic, ecological and socio-economic dimensions, it is important to identify the farm management changes and innovative agro-ecological practices with win-win relationships and those with fewer trade-offs between social, ecological and economic dimensions (Turkelboom et al., 2016, Ruhl et al., 2007, Tallis et al, 2017).

To what extent agro-ecology is capable of realising better economic returns, strengthening the resilience of farms, and marketing agriculture more sustainable compared to conventional agriculture in terms of biodiversity, soil health, nutrient losses, greenhouse gas (GHG) emissions, and energy use? In this study, we investigate this question analysing 13 European farming systems in which different transitions towards more sustainable agriculture were explored through an integrated approach comprising the involvement of local actors and stakeholders and the use of qualitative and quantitative methods to identify and explain potential trade-offs and synergies.

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2. MATERIALS AND METHODS

2.1. Analytical framework of synergies and trade-offs analysis

Task 3.4 is based on an analytical framework integrating the outcome of: i) the multi-actor platform process conducted in Tasks 3.3 and 3.4 and aiming to co-construct strategies for agro-ecological transitions, and ii) the use of decision support tools (DSTs) to convey reliable information on the sustainability of management changes and agro-ecological practices that are expected to improve the sustainability performance of the farms, and required changes in the governance of the farming systems (Landert et al., 2019, Schwarz et al., 2020). In the context of the overall case study (and project) aim of enhancing the understanding of barriers and drivers of agro-ecological transitions, Task 3.3 paid particular attention to the role and involvement of farmers, actors in the value chain, consumers, educators and policy makers and the desired cooperation between the different actors in implementing transition strategies. The multi-actor process, yielded, beside the agro-ecological practices to be modelled with the DSTs in Task 3.4, the general aspects of the decision context (i.e. objectives, key sustainability issues) and a better understanding of the changes in the governance of farming systems that address drivers and barriers of the implementation of agro-ecological practices across the case studies of UNISECO.

2.1.1. Definition of transition strategies

The definition of transition strategies is at the highest level in the analytical structure of the analysis of Task 3.4 (Figure 1). The transition strategies are divided into two distinct dimensions: i) Practice / farm management dimension and ii) Governance dimension. The practice / farm management dimension identifies changes to the farm management integrating different agro-ecological practices (AEP) at field and farm scale and explores which farm management changes and agro-ecological practices are expected to be effective and acceptable at a particular stage of the transition. The dimension of the strategies thus identifies possible answers to the question what the farm management changes are and the AEPs that have the potential to address the key dilemma and improve the sustainability performance of the case study farming system. The governance dimension identifies the roles of the different actors and how they can cooperate to address the transition barriers and drivers and facilitate the implementation of the agro-ecological practices by the farmers. The governance dimension aims to identify changes in ‘who, how and with whom’ involved in addressing barriers and drivers of initiating or progressing the agro-ecological transition of the farming system in the case study, and explores changes in rules that foster cooperation of actors (Schwarz et al., 2020). In that respect, changes in rules can include formalised contracts of collaborations, informal rules such as sharing or agreeing on common values amongst the different actors, and changes in market institutions and external policy-related rules such as changes in laws and regulations and identifies innovative market and policy incentives that facilitate and support the implementation of the agro-ecological practices.

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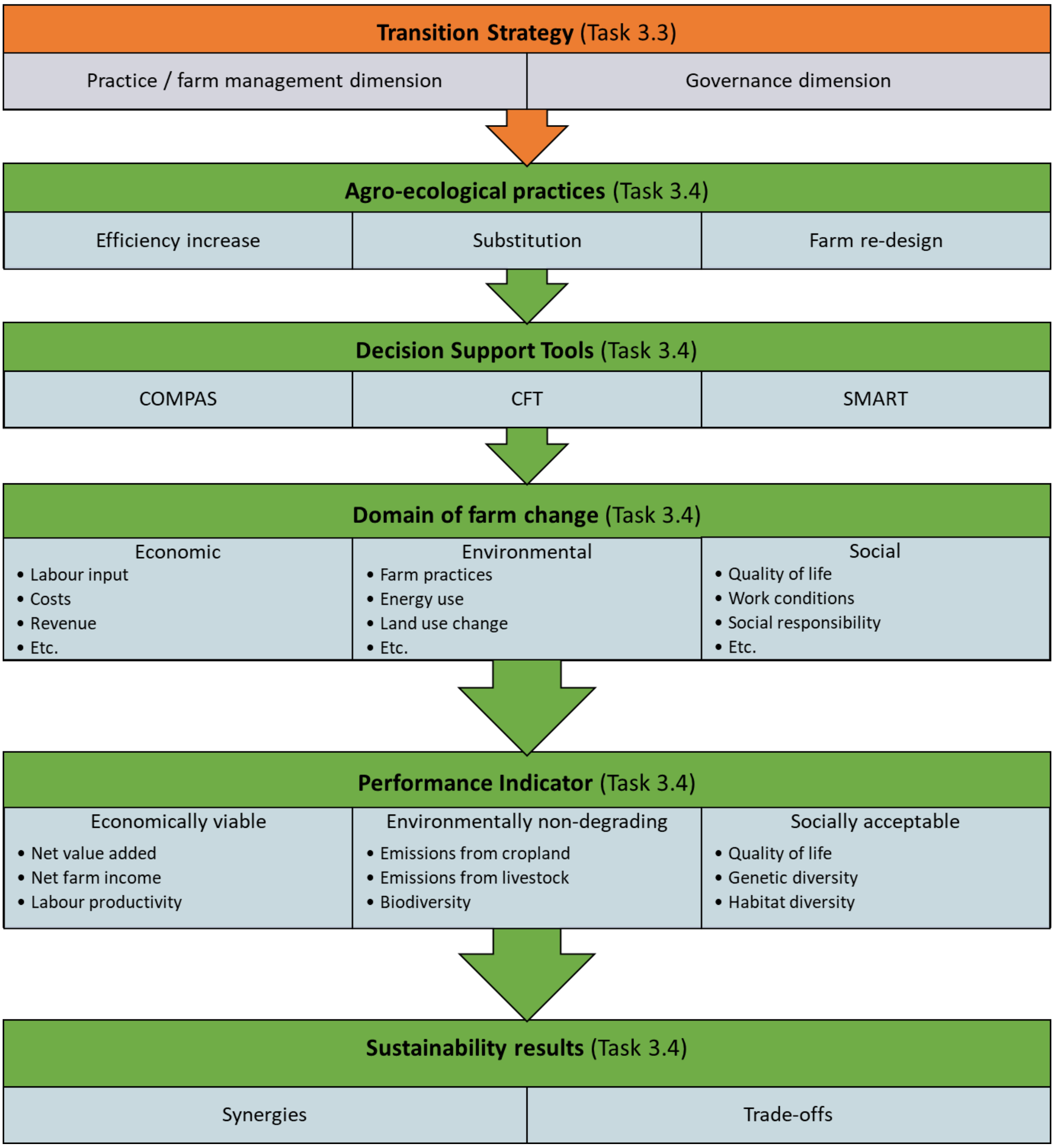

Figure 1: Hierarchical levels of the analytical framework applied in Task 3.4.

2.1.2. Definition of agro-ecological practices

The strategies co-constructed in Task 3.3 comprised information on the farm management changes and agro-ecological practices that are seen as effective and acceptable in each of the case studies. In Task 3.4 we classified AEPs according to the analytical framework of Hill and MacRae (1995) and Wezel et al. (2014), which described the transition towards sustainable agriculture by defining three stages: i) Efficiency increase, ii) Substitution practices, and iii) Farm re-design. Efficiency increase refers to practices that reduce input consumption within the farm boundaries (e.g. water, pesticides, and fertilisers). Substitution practices refer to the substitution of an input or a practice (e.g. replacing chemical pesticides by natural pesticides). While, farm re-design refers to a more fundamental change in crop management, herd

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characteristics, or even farming system. In addition to the implementation of practices at field, farm and landscape levels, also farm level implications of changes to the territorial governance of the farming system as part of a re-design of the farming system and changes in market institutions were simulated in some case studies[1].

But it is important to note that a particular practice (e.g. reduced tillage or intercropping) could correspond to more than one category of such a framework, i.e. correspond to different stages of the transition (Wezel et al., 2014) of such a framework. Across all stages, AEPs can cover aspects such as crop choice, crop spatial distribution, crop temporal successions, tillage management, fertilisation, irrigation, or weed, pest, and disease management. Table 2 reports the list of AEPs selected in Task 3.4 across the 13 case studies of UNISECO for the identification of synergies and trade-offs.

2.1.3. Performance indicators and definition of synergies and trade-offs

Ecological, social and economic processes that impact on the implementation of AEPs are directly or indirectly related within one another (Dale and Polasky, 2007). This means that, to understand the impact of different drivers of change (e.g. economic motives, soil nutrient budgets, product quality outcomes) from different domains at farm level, it is importance to apply multidisciplinary approaches capable to simulate ecological, biophysical and socio-economic processes occurring in various aspects of sustainability associated with the farm management changes and AEPs. The intermediate level of the analysis of Task 3.4 (Figure 1) includes the use of DSTs such as SMART (Sustainability Monitoring and Assessment RouTine), COMPAS (Comparative Agriculture System Model), and CFT (Cool Farm Tool) (see Section 2.2 for additional details). The ecological, biophysical and socio-economic processes simulated by the DSTs permit to identify and analyse the impact on a number of sustainability indicators related to the performance of agro-ecological practices implemented at farm level, providing a definition of sustainable agriculture that is economically viable, environmentally sound and socially acceptable.

Within each case study, we collected primary data from the participatory farm surveys as well as secondary data from the literature to determine potential outcomes on indicator not directly assessed by the DSTs (e.g. subsidies, fertilization level, or potential risks). The use of this information allowed to assess the current sustainability performance of farms (Landert et al., 2019) as a status-quo for 17 key sustainability indicators and first step to determine the potential synergies and trade-offs arising from the implementation of the AEPs at farm level (Table 1). Depending by the case study, the analysis focussed on the simulation of individual AEPs, or the simultaneous simulation of multiple AEPs simulating more complex changes to

[1] Due to their particular context and case study dilemma or an already advanced stage of agro-ecological transition, in some case studies (e.g. in Spain and Sweden) the co-constructed transition strategies did not identify and include new AEPs, but rather focussed on changes to the institutional settings of the farming system. In those cases, the farm level implications of changes to the governance of the farming system were assessed.

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current farm management. The pair-wise comparison of the sustainability indicators, before (i.e. status-quo of the farm) and after the implementation of the AEPs, provides the general direction and strength of positive and/or negative outcomes arising from different economic, environmental and social factors that cause the relationship between multiple services to develop and change at farm level. The final results of the sustainability indicators as average relative change (%) before and after the implementation of the farm management changes. When the value of the indicators is equal to zero in the initial stage of the farms, the results are omitted due to the impossibility to report the relative change impact from the implementation of the AEPs.

Table 1: Key sustainability indicators of CFT, COMPAS and SMART that convey qualitative and quantitative information on socio-economic and socio-environmental factors at farm level. In the unit column, ha stands for hectare, and FPCM stands for fat- and protein-corrected milk, and LC stands for local currency.

Sustainability Indicator	Dimension	DST	Type	Unit
Species diversity	Environmental	SMART	Qualitative	%
Habitat diversity	Environmental	SMART	Qualitative	%
Genetic diversity	Environmental	SMART	Qualitative	%
Water quality	Environmental	SMART	Qualitative	%
Soil quality	Environmental	SMART	Qualitative	%
Quality of life	Socio-Economic	SMART	Qualitative	%
GHG emissions	Environmental	SMART	Qualitative	%
Net value added	Socio-Economic	COMPAS	Quantitative	LC
Net farm income	Socio-Economic	COMPAS	Quantitative	LC
Labour productivity	Socio-Economic	COMPAS	Quantitative	LC
GHG emissions intensity from cropland	Environmental	CFT	Quantitative	CO_{2e}/ha
GHG emissions intensity from livestock	Environmental	CFT	Quantitative	CO_{2e}/ton
GHG emissions intensity from dairy	Environmental	CFT	Quantitative	CO_{2e}/FPCM
Benefits to biodiversity from farming products	Environmental	CFT	Qualitative	%
Benefits to biodiversity from farming practices	Environmental	CFT	Qualitative	%
Benefits to biodiversity over small farm habitats	Environmental	CFT	Qualitative	%
Benefits to biodiversity over large farm habitats	Environmental	CFT	Qualitative	%

Synergies are often described with the concept of winning situations, where the interaction of two or more changes, that occur within the process of decision-making, lead to an impact greater than the sum of their individual effects (Turkelboom et al., 2016, Luukkanen et al., 2012). Therefore, in our analysis synergy is a positive response from the implementation of the AEPs on more than one sustainability indicator at farm level. Trade-offs, vice versa, describe antagonistic situations that involve losing one quality or benefit of a service in return for gaining another (Cord et al., 2017).

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2.2. Description of the Decision Support Tools (DST)

The project partners applied three decision support tools (DST) in the study: SMART, COMPAS and Cool Farm Tool. Whereas SMART covers a wide range of sustainability themes, COMPAS focuses in depth on economic parameters, and Cool Farm Tool calculates the carbon and water footprint for a given farm enterprise. Cool Farm Tool also offers a biodiversity assessment of the whole farm, based on a multi-criteria assessment, similar to SMART.

2.2.1. SMART

SMART (Sustainability Monitoring and Assessment RouTine) is an innovative instrument for analysis of sustainability and the assessment of food production companies and farms. It is based upon the globally recognised Sustainability Assessment of Food and Agriculture (SAFA) guidelines (Schader et al., 2016).

The SAFA Guidelines were developed for assessing the impact of food and agriculture operations on the environment and people. The guiding vision of SAFA is that all four dimensions of sustainability are required to characterize food and agriculture systems worldwide: good governance, environmental integrity, economic resilience and social well-being. These four dimensions are organised in 21 themes that represent universal sustainability goals, which can be sub-divided into 58 subthemes that represent the sustainability objectives of the supply chain. For each subtheme there are indicators for the measurable criteria of a sustainable performance. The SMART tool collects context specific, farm enterprise specific information that enables the scoring of very different farm enterprises in a comparable manner using the four-sustainability dimensions with different levels of detail.

At its core, the SMART tool performs a multi-criteria analysis that makes use of expert derived weights to aggregate indicators of subthemes. The subtheme scores range from 0% (worst) to 100% (best) and are mapped onto a colour scheme with five underlying categories of goal achievement.

The farms assessed can be compared across subthemes, themes and dimensions. SMART can be used to aggregate groups of farms and compare the performance between these groups. This feature is used in UNISECO to compare groups of farms that represent different stages on the agro-ecological transition pathway, enabling the identification of the trade-offs and synergies in the agro-ecological transition.

The SMART tool was developed by sustainability experts at the three research institutes FiBL Switzerland, FiBL Austria and FiBL Germany.

2.2.2. COMPAS

COMPAS (Comparative Agriculture System Model) is a comparatively static, process analytical model used to analyse, in detail, economic and technological changes at a farm level. Agricultural production is represented by 73 crop and 36 livestock activities. The model uses either bookkeeping data from FADN or data specifically collected for farms are used as a primary source. Farm data (or, alternatively, normative data from farm management

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handbooks) are processed to calculate technical as well as monetary input-output coefficients of the farm model.

Model analysis is divided into two steps. The first step is a base run is done to analyse the status-quo of the farm. In the second step, specific model parameters (price, costs, additional activities, technologies or production processes) can be changed and compared with the status-quo. The output of COMPAS consists of various economic indicators of which the following have been selected to meet the purpose of the sustainability assessment. They follow the FADN definition (FADN, 2018) and the abbreviations in the brackets correspond to each indicators' FADN ID:

- *Annual Working Unit (SE010)*
- *Family Working Unit (SE015)*
- *Total Input*
- *Total intermediate consumption (SE275)*
- *Total Output (SE131)*
- *Total output crops & crop production*
- *Total output livestock & livestock products*
- *Other outputs*
- *Net Value Added (SE415)*
- *Labour productivity (SE425)*
- *Net Farm Income (SE420)*
- *Gross margins*
- *Total subsidies received*
- *Total output per total input (ratio)*

2.2.3. Cool Farm Tool

The Cool Farm Tool (CFT) is an online decision support tool used to estimate the environmental impacts of food production (https://app.coolfarmtool.org/). The tool estimates on-farm greenhouse gas (GHG) emissions from crops and livestock farms. It consists of a generic set of empirical models, ranging from Tier 1, Tier 2, and simple Tier 3 approaches (see IPCC, 1997 for a definition of Tiers for GHG estimation in national greenhouse gas inventories), to estimate full farm-gate product emissions. A

The development of Cool Farm Tool started in 2008 as an on-farm GHG emission calculator based on a collaboration between the University of Aberdeen, the Sustainable Food Laboratory and Unilever. The tool was first developed as an MS Excel spreadsheet and published in 2011 (Hillier et al., 2011). The biodiversity module was released in 2016 and based on the Gaia biodiversity yardstick (CFA, 2019, CLM, 2019). While, the water module was released online in 2017, and published in 2019 (Kayatz et al., 2019).

The calculator has seven input sections, each on separate web pages relating to farm Settings (location, climate etc.), general information (product, year, co-products etc.), characteristics of the growing area, field treatments (crop protection, fertiliser use, residue management etc.), management practices (land use and management, above ground biomass etc.), energy and processing (energy use, farm machinery, etc.), and transport activities.

ANNEX I shows in more detail the structure of the GHG calculator and biodiversity questionnaire of CFT. Each section of CFT was designed to enable farmers to input information specific to their own farm system, and to be able to manipulate the data entry to gain insight into the potential emission reductions that can result from the change in farm management practices. Therefore, the development of the tool was driven by the need to provide a simple,

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yet comprehensive GHG footprint for a specific farm or product, whilst remaining generic across crops, livestock and geographies.

2.3. Overview of the case studies and description of the workflow and processes applied in the synergies and trade-offs analysis

This section describes the main farm activities and factors that were changed to analyse in the DSTs the sustainability of farm management changes and AEPs across 13 European case studies. The cases were selected to cover a wide range of farming systems, pedoclimatic conditions and diversification strategies (Prazan and Aalders, 2019). In that respect, the heterogeneity of the case studies in terms of farm context, menu of the agro-ecological practices and their transition stages provide a broad basis for an initial assessment and discussion of the sustainability implications of enhanced implementation of AEPs in Europe.

Overall, 40 distinct AEPs were simulated for 48 farms across Europe (Table 2). Depending by the decision context of the case studies and the agro-ecological transition strategies developed in Task 3.3, the analyses were conducted on distinct AEPs, or on multiple AEPs as a bundle. In this context, a bundle of AEPs means that although in the method section, the changes in input parameters are separately explained for different AEPs or combinations of them, they were simulated in one run and generated only one set of simulation results. The reason for this approach was that those bundled AEPs belong to the same transition strategy and are optimally implemented jointly in practice.

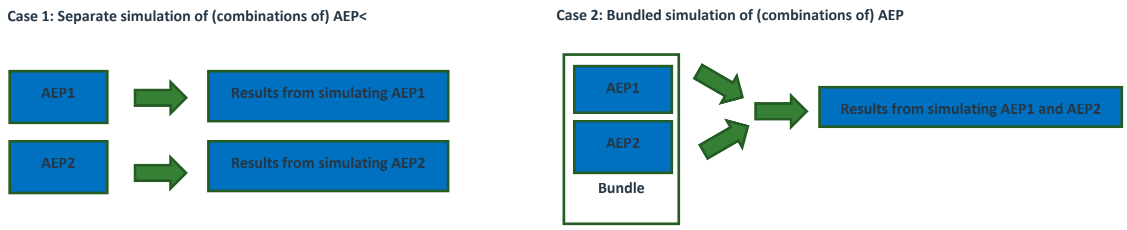

Figure 2: Diagram explaining the approach used in Task 3.4 to simulate the AEPs

The simulation of the AEPs required the simultaneous change of multiple input parameters across the three DSTs. These inputs correspond to the relevant drivers that in the implementation of the AEP cause the relationship between multiple services to develop and change at farm level. The direction (positive and/or negative) and degree of change of the input parameters play a fundamental role in the sustainability outcomes of the AEPs. Annex I, II, and III report the structure of the DSTs with the sections, subsection and input parameters.

The following sections outline the workflow and processes applied across the 13 case studies to assess the farm level sustainability implications of the co-constructed agro-ecological transition strategies. As described in Section 2.1.3, the baseline farm scenarios used in the analysis included information collected in the participatory farm surveys carried out in Task 3.2, which were influenced by local farm context, data interpretations during the interview process, and missing information. This heterogeneity in the baseline farm scenarios greatly affected the workflow and processes implemented in the simulations across the case studies.

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Table 2: Agro-ecological practices (AEPs) simulated in Task 3.4 by the 13 European partners of UNISECO

Case study	Agro-ecological practice simulated		Farms
Finland	Use of biofertilizer and biofuel		6
France	Reduction or removal of synthetic pesticides and implementation of green manure simulated as a bundle of AEPs		2
Germany	Intercropping, reduced tillage, and flower and buffer strips simulated as a bundle of AEPs		3
Greece	Reduction of mineral fertilisers, reduction of irrigation and cover crop simulated as a bundle of AEPs		2
Hungary	Reduced tillage; No tillage; No plough		1
Italy	Pest monitoring; Composting; Inter-row green cover		3
Latvia	From conventional to organic farming:	Organic fertilizers and no synthetic pesticides simulated as a bundle of AEPs	2
Lithuania	Increase of compound feeds; Balancing temporary and permanent grassland		5
Romania	From conventional to organic farming:	Organic fertilizers and no synthetic pesticides simulated as a bundle of AEPs	2
Spain	Collective post-harvest activity; Strengthened farmer network; Improved access to land		6
Sweden	From feeds to food crops; Increased payments		
	From conventional to organic farming:	Organic fertilizers, no synthetic pesticides, change of herd characteristic, change of grassland type, and change of animal feeding simulated as a bundle of AEPs	9
Switzerland	Extensification and direct marketing	Extensification and direct marketing and fruit growing	2
United Kingdom	Organic fertilizers; No tillage and direct drilling		5

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2.3.1. Finland (Nivala region – dairy farms)

In UNISECO the Finish case study focused on three farm groups along the agro-ecological transition pathway of dairy farms from conventional dairy farms (FADN 450) to conventional dairy farms involved in a biogas project, and organic diversified dairy farms (FADN 832). The biogas project consists of a centralized off-site biogas plant (large scale) that cooperates with local farms in Nivala. The farm provides feedstock (input) in the form of cattle manure and leftover grass silage (feed) to the plant and in exchange they receive biogas and biofertilizer.

In Task 3.4, this case study analysed two AEPs on six farms applying SMART. In the first AEP, the partners focussed on analysing the substitution of existing organic and mineral fertilizers with biofertilizer produced at the biogas plant and derived from the manure and silage produced at the farms. While, the second AEP simultaneously simulated the substitution existing organic and mineral fertilizers with biofertilizer with the substitution of fossil fuels (diesel and petrol), used in field operations and/or product processing operations, with biofuel such as bio-methane derived from the manure and silage produced at the farms.

Use of biofertilizer

- **SMART**
  - Fertilisation
    - Mineral Fertilizer amount
    - Organic Fertilizers amount imported on farm
    - Organic Fertilizers amount spread on farm
    - Organic Fertilizers dry matter
    - Organic Fertilizers N-content
    - Organic Fertilizers selection
    - Organic Fertilizers P-content
  - Local procurement
    - Externally sourced Input: Cost of input

Use of biofertilizer and biofuel

- **SMART**
  - Fertilisation
    - Mineral Fertilizer amount
    - Organic Fertilizers amount imported on farm
    - Organic Fertilizers amount spread on farm
    - Organic Fertilizers dry matter
    - Organic Fertilizers N-content
    - Organic Fertilizers selection
    - Organic Fertilizers P-content
  - Local procurement
    - Externally sourced Input: Cost of input
  - Waste management
    - Biogas plant: share organic residues
  - Energy management
    - Energy: Share own production

Figure 3: Sections and input parameters managed in SMART to carry out the simulations in the Finnish case study.

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2.3.2. France (Auvergne-Rhone-Alpes region)

The France case study comprises wine producers located in different departments of the region Auvergne-Rhône-Alpes (FADN 192/193), and explored AEPs specifically related to the reduction of fertiliser and pesticide along the gradient of organic certification, comparing conventional, organic and organic Demeter farms.

In Task 3.4 the French case study aimed to simultaneously analyse two AEPs on two conventional farms to simulate their transition to organic wine farming. The first AEP refers to the reduction of synthetic pesticides, such as fungicides and herbicides, balanced by the use of copper and sulphur integrated with decoctions and infusion of plant and herbs such as meadowsweet (*Filipendula ulmaria*). AEP1 is accompanied by biological pest control and grow of grass in vineyard. The biological pest control corresponds to a set of natural plant protection methods based on micro-organisms, chemical mediators such as pheromones and kairomones, or natural substances of plant, animal or mineral origin. While the under-row and inter-row grassing aims to increase soil biodiversity and fertility, and to reduce soil erosion, soil compaction. The grass is partially plough into the soil once a year.

The second AEP included the application of green manure crop (e.g. Nitrogen fixing crops) in the inter-row to increase soil fertility, reduce soil erosion, and suppress the potential weeds deriving from the grassing in vineyard.

The analysis of these two AEPs were carried out as a bundle using SMART and COMPAS (Figure 4). CFT was omitted in the analysis as the baseline results from the participatory farm assessments for this DST from Task 3.2 were unavailable due to operational issues at the time of finalising this report. In general, the partners assumed an increase of costs for new machineries, plant protection products, fuel costs for additional field operations, and labour inputs. Green manure was anticipated to act as an organic soil amendment reducing mineral fertilization. While inter-row grass grow would increase farm biodiversity and soil fertility. A decrease in crop yield by 49% and 29% in farm 1 and farm 2, respectively, was assumed. This discrepancy in the yield tendency between the two farms was justified by the different impact of

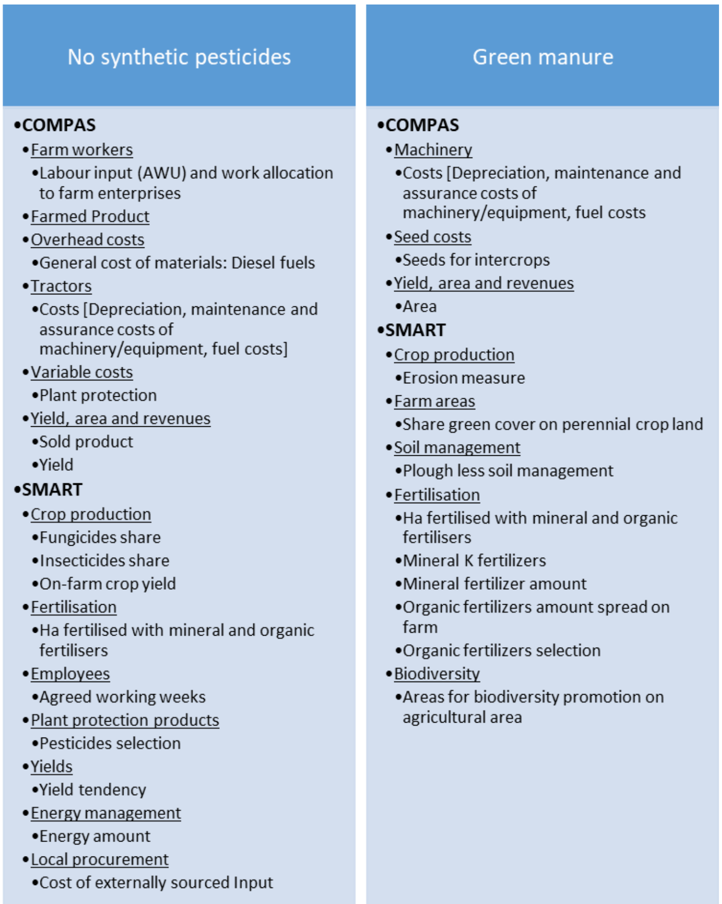

Figure 4: Sections and factors managed in COMPAS and SMART to carry out the simulations. In the French case study these two AEPs have been selected and implemented as a bundle for assessing their trade-offs.

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establishing inter-row grass cover in the locations of the two farms. Despite the decrease in productivity from the implementation of these two AEPs, however, it was assumed that in both farms the revenue from sold products would increase by approximately 35% due to higher price margins.

2.3.3. Germany (Nienburg in Lower Saxony – arable farms)

The German case study comprises an intensive agricultural area with specific sustainability issues regarding biodiversity loss and water pollution threats related to intensive livestock regions with severe issues of manure management and impacts on land (rental) prices. This case study, in particular, consists of farms with relatively low level of agro-ecological innovation, which implement largely only mandatory measures or some (voluntary) agro-ecological practices such as flowering strips and protection strips for wild herbs, tillage practices, extensive field margins or cover and catch crops.

As a consequence of conventional, market-oriented farming practices as a response to market pressures and land prices, the current agricultural system in Nienburg contributes to biodiversity loss and water pollution. To initiate a practically feasible and generally accepted transitions towards a more sustainable agricultural system, key is identifying and integrating suitable AEPs which address the sustainability issues but result in no significant (or rather limited) negative impacts on the economic viability of farms. In the course of co-constructing an agro-ecological transition strategy in workshops and interviews with members of the Multi-Actor Platform, a variety of AEPs has been identified. The following three have been selected and implemented as a bundle for assessing their trade-offs in further detail, namely:

- AEP1: Reduced tillage is applied on all suitable agricultural production areas. This excludes (a) potatoes production areas (not applicable for the three considered farms), (b) grassland areas and (c) production areas at which reduced, or no tillage practices were already applied in the status quo assessment. The implementation of this AEP included an increase of plant protection and fertilization practices in arable land of approximately 10%, and increase of costs for disc tillage operations in new areas undergoing reduced tillage, and the reduction of costs from the removal of ploughing operations.
- AEP2: Due to various social, economic and policy related barriers (which are analysed in detail in other tasks) only few agri-environmental measures (AEMs) are applied in the Nienburg case study. With the overall aim of enhancing the implementation of AEMs (and similar measures), AEP2 entails that 10% of the previous agricultural production area is allocated to flower strips (up to 10 ha, the maximum amount for receiving EU funding) and buffer strips. Financially, this AEP entailed the costs to implement the AEMs (310 euro/ha) followed by an increase of subsidies of 975 euro/ha for flower strips and 540 euro/ha for buffer strips. Both SMART and CFT provided the qualitative assessment of the benefits for biodiversity derived from the AEMs.
- AEP3: Maize is intercropped with field beans. As the demand, e.g., by the processing industries/wholesale, is perceived as insufficient for other combinations (which, for instance, require a subsequent separation of the mixed crops), other intercropping constellations are - under the current circumstances - less feasible. The mix of maize and field beans still serves the purpose of the production of merely maize in the status quo, namely bioenergy and fodder. Give the above conditions, the simulation of AEP3 comprised

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a reduction of approximately 10% of maize yield and corresponding fertilizer operations (mineral and organic). The increase of advisory costs of 1000 euro/year, 50% increase of seeding costs in maize, and the reduction of revenue from maize due to 3% decrease of market price.

AEP1
Reduced Tillage

- CFT
  - Biodiversity - Farming practices
    - What good practices do you use to improve soil health in crop fields?
  - Plant protection inputs
    - Application doses
  - Carbon Change & Sequestration
    - Change of tillage practice (TC)
- **COMPAS**
  - Machinery
    - Costs [Depreciation, maintenance and assurance costs of machinery/equipment, fuel costs]
  - Variable costs
    - Machinery cost
    - Plant protection
- **SMART**
  - Soil management
    - Plough less soil

AEP2
Flower and buffer strips

- CFT
  - General farm information
    - Crop area
- **COMPAS**
  - Subsidies/Payments
    - Payments for agri-environmental measure
  - Yield, area and revenues
    - Area (ha)
  - Overhead costs
    - Other operating expenses: Other costs
- **SMART**
  - General information
    - Ha. of arable land
  - Biodiversity
    - Areas for biodiversity promotion
  - Fertilization
    - Ha. fertilised with mineral and organic fertilisers

AEP3
Intercropping (Maize - Bean)

- CFT
  - Biodiversity - Farming practices
    - What good practices do you use to improve soil health in crop fields?
  - Biodiversity - Farmed product
    - How many different crops do you grow?
  - Biodiversity - Small habitats
    - Do you have areas of grass and flowering plants that are not for production?
    - What wildlife friendly management measures do you carry out along water courses?
  - Fertilizer inputs
    - Fertilizer rate
- **COMPAS**
  - Seed costs
  - Variable costs
    - Mineral fertiliser
    - Plant protection
  - Yield, area and revenues
    - Sold product
    - Yield
  - Overhead costs
    - Other operating expenses: Advisory costs
- **SMART**
  - Farm area
    - On-farm crop yield
    - Legumes share
  - Crop rotation
    - N. of elements in crop rotations
  - Biodiversity
    - Amount of mineral fertilizer

Figure 5: Sections and factors managed in CFT, COMPAS and SMART to carry out the simulations in each AEPs. In the German case study these three AEPs have been selected and implemented as a bundle for assessing their trade-offs.

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2.3.4. Greece (Imathia Region of Central Macedonia – fruit farms)

In UNISECO, the Greek case study focussed on the integration of crop management and insect sexual confusion methods for pest control in conventional fruit production farms. Integrated crop management consists of the limited use of fertiliser, pesticides or irrigation, while insect sexual confusion method refers to the replacement of chemical pesticides with dispensers which release synthetic pheromones with the aim to disrupting insect mating.

In Task 3.4, this case study aimed to convert two conventional fruit orchard farms to a so called two-dimensional (2D) canopy fruit orchards, including the establishment of inter-row cover crop and the application of green manure between the fruit tree rows. The two farms, in particular, were grouped in the eco-efficiency and input substitution stages on the agro-ecological transition pathway, applying either disruption methods or integrated farming management. The conversion to a 2D canopy controls dense vegetation allowing better sunlight interception, which in turn maximises photosynthesis, reduces the irrigation water volume and prevents from pests and diseases, since temperature and humidity do not favour the presence or spread of pests. Moreover, this system enables the mechanisation of farming operation, such as pruning and harvest, but requires advisory and support services for the two farms (Miranda Sazo, 2018). The simulation of this AEP in CFT and SMART aimed to replicate the benefits deriving from growing of cover crop between the tree rows. In particular, the harvested cover crop was assumed to be mulched, and incorporated in soil as green manure, to increase organic matter and nutrients in the soil, and to reduce the application of mineral fertilisers and its related field operations for the farmers. Moreover, green manure was assumed to prevent the germination of undesired seeds, control weeds, and encourage the population of beneficial soil invertebrates to proliferate.

Reduced chemical inputs and water consumption

- **CFT**
  - Carbon change & sequestration
    - Cover crop (CC)
  - Crop protection inputs
    - Application doses
  - Direct energy use
    - Category of energy use
    - Energy used
  - Fertilizer inputs
    - Fertilizer rate
  - Irrigation
    - Water used per week
  - Bioenergy - Small habitats
    - Do you have areas of grass and flowering plants that are not for production?
    - What wildife habitats do you provide in and around your farm buildings?
  - Soil
    - Soil Organic Matter
- **COMPAS**
  - Farm workers
    - Yearly salary
  - Overhead costs
    - General cost of materials: Contract work and machine rental
    - Other operating expenses: Advisory costs
  - Seed costs
    - Seeds costs
    - Seeds for intercrops
  - Variable costs
    - Contract cost
    - Mineral fertiliser
    - Plant protection
    - Water
- **SMART**
  - Crop rotation
    - Humus formation: catch crops
  - Soil management
    - Agricultural area: share of mulching
  - Fertilisation
    - Mineral fertilizer amount
  - Biodiversity
    - Areas for biodiversity promotion off agricultural area
  - Energy management
    - Energy amount

Figure 6: Sections and factors managed in CFT, COMPAS and SMART to carry out the simulation in the Greek case study.

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This means that, in CFT and SMART the analysis included the reduction herbicides activities, and the modification of factors directly related to the biodiversity in the farm, such as the increase of farm area promoting plant flowering and wildlife habitats and soil health.

Interestingly, the 2D conversion, which aimed to controls canopy densities allowing better sunlight interception and photosynthetic plant uptake, was not assumed to impact crop yields and farm revenues. However, in COMPAS, the simulation of the two-dimensional (2D) conversion and inter-row cover crop reduced the variable costs for plant protection products (-15%), mineral fertilizers (-30%), water consumption (-15%), as well as internal labour costs (-20%) for the two farms. The 2D transition of the fruit orchards and the implementation of cover crop introduced additional costs for contractor works and the advisory services.

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2.3.5. Hungary (Belső Somogy region – arable farms)

Apart from conventional tillage, three different levels of soil conservation management regimes were considered: 1) reduced tillage (tillage every 2 to 3 years in line with crop rotation), 2) no plough (substitution of plough with other tools) and 3) no-till (direct seeding instead of soil cultivation). One farm in the case study applies no-till system with direct seeding and cover cropping. Most of the farms apply no plough regime using cultivator and subsoiler combined with precision agriculture methods to increase efficiency by reducing pesticide and fertiliser use.

In Task 3.4 this case study further investigated the incremental impact of conservative tillage practices by simulating three distinct stages:

- AEP1 “from conventional tillage to reduced tillage”
- AEP2 “from AEP1 to no plough”
- AEP3 “from AEP1 or AEP2 to no-tillage”

Due to the lack of economic data from the participatory farm assessments carried out in Task 3.2, the sustainability analysis was carried out in the economic model of a theoretical farm that was created based on information and data partly collected during interviews with farmers in Task 3.1 for the socio-ecological system assessment, in Task 3.2 for the SMART assessment, and partly relying on a regional database of economic information on agricultural operational costs, market value of agricultural machinery and farming products, and potential revenue of similar arable farms in the region. This way the hypothetical farm is considered to be a plausible model of the average of the actual farms interviewed. Prior to the analysis in Task 3.4, the economic model of this theoretical farm was verified during the engagements with the local Multi-Actor Platform conducted in Task 3.3. The analysis of the three AEPs did not include the results from CFT.

The transition from conventional farming to AEP1 included limited changes of financial factors in COMPAS such as machinery costs (-5%), fuel consumption (-4%), and other costs related to maintenance, insurances and depreciation of machinery (+3%). While in SMART included the improvement of qualitative scores related to soil management (soil degradation, humus formation and fertilization requirements), and the deterioration of a factor related to soil compaction (-50%) (Figure 7). Compared to AEP1, in the analysis of AEP2 additional savings for the farm in term of machinery costs (-2%) and fuel consumption (-5%) were considered, as well as the reduction of costs for plant protection products (-5%). It is interesting to mention that in the analysis of SMART the case study partner indicated a slight increase in the number of pesticides applications. Further improvements of scores related to soil management, and positive scores related to the knowledge of climate change problems and soil fertilization requirements.

Finally, the transition from reduce tillage or no plough to no-till (AEP3) indicated numerous positive effects for the farm. The additional economic savings were: -11% for machinery costs, -18% for fuel consumption and -7% for other farm costs. No changes were reported on costs related to field operations, related to plant protection, and no crop yield losses would occur due to lack of water. AEP3, however, included a positive change of numerous factors in SMART regarding crop rotation and soil management practices, benefit for biodiversity in the

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farm, training and commitment to sustainable farming, and other participatory environmental activities outside the farm (Figure 7).

AEP1
from conventional tillage to reduced tillage

- **COMPAS**
  - Machinery
    - Costs [Depreciation, maintenance and assurance costs of machinery/equipment, fuel costs
  - Variable costs
    - Diesel/fuel
    - Machinery cost
- **SMART**
  - Soil management
    - Soil degradation: measures taken to counter
    - Soil degradation: severe soil compaction
    - Plough less soil management
    - Humus Formation: crop residues
    - Humus Formation: humus balance
  - Fertilisation
    - Determining fertilizer requirements

AEP2
from AEP1 to no plough

- **COMPAS**
  - Variable costs
    - Diesel/fuel
    - Machinery cost
    - Plant protection
- **SMART**
  - Soil Management
    - Soil degradation: measures taken to counter
    - Soil degradation: compaction due to heavy machinery
    - Plough less soil management
  - Fertilisation
    - Determining fertilizer requirements
  - Biodiversity
    - Promotion of beneficial organisms
  - Risk management
    - Knowledge of climate change problems

AEP3
from AEP1 or AEP2 to no-till

- **COMPAS**
  - Machinery
    - Costs [Depreciation, maintenance and assurance costs of machinery/equipment, fuel costs]
  - Variable costs
    - Diesel/fuel
    - Machinery cost
- **SMART**
  - Crop Production
    - Erosion Measure
  - Crop Rotation
    - Number of elements in crop rotation
    - Arable land: Share of green cover outside growing period
  - Soil management
    - Agricultural area: share of mulching
    - Soil degradation: measures taken to counter
    - Soil degradation: severe soil compaction
    - Soil degradation: compaction due to heavy machinery
    - Plough less soil management
    - Humus formation: humus balance
    - Arable land: share of direct seeding
  - Fertilisation
    - Determining fertilizer requirement
  - Biodiversity
    - Promotion of beneficial organisms
  - Yields
    - Yield decreases resulting from lack of water
  - Training
    - Training on sustainability
  - Conflicts
    - Fair resolution of conflicts
  - Participation
    - Environmental involvement outside the farm: Costs
  - Sustainability management
    - Verbal commitment to sustainability
    - Oral information sustainability improvements
  - Risk management
    - Knowledge of climate change problems
    - Climate change adaptation measures

Figure 7: Sections and factors managed in COMPAS and SMART to carry out the simulations in the Hungarian case study.

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2.3.6. Italy (Chianti region, Tuscany – winegrowers)

The Italian case study consists of both conventional and organic winegrower farm systems. The conventional farms are characterised by intensive production methods, while the organic winegrowers include advanced soil management approaches such as inter-row and under-row grass cover. In Task 3.4 the Italian case study investigated three distinct AEPs:

AEP1 "*Inter-row green cover*". Although this practice is already applied in the area, the lack adequate knowledge is limiting its effectiveness in increasing soil biodiversity and fertility, as well as reducing soil erosion and soil compaction. The analysis targets the gradual implementation of this AEP in combination with green manure crop (e.g. N fixing crops) to establish the correct mixture composition of plant species to cover vine inter-rows change in space and in time. The impact of AEP1 was investigated on one farm by converting 70% of the farmland from arable to grassland, and the removal of tillage practice in the farm. The analysis assumed a reduction of inputs (fuel and labour) for field operations related to weed control and no-tillage of 36%, no changes in farming costs and crop yield, and an increase of revenue from sold products of 15% (Figure 8).

AEP2 "*Composting*". This AEP is seldom applied by winegrowers because of the high equipment costs involved in its implementation. It focuses on the composting of vineyard crop residues, and processing waste from agricultural and livestock raw materials. The aim is to reduce dependence on external fertilizers, improves soil organic carbon balance, solving the problem associated with the practice of burning residues on field. The analysis carried out on five farms included the change of crop residue management from chopping and burying pruning residues to composting for organic soil fertilization, and the consequential abatement of 50% of mineral fertilization inputs (Figure 8). The implementation of AEP2 substantially increase the costs for additional machinery, diesel consumption and labour input, as well as the access to subsidies and investment grants (from 100 to 1410 euro/year).

AEP3 "*Pest monitoring*". This AEP could be considered a precision agriculture technology for limiting crop losses to pests. Its implementation involves the installation of weather stations in the middle of the orchards to integrate real time monitoring with fast prevention activities achieved through precise plant protection treatments. The overarching aim of AEP3 is to develop systematic crop protection treatments in different periods of the cropping season which, if adopted systematically by many farms in the same region, can contribute to establish weather networks for high quality phytosanitary bulletins. In the three DSTs, the simulation of AEP3 included the decrease of factors such as fuel consumption (-37%), labour inputs (-32%) for field operations related to plant protection and equipment installation, the increase of equipment costs and farm subsidies, and the change of pesticides products used in the farms (Figure 8).

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AEP1
Inter-row green cover

- **CFT**
- Carbon change & sequestration
  - % of field affected by LUC
  - Land Use Change type (LUC)
  - N. of years from change
- Bioenergy - Farming practices
  - Do you add organic matter to your fields?
  - What good practices do you use to improve soil health in crop fields?
- Field operations energy use
  - Fuel quantity
- **COMPAS**
- Seed costs
- Subsidies/Payments
  - Payments for agri-environmental measure
- Variable costs
  - Diesel/fuel
- Labour input
- Plant protection
- Yield, area and revenues
  - Sold product
- **SMART**
- Farm areas
  - Share green cover on perennial crop land
- Soil management
  - Agricultural area: share of mulching
  - Soil degradation: severe soil compaction
  - Soil degradation: compaction due to heavy machinery
  - Plough less soil management
- Plant protection products
  - Pesticides selection
- Biodiversity
  - Areas for biodiversity promotion on agricultural area
  - Management of riparian strips
- Yields
  - Yield tendency
- Energy management
  - Energy amount

AEP2
Composting

- **CFT**
- Bioenergy- Farming practices
  - Do you add organic matter to your fields?
- Fertilizer inputs
  - Fertilizer type
- Field operations energy use
  - Fuel quantity
- Residues management
- **COMPAS**
- Machinery
  - Costs [Depreciation, maintenance and assurance costs of machinery/equipment, fuel costs]
- Subsidies/Payments
  - Investment grants
- Variable costs
  - Diesel/fuel
  - Labour input
  - Organic fertiliser
- **SMART**
- Fertilisation
  - Mineral fertilizer amount
  - Organic fertilizers amount imported on farm
  - Organic fertilizers amount spread on farm
  - Organic fertilizer selection
- Local procurement
  - Externally sourced input: point of origin: domestically (non-locally)
  - Externally sourced input: point of origin: Origin of input is known
  - Externally sourced input: proportion locally produced
- Cooperation with suppliers
  - Quality of cooperation with suppliers
  - Secure supply of farm inputs

AEP3
Pest monitoring

- **CFT**
- Farming Practices
  - What good practices do you use when applying crop protection products?
- Field operations energy use
  - Fuel quantity
- **COMPAS**
- Machinery
  - Costs [Depreciation, maintenance and assurance costs of machinery/equipment, fuel costs]
- Subsidies/Payments
  - Investment grants
- Variable costs
  - Labour input
  - Plant protection
- **SMART**
- Plant protection products
  - Pesticides selection

Figure 8: Sections and factors managed in CFT, COMPAS and SMART to carry out the simulations in the Italian case study.

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2.3.7. Latvia (countrywide – dairy farming)

The Latvian case study aims to explore transition strategies which address barriers and drivers of the economic viability of conventional and organic, largely grass-based, dairy farms by identifying actions that strengthen organic and agro-ecological farming practices, increasing the amount of certified organic milk processed into organic dairy products and stimulating consumer demand for organic dairy products.

In line with the above aims, in Task 3.4 the analysis focussed on the conversion of two conventional dairy farms to organic farming while maintaining the same herd size and comparable milk production (Figure 9). The implementation of this agro-ecological strategy assumed a reduction of 45% and 50% of yield from the wheat and oats fields, respectively. This outcome was justified by the absence of any mineral fertilization and plant protection products. The dairy enterprise in the two farms, however, was reported to produce the required soil organic fertilization, such as manure, which for the two feed crops was assumed to balance the loss of soil nutrient from mineral fertilization.

To overcome the decrease in crop productivity, the two farms were assumed to increase the purchase of feedstuffs (oats and wheat) for the dairy enterprise (25 tonnes on farm 1 and 200 tonnes on farm 2). Interestingly, the reduction of crop yields was not reflected in a reduction of costs related to crop inputs, field operations, and processing of products. The conversion to organic farming, however, increased the annual farming subsidies by Euro 118/ha.

Figure 9: Sections and factors managed in CFT, COMPAS and SMART to carry out the simulations in the Latvian case

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2.3.8. Lithuania (countrywide – dairy farming and cheese making)

The overall aim of the Lithuanian case study is to investigate the agro-ecological transition of highly specialized conventional dairy farms to extensive specialized dairy farms and extensive mixed dairy farms. In Task 3.4 the partners from Lithuania simulated two distinct AEPs:

AEP1 "Balancing temporary and permanent grassland for grazing and feed". This AEP aims to find the ideal balance between grassland productivity and environmental performance at farm level. Different balances of permanent to temporary grasslands were simulated on three farms, considering the use of optimal locally adapted grass crop mixtures that enhance biodiversity and meadow longevity (i.e. 40% proportion of legume and a 5-year rotation). On farms, where roughage is externally sources, the analysis included a sustainable increase in an area of temporary meadows and a better utilisation of permanent grasslands was also looked at in one farm to fulfil the internal production of roughage. While, in the farms with underutilised highly productive temporary grassland, a conversion from temporary to permanent grassland is simulated. The sustainability assessment varied across the farms and, depending by the needs and grassland typology, it comprised an incremental increase of temporary grassland (100% permanent, 50%-50% temporary-permanent, 100% temporary), or a conservative management of temporary and permanent grassland already present in the farms. The analysis assumed that the productivity of temporary grassland was three times higher than the productivity of permanent grassland, and that the balance between temporary and permanent grassland ensured the annual internal needs of feedstuff for the livestock. Finally, farming inputs such as fuel consumption and labour for field operations and product processing, as well as costs for seeding varied based on the degree of conversion between temporary and permanent grassland. And mineral fertilization in grassland was avoided by including Nitrogen fixing species in the grass composition (Figure 10).

AEP2 "Use of mineral supplements to improve productivity the health and lifespan of grass-fed animals, and the overall farm performance". This AEP aims to simulate the necessary steps to improve the mineral balance in ruminant diets through the provision of mineral enriched boluses at the beginning of each lactation. AEP2, in particular, was experimented on 5 farms to investigate its direct impact on livestock productivity. In the analysis of AEP2, the degree of change of these factors depended on the initial conditions of the five farms considered in the simulations. In general, the increase of productivity and health of the livestock coincided with an increase of input parameters such as costs for buying mineral supplements, costs of product processing and milk production, revenue from milk, and the decrease of costs for medical products and veterinary services (Figure 10).

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AEP1
Management of permanent and temporary grassland

- **CFT**
  - Crop details
    - Area
    - Gross yield
  - Biodiversity - Farmed product
    - Do you have any grassland?
  - Biodiversity - Farming practices
    - What good practices do you use to improve soil health in grassland fields?
    - What measures do you take to provide flower resources in your productive fields?
  - Field operations energy use
    - Fuel quantity
- **COMPAS**
  - Farm workers
    - Labour input (AWU) and work allocation to farm enterprises
  - Animal feeds
    - Bought-in
    - Own production
    - Price
    - Total cost
  - Overhead costs
    - Other operating expenses: Soil analyses
  - Seed costs
  - Variable costs
    - Diesel/fuel
    - Labour input
  - Yield, area and revenues
    - Area
    - Own use feedstuff
    - Yield
- **SMART**
  - Crop production
    - Crops area
    - Crops selection
    - Legumes share
    - On-farm crop yield
    - Actual weekly working hours
  - Farm areas
    - Hectares of permanent grassland
    - Hectares of temporary grassland
  - Grasslands
    - Permanent grasslands: mowing frequency
    - Permanent grasslands extensively managed
    - Permanent grasslands: conversion
    - Permanent grasslands: renewal
  - Crop rotation
    - Number of elements in crop rotation
    - Crop resistance
  - Animal feeds
    - Proportion bought-in roughage
    - Bought-in concentrated feed
  - Energy management
    - Energy amount
  - Local procurement
    - Cost of externally sourced input

AEP2
Increas of compound feed

- **CFT**
  - General farm information
    - Weight finished product
    - Milk produciton
    - Total milk production
- **COMPAS**
  - Other costs
    - Medical products
    - Other costs
    - Veterinary service
  - Production system
    - Millk performance
  - Revenues milk
    - Milk quantity (on-farm processing)
    - Other milk revenues
    - Revenues (dairy)
    - Revenues (processing)
    - Sold milk quantity
- **SMART**
  - Local procurement
    - Cost of externally sourced input

Figure 10: Sections and factors managed in CFT, COMPAS and SMART to carry out the simulations in the two AEPs of the Lithuanian case study.

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2.3.9. Romania (Transylvania and Maramures region – mixed farms)

The Romanian case study includes three farm production types: Dairy farms (FADN 470), farms with cattle - rearing and fattening (FADN 460) and farms with permanent crops and grazing livestock combined (FADN 842). For all the farm production types, the following agro-ecological groups were defined in addition to the conventional baseline: Organic dairy farms, transitional cattle –rearing and fattening farms, and transitional/ organic farms with crops and grazing livestock combined.

The analysis of Task 3.4 focussed on the conversion of two conventional dairy farms including arable and grassland, to organic farming. Both farms derive all revenue from selling the milk as raw material and use their crop production to produce feed and to increase the dairy revenue.

On farm 1 the conversion to organic farming focussed on changing the arable enterprise, maintaining the initial conditions of the dairy enterprise. Although the extensification of farming practices in arable land was assumed to reduce crop yields by 50%, the internal production of feedstuff of this farm was still sufficient to the meet the annual dairy needs. Overall the conversion to organic farming was assumed to change the soil fertilization regimes replacing the use of mineral soil fertilization with organic cattle manure (up to 187.5 kg/ha), remove the use of chemical plant pretention products, reduce the revenue from the selling of feedstuff (-70% for wheat and barley, -81% grain maize, -100% maize silage), decrease the energy consumption for feed product processing, and increase the subsidies from organic farming by 500 euro per hectare (Figure 11).

Similarly to the above farm, on farm 2 the conversion to organic farming focussed on changing the arable enterprise, maintaining the initial conditions of the dairy enterprise. Overall the conversion reduced feed crop production by 50% requiring the need to buy feedstuff (+20% of vetch and lucerne). Organic fertilization replaced the use of mineral soil fertilization (up to 162 kg/ha of cattle manure), removed the use of chemical plant pretention products, reduced the revenue from the selling of feedstuff (-70% for wheat, barley and grain maize, and -100% maize silage), decreased the energy consumption for feed product processing, and increase the subsidies from organic farming by 500 euro per hectare.

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From conventional to organic farming

- **CFT**
  - Crop_details
    - Gross yield
  - Crop protection inputs
    - Application_doses
  - Bioenergy - Farming_practices
    - What type of crop protection products do you use?
    - What good_practices do you use to improve soil health in grassland fields?
  - Fertilizer inputs
    - Fertilizer type
  - Field operations energy use
    - Machine type
    - N. of operations
- **COMPAS**
  - Animal feeding
    - Total cost
  - Subsidies/Payments
    - Area payments for organic farming
  - Variable costs
    - Mineral fertiliser
    - Plant protection
    - Organic fertiliser
  - Yield, area and revenues
    - Own use feedstuff
    - Sold product
    - Yield
- **SMART**
  - Fertilisation
    - Fertilised with mineral and organic fertilisers
    - Mineral K fertilizers
    - Harmful substances P-fertilisers
    - Mineral fertilizer selection
    - Organic fertilizers amount imported on farm
    - Organic fertilizers amount spread on farm
    - Organic fertilizers selection
  - Plant protection products
    - Growth regulation
    - Use of chem. synth. seed dressings
    - Flowering regulation
    - Pesticides selection
  - Crop production
    - Fungicides share
    - Herbicides share
    - Insecticides share
    - Legumes share
    - On-farm crop yield (farmer's estimation)
  - Yields
    - Yield tendency
  - Feeding
    - Proportion bought-in roughage
  - Animal welfare
    - Use of antibiotic drying agents

Figure 11: Sections and factors managed in CFT, COMPAS and SMART to carry out the simulations in the Romanian case study.

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2.3.10. Spain (Basque Country and Navarra region – cereal farms)

The Spanish case study focuses on arable farms that are in an advanced stage of agro-ecological transition with different agro-ecological practices already implemented. The case study analyses governance changes of farms belonging to the regional social and farmer association of EHKO (https://ehkolektiboa.eus/), with small sized farms under organic production, with diversity of crops, which work in a local context as much as possible using short marketing channels. The farm assessments carried out in Task 3.2 on 10 farms, grouped into conventional, agro-ecological, and in transition to become agro-ecological, showed important differences in terms of environmental sustainability between different farm groups. In that respect, the pairwise comparisons between the farms revealed that, due to the economic and social fragility of the farms, it is at the post-harvest productive stage that the farmers in the Spanish case study encounter some of the most difficulties to develop their agro-ecological farm model.

Considering the above findings, the AEPs analysed in Task 3.4 are not directly related to practices carried out in the field during the crop production stages but are more related to the social and economic dimensions of the arable farms (i.e. political and market initiative strategies). The sustainability analysis of this case study, in particular, aims to provide information related to the dimension of good governance, linking the agro-practices, barriers and drivers to be addressed, actors to be involved, required changes in the institutional setting and a list of candidate Market and Policy Instruments.

AEP1 "*Strengthened farmer network*". The farm assessments of Task 3.2 showed that three farmers of this case study (members of EHKO farmers) in an advanced stage of agro-ecology had positive impacts of being part of a farmer network. Therefore, these 3 farmers have also been included in the analysis of task 3.4 because these cases show more room for improvement. Being part of a network is particularly important in the transition stage as it helps and encourages farmers into the transition, by reducing the farmer's sense of loneliness and by putting them in contact with other farmers with more knowledge and experience. Within this AEP, specific initiatives have been identified, such as mentoring to young farmers, the creation of formal and informal networks among farmers, projects for the integration of farmers within their local communities and the "substitution initiative" that promotes the participation of farmers in politics and policymaking. By applying COMPAS and SMART, the analysis of this AEP investigates benefits derived from: technical, economic and/or bureaucratic support or advice, greater transfer of knowledge among farmers, lower feeling of loneliness and greater feeling of belonging to the community, improvement in the resolution of local conflicts, and an increase in citizen participation (Figure 12).

AEP2 "*Collective post-harvest activities*". One of the great challenges identified in the Spanish case study resides in the agri-food chain, once the harvesting activities have been completed. In that respect, a lack of structure has been identified in the value chain for agro-ecological farmers, and the need to develop these structures so that small sized and organic farmers can carry out product processing and marketing activities (increasing the added value of the products) in a local context. The solutions to these problems are initiatives that seek the collectivization of activities among agro-ecological farmers, which include services and infrastructures, such as the experience of EKOALDE (focused on distribution) or the group of the grain selector (focused on storage, selection, cleaning and in the future,

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commercialization). Using COMPAS and SMART, the analysis of AEP2 targets benefits deriving from: less complexity in the commercialization and marketing stage, less workload, more free time (to spend as holidays or developing other aspects of the farm), new commercialization channels, and reaching new clients (Figure 12).

AEP1 – Strengthened farmer network

- **SMART**
  - Sales
    - Proportion of products meeting social standards
  - Staff
    - Availability of adequate replacement of farm manager
  - Training
    - Access to advisory services
  - Conflicts
    - Cooperation with other farms
    - Resource conflict prevention
  - Participation
    - Cost of social involvement outside the farm
    - Costs of environmental involvement outside the farm
    - Involvement in improving laws and regulations

AEP2 – Collective post-harvest activities

- **COMPAS**
  - Facilities
    - Depreciation of agricultural buildings
  - Agrarian buildings
    - Maintenance costs of agricultural buildings
  - General costs
    - Depreciation, maintenance and assurance costs of agricultural buildings
  - Performance / Revenues / Soil
    - Sales products: barley, oats, triticale, wheat, broad bean, chickpea. lentil, pea, vetch, white bean, asparagus, vegetables, olive tree, vineyard.
- **SMART**
  - Sales
    - Diversification of sales
    - Processing on the farm
    - Dependency on main customer
    - Length of customer relationships
    - Collective marketing
    - Producer price vs. market price level
  - Work conditions
    - Work-Life-Balance family workers (holiday)
  - Accounting
    - Farm net income

AEP3 – Improved access to land

- **COMPAS**
  - General data of the farm
    - Average lease price: arable land, fruit trees, other land of permanent crops, total, vineyard.
    - Owned land: arable land, fruit trees, other land of permanent crops, total area, vineyard.
    - Rented land: arable land, fruit trees, other land of permanent crops, total area, vineyard.
  - General costs
    - Agricultural land rental expenses
- **SMART**
  - Farm areas
    - Land ownership
  - Staff
    - Farm succession

Figure 12: Sections and factors managed in COMPAS and SMART to carry out the simulations in the Spanish case study.

AEP3 "*Improved access to land*". Another important barrier analysed in the Spanish case study is the problem of access to land, which affects all farmers (conventional, in agro-ecological transition and in an advanced stage of agro-ecology). For organic producers this problem is even more complicated, as it is very unlikely that a tenant farmer invests the necessary labour and survives the conversion to organic without guarantees on the long-term access to specific land. In the analysis of AEP3 only the three organic farms were considered, simulating the effect of promotional initiatives such as the "territorial farming contracts" and the "land bank" to improve access to land. In COMPAS and SMART, these initiatives have an impact in the price of land, encouraging farmers to buy some plots instead of renting them, and lowering the leasing price. They should also improve the generational replacement rate as well as favouring the installation of young farmers (Figure 12).

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2.3.11. Sweden (countrywide – ruminant farms)

The Swedish case study investigates the challenges and possibilities for diversifying specialised livestock farms (conventional and organic) to include more crops for direct human consumption while simultaneously integrating more agro-ecological principles to enhance sustainability performance in an economically highly strained production sector. This case study in particular assessed livestock diversity across 3 different agro-ecological stages, focusing on both dairy and fattening. Stage 0 of the transition pathway grouped conventional farms (only fattening), stage 1 grouped partly organic and diversified fattening or dairy farms, and the final stage 2 grouped diverse fully certified organic farms.

In Task 3.4 the Swedish case study simulated two higher level AEPs that re-design the farming system:

AEP1 "*More crops for food and increase payments*". Nine farms of this case study have already started delivering more crops for food instead of feed, with six of them delivering oats to Oatly receiving 50% increased payment. AEP1, therefore, reflects changes in the governance of the farming system and changes in market institutions and simulates the resulting benefits of the increase in productivity and selling of crops for human consumption, such as legumes and potatoes, investigating what happens in the value chain and post farm-gate rather than changes to management practices on the farms. This included the increase of direct marketing (collaboration with buyers) and its revenue, as well as the implementation of extensively grazing in dairy farms.

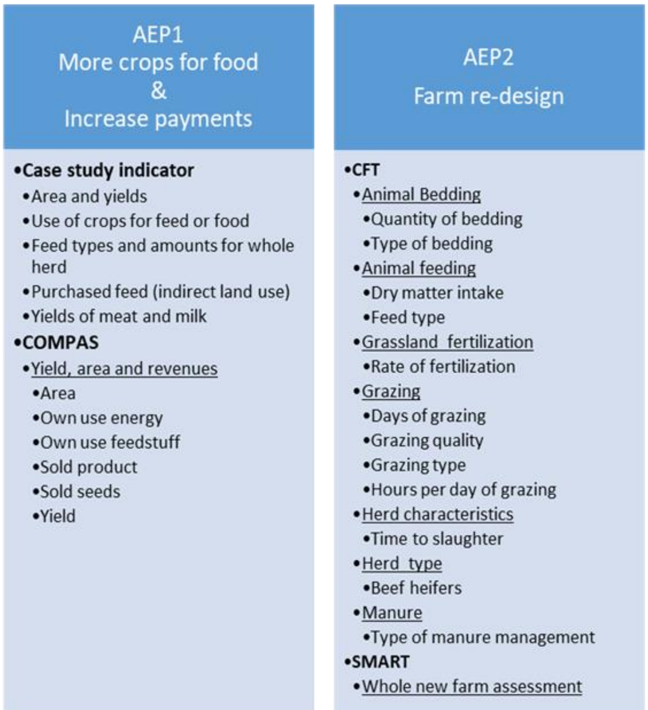

Figure 13: Sections and factors managed in CFT, COMPAS and SMART to carry out the simulations in the Swedish case study.

AEP2 "*farm re-design*". The overarching objectives of AEPs are to reduce the climate impact of the farm by improving crop rotations, animal welfare, biodiversity, and the exclusion of synthetic pesticides and chemical fertilizers. The sustainability analysis of TS2 focuses on the transformation of a conventional livestock farm in organic cropping and extensive pasture rearing of beef, assuming the shift from 1200 intensively reared cattle to 300 extensively reared cattle integrated with crops. In the DSTs, this was achieved by changing the initial herd characteristics in the farm (from 1200 industrially reared bulls to 350 extensive heifers), the life cycle of the livestock in the farm (slaughter age from 17 to 30 moths), their feeding regime balance between grazing and feedstuff intake, and the management of manure and bedding in the farm.

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2.3.12. Switzerland (Lucerne Central Lakes region – livestock farms)

The main objective of the Swiss case study is to investigate strategies to reduce livestock density and to diversify livestock farms at different agro-ecological stages. The baseline scenario (stage 0) correspond to conventional livestock farms, stage 1 of the agro-ecological transition groups organic livestock farms, and the final stage 2 explores two different options of system re-design: a substitution of livestock with special crops (fruit, berries and vegetables), and a reduction of livestock intensity with a broader livestock diversity with suckler cows as an enterprise (popular alternative to dairy production in the region).

In Task 3.4, this case study investigated two AEPs aiming to reduce stocking densities (dairy and pigs with arable and grassland) on two conventional mixed farms where the fodder grown on the farm was used as the limiting factor for livestock production. As a consequence, for one farm, it was modelled that pig breeding was completely abandoned. For the second farm, the breeding intensity was modelled to be reduced to 14% of the original production.

The first AEP corresponds to the described extensification of animal husbandry, where the fodder demand needs to be satisfied by on-farm production. Additionally, an increase of direct marketing (e.g. farm shop, online shop, vegetable box) and/or joint marketing (e.g. joint farm shop, cooperatives, etc.) is assumed. The analysis of this AEP included the modification of a large number of input parameters across the three DSTs (Figure 14). Focusing only the main changes, pig herd was decreased by 86% or completely removed, and as a consequence also other factors related to this livestock enterprise were reduced (e.g. feedstuff, energy & fuel consumption, labour inputs, costs for veterinary and animal insurance, and revenue from the pig enterprise). Following the change to pig enterprises, some of wheat formally used as fodder was assumed to be sold externally A small share (1%) of was newly assumed to be sold by means of direct marketing. Related to that, the farm costs and labour inputs for carrying out the direct marketing (also of milk) increased by approximately 10%.

In the second step of the analysis, the partners investigated the impact of extensification and increased direct marketing bundled with the conversion of 10% of permanent grassland to apricots plantation. The anticipated limitation of this second stage is that Apricots need warm growing conditions which cannot be assumed for all locations within the Swiss case study region. However, there are first trials in the area and as there is a growing domestic market demand. The sustainability analysis of this AEP included the factor changes applied in the first stage (i.e. extensification and increased direct marketing) plus the changes related to the establishment of apricot tree plantation in the two farms (Figure 14). These, in particular, included the change of soil characteristics caused by the land use change in grassland, and the increase in labour, fuel consumption, and costs for field operations related to field installations, organic soil fertilization (cattle manure produced in the farms), post-emergence plant protection, and revenue from the direct marketing of apricots.

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Extensivation
Increased joint direct marketing

- **CFT**
  - Energy use
  - Fertilizer inputs
    - Fertilizer rate
  - General farm information
    - Weight finished product
  - Herd
    - Adult non productive phase
    - Juvenile phase
- **COMPAS**
  - Farm workers
    - Labour input (AWU) and work allocation to farm enterprises
  - Animal feeding
    - Bought-in
    - Own production
  - Overhead costs
    - General cost of materials
    - Other operating expenses: Other costs
  - Production system (breeding pigs)
    - Annual stocking rate
    - Number boars
    - Number breeding sows
    - Number gilts
    - Replacement rate
  - Revenues
    - Sold culled stock
    - Sold / transfered weaner per sow
    - Weight of sold weaners
  - Revenues milk
    - Revenues (dairy)
    - Revenues (processing)
  - Subsidies/Payments
    - Other grants for animal productions
  - Yield, area and revenues
    - Own use feedstuff
    - Sold product
- **SMART**
  - Livestock production
    - Livestock losses
    - Livestock number
  - Employees
    - Workers actual weekly working hours
    - Workers agreed weekly working hours
  - Fertilisation
    - Mineral fertilizer amount
    - Organic fertilizers amount of exported fertiliser
  - Animal feeds
    - Bought-in concentrated feed
  - Energy management
    - Energy amount

Extensivation
Increased joint direct marketing
and fruit growing

- **CFT**
  - Co-products
    - Crop residues
  - Crop details
    - Area:
    - Gross yield
    - Net yield
    - Type of crops
  - Crop protection inputs
    - Application doses
    - Category
  - Energy use field operations and processing
    - Category of energy use
    - Energy source
    - Energy used
  - Fertilizer inputs
    - Emission Inhibitor from fertilizer
    - Fertilization method
    - Fertilizer origin
    - Fertilizer rate
    - Fertilizer type
  - Irrigation
    - % of land irrigated
    - Event numbers
    - Horizontal distance
    - Method used
    - Power source
    - Pumping depStaffth
    - Water source
    - Water used
    - Water used per week
  - Residues management
    - Residue amount
    - Residue management
  - Soil
    - Drainage
    - Overall moisture
    - pH
    - Soil Organic Matter %
    - Texture
- **COMPAS**
  - Farm workers
    - Labour input and work allocation to farm enterprises
    - Yearly salary
  - Operating facilities/Installations
    - Costs [Depreciation, maintenance and assurance costs of operating facilities/installations]
  - Overhead costs
    - Assurance: Hail insurance
    - General cost of materials: Contract work and machine rental
    - General cost of materials: Diesel fuels
    - General cost of materials: Water, waste water (without irrigation)
  - Seed costs
  - Variable costs
    - Assurance
    - Contract cost
    - Diesel/fuel
    - Labour input
    - Machinery cost
    - Mineral fertiliser
    - Plant protection
    - Water
  - Yield, area and revenues
    - Area
    - Sold product
    - Yield
- **SMART**
  - Crop production
    - Crops area
    - Crops average regional yields
    - Crops erosion measure
    - Crops fungicides share
    - Crops herbicides share
    - Crops Insecticides share
    - Crops Intercrops share
    - Crops legumes share
    - Crops yield losses over the past 5 years
  - Employees
    - Workers actual weekly working hours
    - Workers agreed weekly working hours
    - Workers worker category
  - Farm data
    - Yearly water consumption for irrigation
  - Water Management
    - Irrigation: Low energy technology and pumps
  - Plant protection products
    - Pesticides selection
  - Energy management
    - Energy amount
  - Staff
    - Number of jobs created/removed

Figure 14: Sections and factors managed in CFT, COMPAS and SMART to carry out the simulations in the Swiss case study.

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2.3.13. United Kingdom (Grampian and Tayside Scotland – mixed farms)

The UK case study investigated farm systems of mixed crops and livestock (FADN Farm type codes 83 and 84) and general cropping (FADN Farm type code 16). The case study partner grouped the farms along the agro-ecological transition pathway into conventional farms (both, mixed and general cropping farms), transitional farms (only mixed farms) and organic farms (both, mixed and general cropping farms). Particular challenges identified by actors in the network of farming systems relevant to the case study in North-East Scotland are: i) ensuring the viability of farms and supply chains over the long-term, with particular importance attached to securing the future of local processing facilities, their expansion, and constraints or barriers due to retailers and key players in the agri-food supply chain, and ii) the minimisation of flood risk; soil erosion and reductions in soil health and quality; and threats to pollinators and consequences for the food chain and biodiversity. In this context, the analysis investigated the sustainability of soil management practices such as: i) no-tillage combined with direct drilling (AEP1), and ii) the application of farmyard manure (FYM) on soils (AEP2) in four mixed farms producing barley crop. Barley, in particular, is the dominant cereal crop in the north east region of Scotland, which in the last decade it has seen an expansion by approximately 20% of its production.

The logic applied in the sustainability assessment of AEP1 is centred on the low level of soil disruption associated with no tillage (no-till), a direct drilling practice (The Agriculture and Horticulture Development Board, 2020a). The suitability of AEP1 at farm level is influenced by the climate, soil and crops, and its implementation requires research on equipment choice and a high standard of crop and soil husbandry. No-till practice is anticipated to improve soil biological fertility from the accumulation of organic matter near the soil surface, and structural stability from the increase of bulk density in the top 25 cm of soil, making agricultural soils more resilient to climate change. No-till can give annual crop yields within 5% (above and below) of those after ploughing, but there is greater seasonal variability in yields. Yields are most variable in the first few years of a no-till system. Immediately after adopting no-till, crop yields may be lower than after ploughing due to reduced N availability and increase levels of slug damage. However, farm yields tend to increase as soil structural conditions improve. AEP1 can also promote diversity and abundance of soil life. It is important to note, however, that this latest benefit can include an increase in organisms associated with plant diseases. No-till associated with high level of crop residues on the soil surface can increase fungal contamination in wet conditions, and delay seed germination as a result of poor seed-to-soil contact. In that respect, to ensure that crop residues and planted seeds are not in close proximity, direct drilling and rolling should be considered to lessen the risk of crop failure. Direct drilling is a good means of reducing the risk of nutrient losses by run-off, but it must penetrate the seedbed and place seed accurately without smearing. Following the above knowledge, the implementation of AEP1 was analysed on two conventional tilled farms by assuming that: i) the removal of conventional tillage and the implementation of soil rolling increase the field operations and the diesel consumption by 10%, ii) to avoid the purchase of expensive machinery and training requirements, direct drilling and rolling practices would be carried out by external contractors, iii) the increase in post-emergence plant protection operations would replace the soil protection practices of the conventional farms, iv) no significant changes in labour input would be necessary, and v) no direct and long term effect on crop yield is expected from AEP1 (Figure 15).

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AEP1
No-till and direct drilling

- **CFT**
  - Carbon change & sequestration
    - Change of tillage practice (TC)
  - Crop protection inputs
    - Category
    - Application doses
  - Field operations energy use
    - Machine type
    - Fuel quantity
  - Biodiversity - Farming practices
    - What good practices do you use to improve soil health in crop fields?
- **COMPAS**
  - Overhead costs
    - General cost of materials: Contract work and machine rental
  - Variable costs
    - Diesel/fuel

AEP2
Organic fartilization (FYM)

- **CFT**
  - Field operations energy use
    - Machine type
    - Fuel quantity
  - Fertilizer inputs
    - Fertilizer type
    - Fertilizer rates
  - Biodiversity - Farming practices
    - Do you add organic matter to your field?
- **COMPAS**
  - Machinery
    - Costs [Depreciation, maintenance and assurance costs of machinery/equipment, fuel costs]
  - Overhead costs
    - General cost of materials: Contract work and machine rental
  - Variable costs
    - Labour inputs
    - Machinery cost
    - Mineral fertilizer
    - Organic fertilizer

Figure 15: Sections and factors managed in CFT and COMPAS to carry out the simulations in the UK case study.

The sustainability assessment of AEP2 was based on the knowledge of incorporating FYM in soils (The Agriculture and Horticulture Development Board, 2020b). In general, incorporating FYM or other organic amendments improves soil properties. However, organic amendments require surface cultivation, and specific regulations cover the incorporation of FYM influencing the need for specific tillage operations. This means that the assessment of AEP1 and AEP2 could not be carried out as a bundle across the five farms used in the analysis. AEP2, in particular, was analysed in two mixed crops and livestock farms (one conventional and the other certified as organic) and a conventional arable farm (Figure 15). FYM was assumed to derive from livestock excreta mixed with straw bedding material that can be stacked in a heap without slumping. The simulation of AEP2 included the field operations to spread FYM (labour input, fuel consumption and costs), assuming that only the conventional arable farm would access contract services to carry out the spreading in barley (£20/ha). Finally, FYM was assumed to have a readily available nitrogen (N) content ranging from 10 to 25%, and to maintain the initial levels of barley production the spreading aimed to balance the N inputs from mineral and organic fertilization.

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3. RESULTS

In general, the sustainability results from the AEPs investigated in this task are not directly comparable with each other as they reflect different agro-ecological transition strategies across distinct European farming contexts. Only three out of 28 AEPs were analysed in more than one case study. These are: i) the conservative management of arable tilled soil to reduce and/or no tillage soils in the German, Hungarian and British case studies, ii) the implementation of inter-row green cover in vineyard in France and Italy, and iii) the implementation of organic soil fertilization such as farmyard manure (FYM) in the Latvian, British and Romanian case studies. Even though the French and Italian case studies included the same typologies of farms (vineyard) and simulated similar AEPs, their workflow and processes included different assumptions and factors in their sustainability analysis. The French case study assumed the implementation of inter-row green cover bundled with the reduction or removal of chemical pesticides as a substitution AEP with a reduction of the overall farm yield. While the Italian case study implemented two separate analysis on the sustainability of inter-row green cover (re-design AEP) and pest monitoring (efficiency increase AEP) assuming a constant farm productivity in the agro-ecological transition. The British case study simulated the implementation of FYM soil amendment as a standalone AEP, while in the Latvian and Romanian case studies this AEP was integrated into the broader transition strategy from conventional to organic farming. The Hungarian and Swedish case studies carried out their analysis on hypothetical farm scenarios rather than applying the information collected in the participatory farm surveys of Task 3.2. In the sustainability analysis of the AEP “from animal feed to human food production”, the Swedish case study applied sustainability indicators not linked to the processes simulated in the three DSTs.

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3.1. Identification of synergies and trade-offs in the performance of agro-ecological practices.

Table 3 summarises the average responses of selected sustainability indicators deriving from the implementation of 28 AEPs in the 13 case studies of UNISECO. The results of the full set of sustainability indicators are provided in Annex IV, Table A4-1.

Table 3: Average response of selected sustainability indicators, deriving from the implementation of individual and bundles of agro-ecological practises (AEPs).

		Sustainability indicators (change in %)							
		Environmental					Socio-economic		
AEP category	***Agro-ecological practice (Case study country[A])***	Habitat diversity	Water quality	Soil Quality	GHG emissions (SMART score)	Biodiversity (farming practices)	Net Value Added	Net Farm Income	Labour productivity
Efficiency increase	Increase of compound feed (LT)		-2.2		3.6		-8.0	-2.9	-8.0
	2D fruit orchards and reduced chemical inputs & water consumption (GR)	42.95	7.8		5.5	2.5	8.3	84.9	8.3
	Pest monitoring (IT)	2.7			2.8	17.3	1.5	1.4	0.8
Substitution	Composting (IT)			2.3	1.5	18.7	-1.2	-10.0	-10.0
	FYM application (UK)					22.3	-2.7	-2.8	-2.7
	From conventional to organic farming (LV)	5.1	3.7	1.5		21.4	21.6	29.7	21.6
	From conventional to organic farming (RO)	47.7	20.5	17.3	2.2	23.8	-77.6	-87.8	-77.6
	Biofertilizer production (FI)	-12.5	-10.9	4.7	-4.3				
	Biofertilizer production - biofuel use (FI)	0.5	1.9	3.4	2.5				
Re-design	From permanent to 50 temp. grass (LT)	-1.7	1.3	1.4	-5.3	-4.1	31.7	34.8	26.2
	From permanent to temporary grass (LT)	-10.0			-10.5	-8.2	52.0	57.1	45.6
	From temporary to permanent grass (LT)	37.5	8.2	9.1	13.0	8.6	0.3	0.3	0.3
	Only permanent grass (LT)		-2.2	-2.5	-1.7		11.9	11.9	11.9
	Balancing permanent and temporary grassland (LT)	-9.1	-3.3	-3.7	-6.7	4.1	5.4	5.5	0.4
	Inter-row green cover (IT)	5.5		13.6	5.6	57.7	13.6	15.4	15.4
	Inter-row green cover - no synthetic pesticides (FR)	54.2	32.2	20.3	9.2		-30.8	-32.1	
	Reduced till - Flower and buffer strips – Intercropping (DE)	18.4	5.7	10.4	8.9	9.6	-18.4	-97.9	-18.4
	Reduced tillage (HU)	11.1	4.3	8.3	4.3		16.1		16.1
	No plough (HU)	15.0	7.7	6.1	4.2		0.2		0.2
	No till (HU)	30.4	11.5	26.2	12.0		10.7		10.7
	No Till & direct drilling (UK)					13.9	-2.0	-2.8	-2.0
	Extensification - increased direct marketing (CH)		2.7	2.3	5.5		-49.3	-60.5	-39.0
	Extensification - increased direct marketing - fruit growing (CH)	-3.9	-1.4	-0.8	5.5		-19.7	-25.0	-5.9
	Farm re-design (SE)	61.0	30.3	20.3	20.8	42.4			
	More food crops - increase payment (SE)						82.2	108.8	90.3
	Collective post - harvest activities (ES)						-5.5	-6.4	-5.5
	Improved access to land (ES)							3.4	

[A] CH – Switzerland; DE – Germany; ES – Spain; FI – Finland; FR – France; GR - Greece; HU – Hungary; IT – Italy; LT – Lithuania; LV – Latvia; RO – Romania; SE – Sweden; UK – United Kingdom

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The overview of the responses of selected sustainability indicators indicates that the implementation of the AEPs can lead to four general types of relationships:

a. trade-offs in the form of environmental benefits at the cost of adverse economic effects (e.g. Composting (IT); Extensification - increased direct marketing (CH)),
b. trade-offs in the form of reduced environmental performance but better economic performance (e.g. different scenarios of the AEP balancing grassland management (temporary vs permanent) (LT)),
c. synergies in the form of positive responses across all affected indicators (e.g. 2D fruit orchards and reduced chemical inputs & water consumption (GR); No till (HU)),
d. mostly negative responses across affected indicators (e.g. Increase of compound feed (LT)).

The most common types of relationships of the indicator responses are types (a) and (c). The next sections outline and discuss in greater detail the results of the sustainability analysis of each AEP. The category “Increased efficiency” included only three AEPs, and between these the reduction of chemical inputs and water consumption in fruit tree plantations in Greece showed significant synergies between environmental and socio-economic indicators. The increase of mineral supplements in dairy farms to improve livestock productivity, health and lifespan, resulted in a number of small positive indicator responses for the farmers due to the improvement of economic indicators such labour productivity, net farm income and net value added. In the category “Substitution practice” the implementation of organic soil fertilization, such as FYM and compost, provided clear environmental benefits in four case studies (Italy, Latvia, Romania, and UK) from the increase of soil biodiversity, carbon sequestration, and lower energy consumption at farm level. In this context, the Romanian case study showed important trade-offs between economic and environmental indicators due to the need of external inputs on organic fertilizer. In the category “Farm re-design”, which included bundles of AEPs, confirmed that on average practices targeting cultivation and crop establishment factors (e.g. ploughing, soil tillage, etc.) have the potential to create important synergies at farm level. Among these, the Lithuanian case study analysed the potential win-win situations that derive from right balance between permanent and temporary grassland in conventional dairy farms. Whereas the producing more crops selling of crops for human consumption than for livestock feed simulated in the Swedish dairy farms showed very large synergies between socio-economic and biodiversity indicators from the use of farmland for food production and extensively grazed grassland. Finally, within the category of “Changing of territorial governance”, the AEP “Strengthened farmer network” showed important socio-economic synergies derived from the predisposition and the behaviour of farmers towards more sustainable farm management.

3.1.1. Synergies and trade-offs from increased efficiency practices

Greece: Reduced chemical inputs and water consumption in fruit tree plantation

The two-dimensional (2D) conversion of the fruit tree plantation, combined with the growing of inter-row cover, have the potential to provide several economic and environmental synergies at farm level. Ecosystem services such as genetic, species, and habitat diversity increased by 30±2%, 16.3±0.5%, and 43±1% respectively (Figure 16). Interestingly SMART did not provide any improvement on soil quality from the implementation of green cover and green manure. In addition, GHG emissions from soil cultivation and field operation decreased by only 4.4±0.6%, and the benefit on farm biodiversity from farming practices improved by just 2.5±2.5%. In that respect, lower application doses of fertilisers, crop protection products and irrigation water may lead to less energy consumption, this is likely to be counterbalanced by increased fuel consumption due to higher tree densities and increase in cover crop planting.

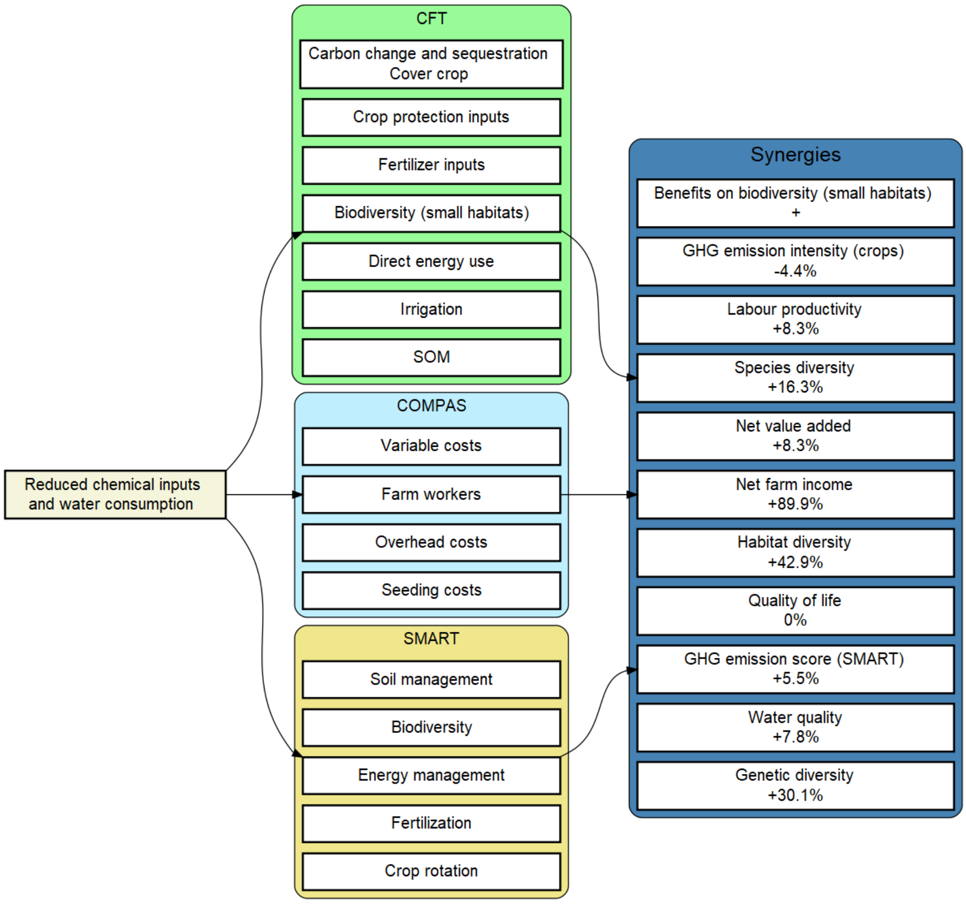

Figure 16: Sustainability results of the agro-ecological practice (AEP) analysed in the Greek case study. The boxes in the middle show the main sections of CFT, COMPAS and SMART managed to simulate the AEP. The sustainability indicators in the blue box exhibit a positive response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP. The infinity value on the indicator "benefit on biodiversity in small areas" is due to the value zero in the biodiversity score of the baseline farm.

Despite the increased use of mechanical equipment for pruning and harvesting and intermediate consumption costs related to planting and managing cover crops, high density planting, machinery rental, contract work as well as access to agricultural advisory services, the transition to 2D fruit tree plantation showed important economic benefits (Figure 16). The partners of the case study outlined, in particular, that the investments in machinery and use of advanced techniques that mechanise the agricultural work improved the labour productivity of the farms, decreasing the labour hours of workers, which in turn affects the generation of farm income. This was the case for one farm involved in the simulation, which showed a significant decrease in employing seasonal workers, while family members operate the farm activities. In that respect, the practices here simulated could play a positive role in

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sustaining the long-term economic viability of fruit farms whilst protecting the natural resources.

ITALY: Pest monitoring in conventional vineyard farms

Pest monitoring in this case study refers to precision agriculture technology based on the installation of weather stations in the middle of the orchards with the aim to integrate real time monitoring with fast prevention activities achieved through precise plant protection treatments. Overall, the implementation of this AEP provided interesting positive indicator responses related to the improvement of biodiversity in the farms (+17±3%), mainly due to the reduction in plant protection chemical inputs used by the two conventional farms (Figure 17). In addition, SMART estimated a positive impact from the implementation of the AEP, and COMPAS estimated an overall increase of 1.4±1.6% in net farm income, and +1.5±1.6% in net value added indicating synergies between biodiversity and economic benefits at farm level.

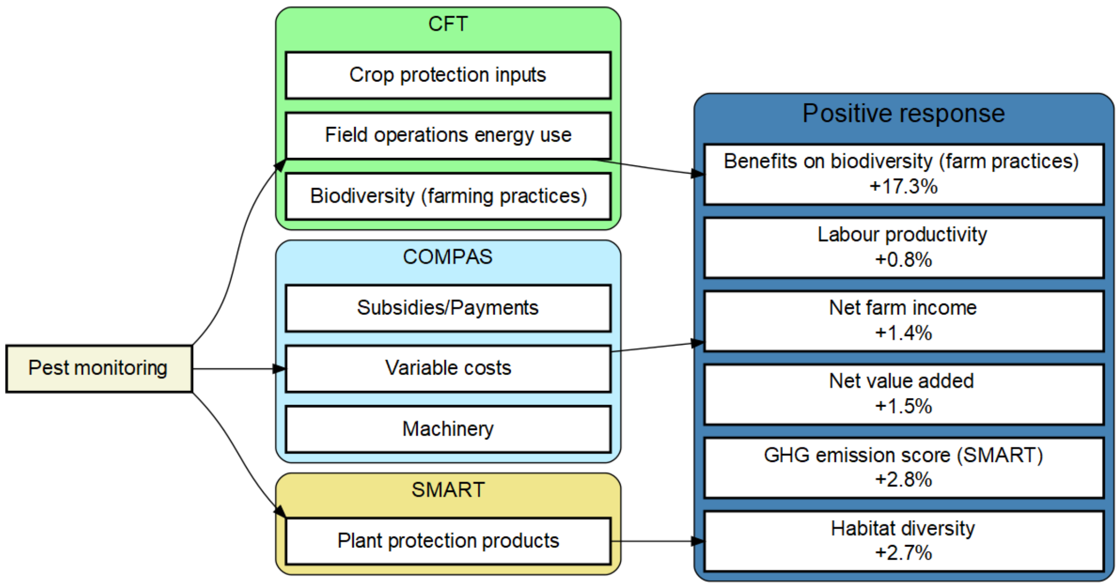

Figure 17: Sustainability results of the agro-ecological practice (AEP) analysed in the Italian case study. The boxes in the middle show the main sections of CFT, COMPAS and SMART managed to simulate the AEP. The sustainability indicators in the blue box exhibit a positive response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.

LITHUANIA: Increase of compound feeds

This AEP refer to the use of mineral supplements (e.g. mineral enriched glass boluses) to improve livestock productivity, health and lifespan. This issue is particular important in livestock farms suffering from mineral imbalance in ruminant diets due to: i) feeds produced in low quality tilled soils, ii) feeds produced in high concentration of mineral sulphates and iii) feeds irrigated using treated drinking water.

The analysis involved five extensive farms (three conventional and two extensive). On average this AEP resulted in a reduction of 5.7±0.5% in GHG emissions per kilogram of protein and fat content in milk, and trade-offs between the negative indicator responses with regard to species diversity and water quality and the other sustainability indicators (Figure 18). Labour

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productivity increases by approximately 3.7%, with a comparable increase in absolute income from milk between the two extensive farms. While, in the conventional farms the economic indicators on net farm income and net value added were overall positive.

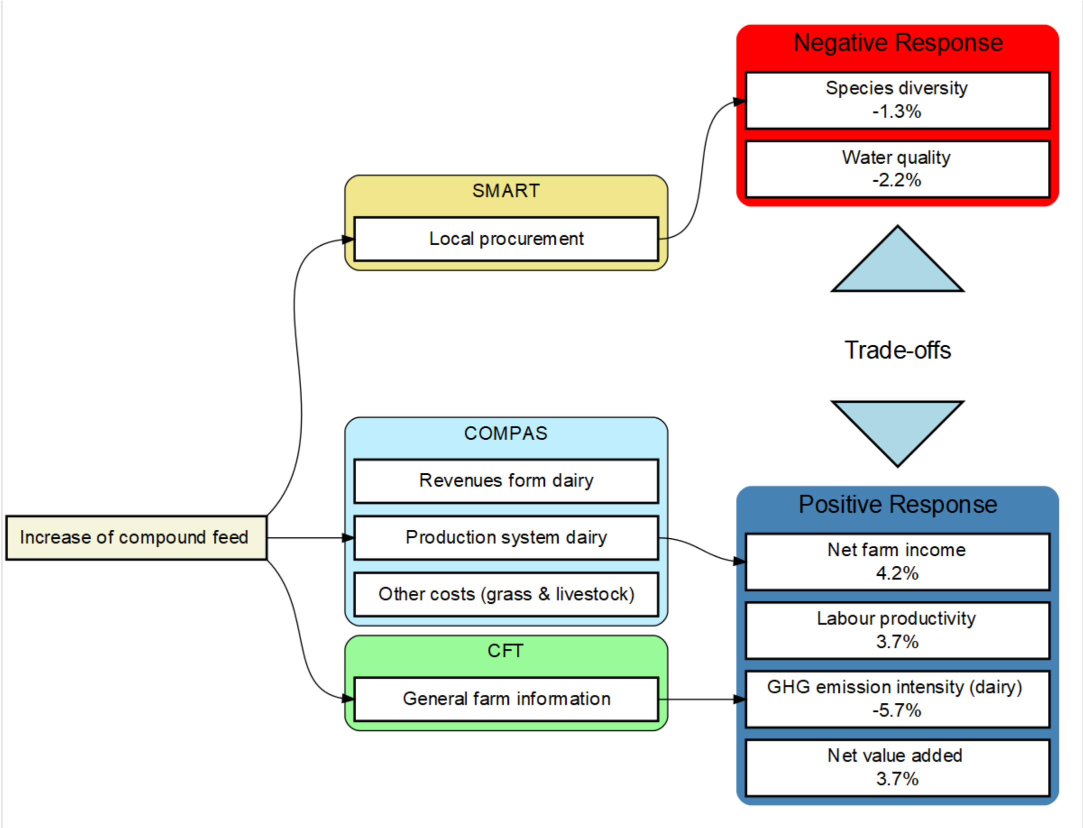

Figure 18: Sustainability results of the agro-ecological practice (AEP) analysed in the Lithuanian case study. The boxes in the middle show the main sections of CFT, COMPAS and SMART managed to simulate the AEP. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.

3.1.2. Synergies and trade-offs from substitution practices

This category included 7 AEPs ranging from the simulation of individual practice changes such as the application of organic fertilizer, to more complex practices such as the conversion to organic farming. The sustainability results of each AEP are reported across the 5 case studies.

Finland: Production and use of biofertilizer and biofuel

This case study analysed the sustainability of two substitution practices comprising the use of biofertilizer and biofuel obtained from the cooperation with a local large biogas plant. Using SMART, the analysis first focussed on the impact of biofertilizer production and use of this as soil amendment (AEP1), and successively on the impact of producing and using both biofertilizer and biofuel (AEP2).

When implemented on two farms, AEP1 showed that the production and use of biofertilizer as a soil amendment has the potential to create important trade-offs between negative

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responses of most environmental indicators and the positive effects of biofertilizer on soil fertility (i.e. soil quality) (Figure 19).

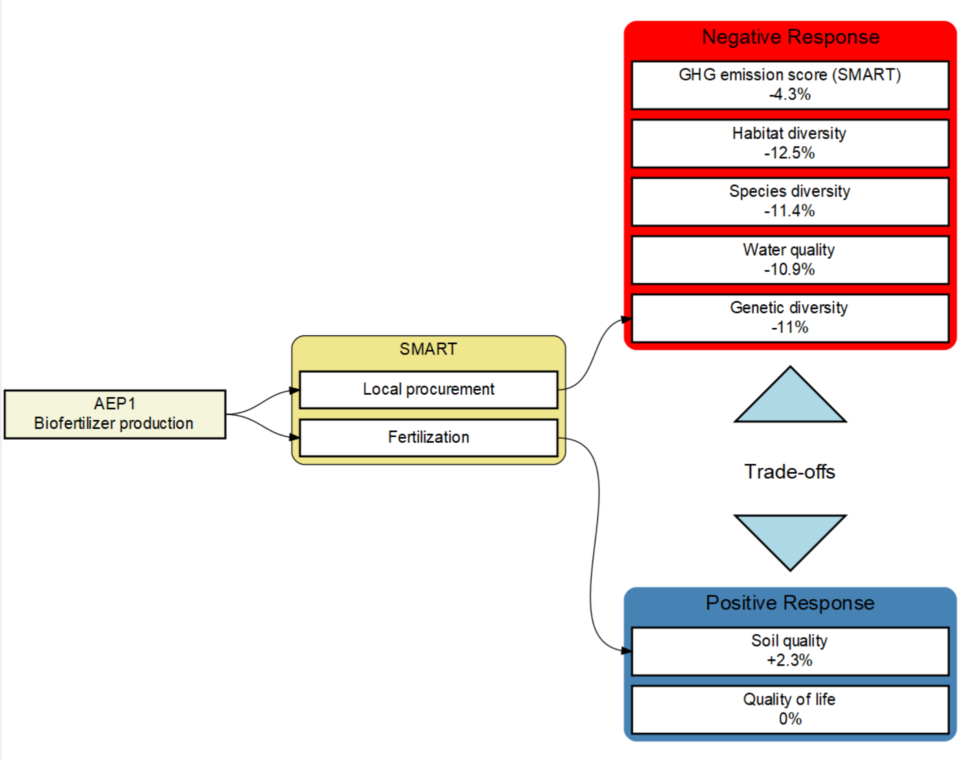

Figure 19: Sustainability results of the agro-ecological practice (AEP1) analysed in the Finnish case study. The box in the middle shows the main sections of SMART managed to simulate the AEP. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.

The implementation of AEP2, instead, showed that the benefits deriving from the cooperation to produce biofuel and its use in various farming operations would potentially offset the trade-offs of AEP1. The results from SMART, in particular, showed moderate and positive impacts in all its sustainability indicators, with ecosystem services such as air, soil and water quality representing the dominant synergies from AEP2 (Figure 20)

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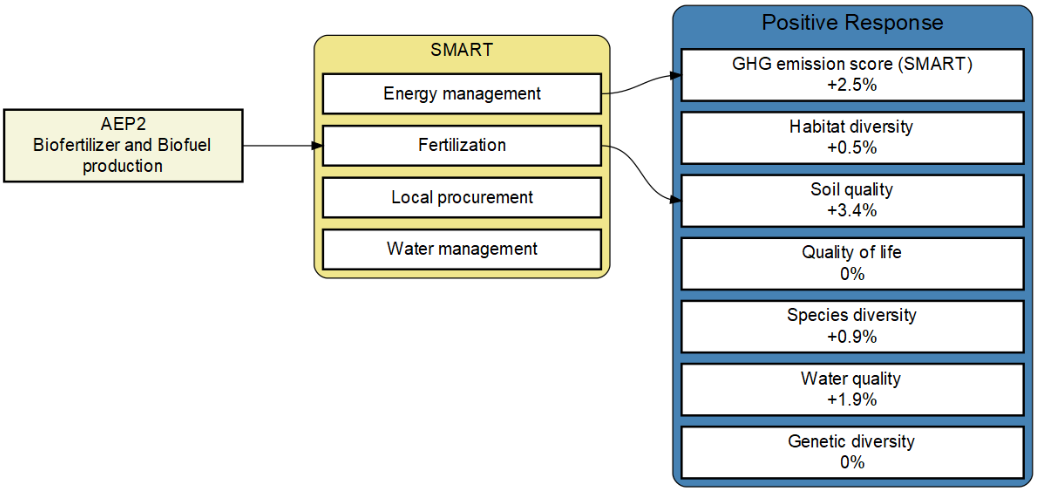

Figure 20: Sustainability results of the agro-ecological practice (AEP2) analysed in the Finnish case study. The box in the middle shows the main sections of SMART managed to simulate the AEP. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.

ITALY: Composting in conventional vineyard farms

This AEP focuses on the composting of vineyard crop residues, and processing waste from agricultural and livestock raw materials. The aim is to reduce dependence on external fertilizers, improve soil organic carbon balance, and avoid the issue associated with the burning residues on field.

The implementation of this AEP in six farms provided important environmental synergies. GHG emissions on average decreased by 35.9±51%, with the reduction in GHGs particularly evident in those farms using fertilizers externally sourced. The amendment of compost in soil is known to increase soil nutrients and this was confirmed by the improvement of soil quality score in SMART and its biodiversity score in CFT (Figure 21). The positive environmental impacts from this AEP created trade-offs with negative responses of economic indicators such as net farm income (-10±17%) and labour productivity (-10±18%). Specifically, in all farms the reduction in fertilizers costs was not completely offset by the increase in energy, labour and capital costs (Figure 21). This low economic performance explains the slow diffusion of the practice in the area.

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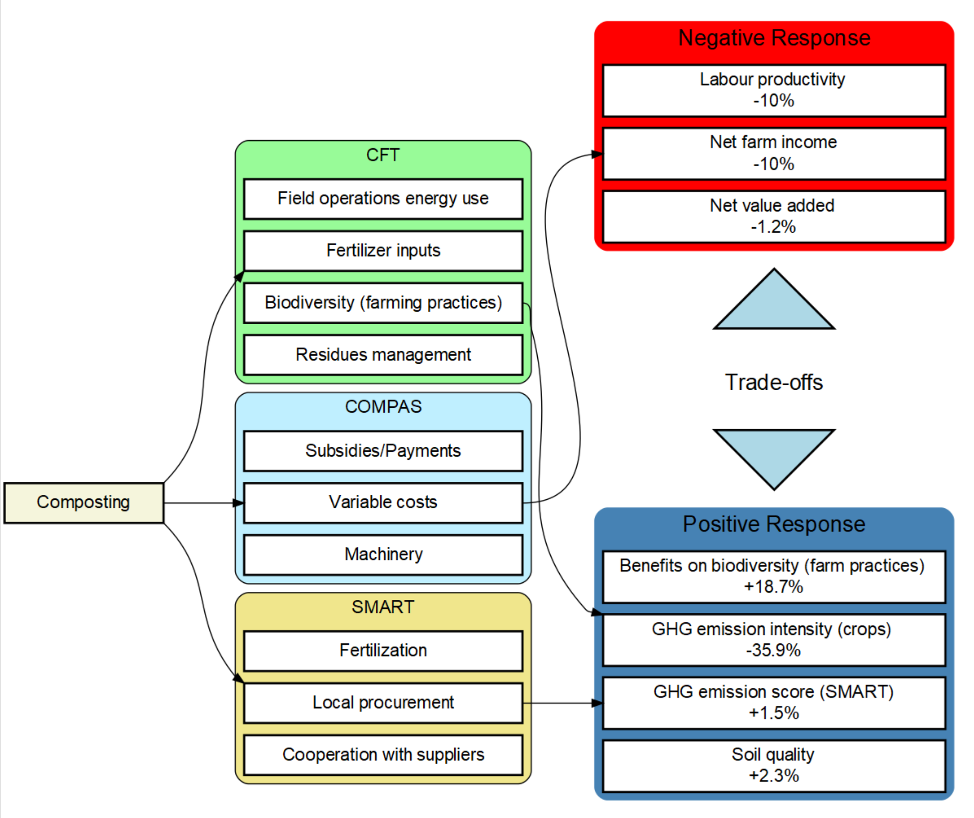

Figure 21: Sustainability results of the agro-ecological practice (AEP) analysed in the Italian case study. The boxes in the middle show the main sections of CFT, COMPAS, and SMART managed to simulate the AEP. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.

LATVIA: From conventional to organic farming

This case study analysed the sustainability of converting two conventional dairy farms to organic farming focussing on the implementation of organic practices in arable and grassland maintaining the same herd size and comparable milk production in the farms.

Overall the AEP resulted in only synergies for the farmers. Noticeable are the synergies between the average reduction of GHG emissions (-22.5±27%), benefit on biodiversity from the organic farming practices (+21.4±30%), and the other sustainability indicators estimated by SMART (Figure 22). Further synergies of the environmental benefits with economic benefits were particularly surprising considering that two farms were assumed to increase the purchase of feedstuffs (oats and wheat) for the dairy enterprise (25 tonnes on farm 1 and 200 tonnes on farm 2) and reduced their crop and grassland yields by 50%. The positive economic indicator responses were mostly linked to the increase of subsidies received for organic farming (118 euro /ha), and included an increase of net farm income (+29.6±12%), net value added (+21.6±6%) and labour productivity (+21.6±6%).

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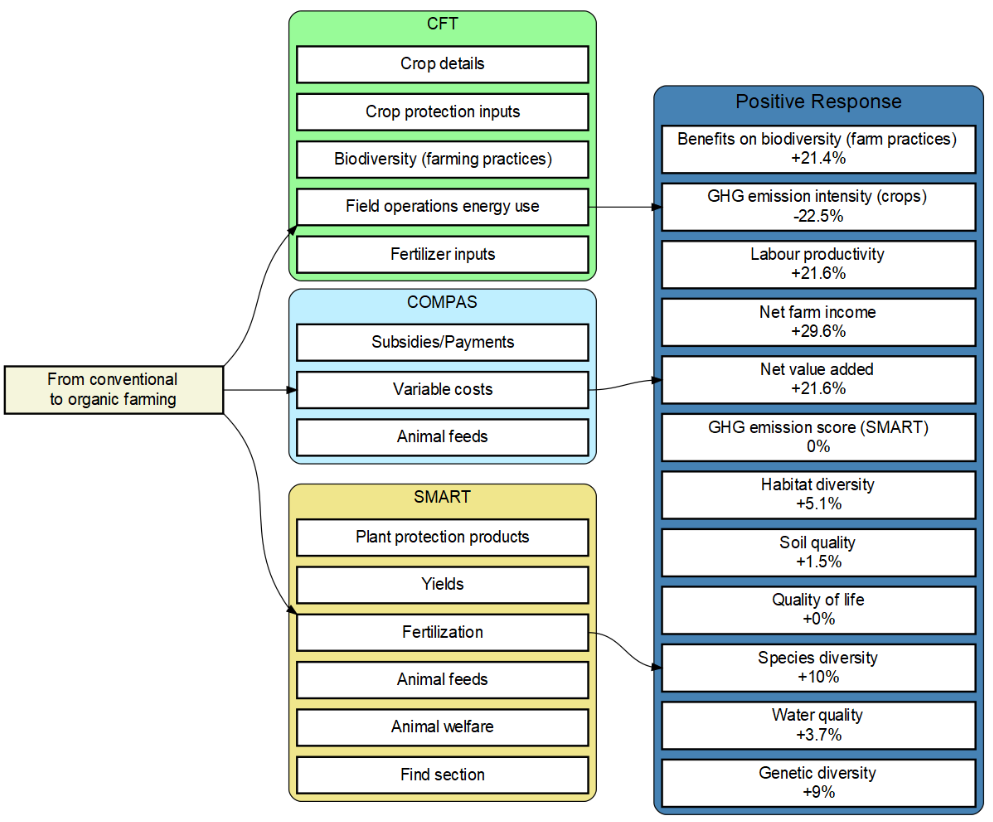

Figure 22: Sustainability results of the agro-ecological strategy analysed in the Latvian case study. The boxes in the middle show the main sections of CFT, COMPAS, and SMART managed to simulate the transition strategy. The sustainability indicators in the blue box exhibit positive responses to the implementation of several AEPs at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEPs as a bundle.

ROMANIA: From conventional to organic farming

Similar to the Latvian case study, the Romanian partners analysed the sustainability of converting the management in arable and grassland of two conventional dairy farms to organic farming, maintaining the initial conditions of the dairy enterprise. The implementation of this AEP is based on careful estimation on the amount of organic fertilizer needed by the arable crops, the change of costs related to farming inputs and operations in both the arable and livestock enterprises.

The analysis showed two contrasting situations in the two farms. In particular, one farm had to buy organic fertilizer (i.e. compost at 30 EUR/t), and the other farm produced a sufficient amount to support its organic soil treatments. Even though the Romanian case study assumed higher CAP support payments received for organic farming than the Latvian case study (500 euro/ha), and the same reduction in crop yield (-50%), the implementation of organic practices resulted in poor economic performance for the two farms. On average, net farm income, net value added, and labour productivity decreased by 88±22%, 78±52%, and 78±52% respectively (Figure 23). The reductions in production directly affected the sales of crops in the two farms, which before the simulation produced more than internally needed for families and livestock feed. This led to lower sales of Vetch and Lucerne, and the need to purchase more feedstuff (roughage) to compensate for lower on-farm crop feedstuff.

Organic farming contributed to improve the overall environmental performance of the farms. On average GHG emissions were reduced by 47±42%, due to the increase in soil carbon stock and lower N_2O emission from mineral fertilization, and ecosystem services such as soil and water quality increased by 17.3±13% and 20.5±13% respectively (Figure 23).

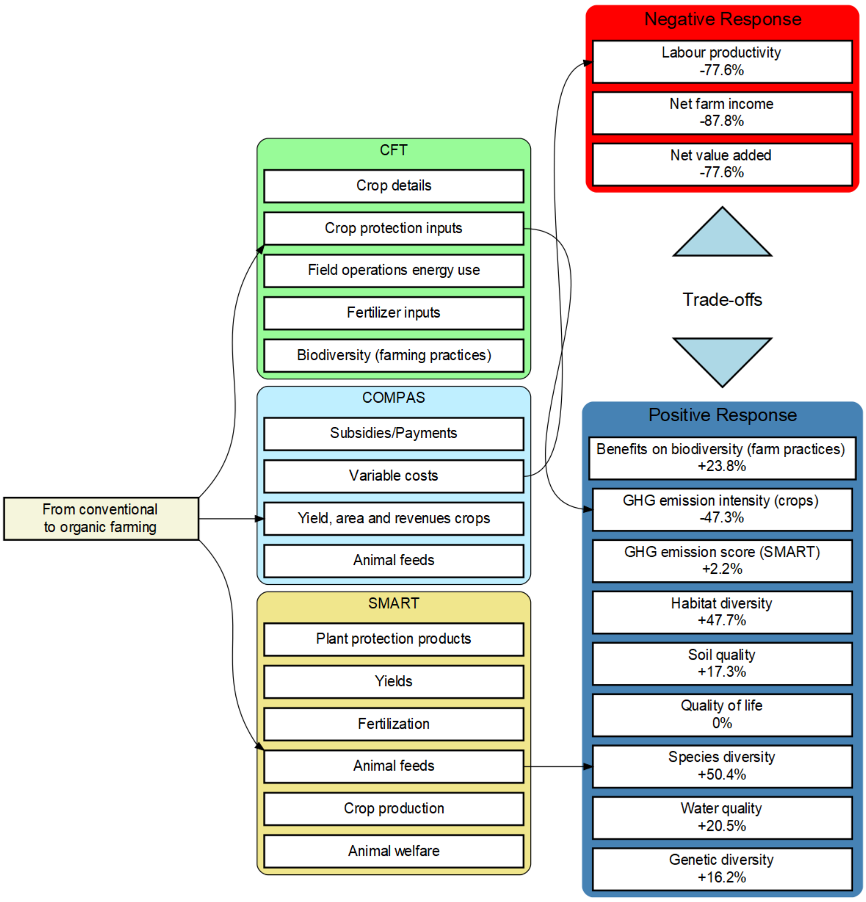

Figure 23: Sustainability results of the agro-ecological strategy analysed in the Romanian case study. The boxes in the middle show the main sections of CFT, COMPAS, and SMART managed to simulate the transition strategy. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEPs as a bundle.

UNITED KINGDOM: Application of Farmyard Manure

The sustainability of FYM in arable soils was analysed in two mixed crops and livestock farms (one conventional and the other certified as organic) and one conventional arable farm applying CFT and COMPAS. As expected, the AEP positively influenced the environmental performance of the farms. The conventional arable farm showed more important reductions of GHG emissions (-52.3%) than in the two mixed farms (-40±61%). This was due to the higher reduction of soil GHG emissions from mineral fertilizations and higher reduction of diesel consumption in the arable land.

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The transition to organic fertilization showed moderate negative indicator responses for both farm types (Figure 24). In the arable farm, the AEP had lower economic performance due to the cost associated with the purchase of FYM, which in the mixed farm was internally sourced from the livestock enterprise.

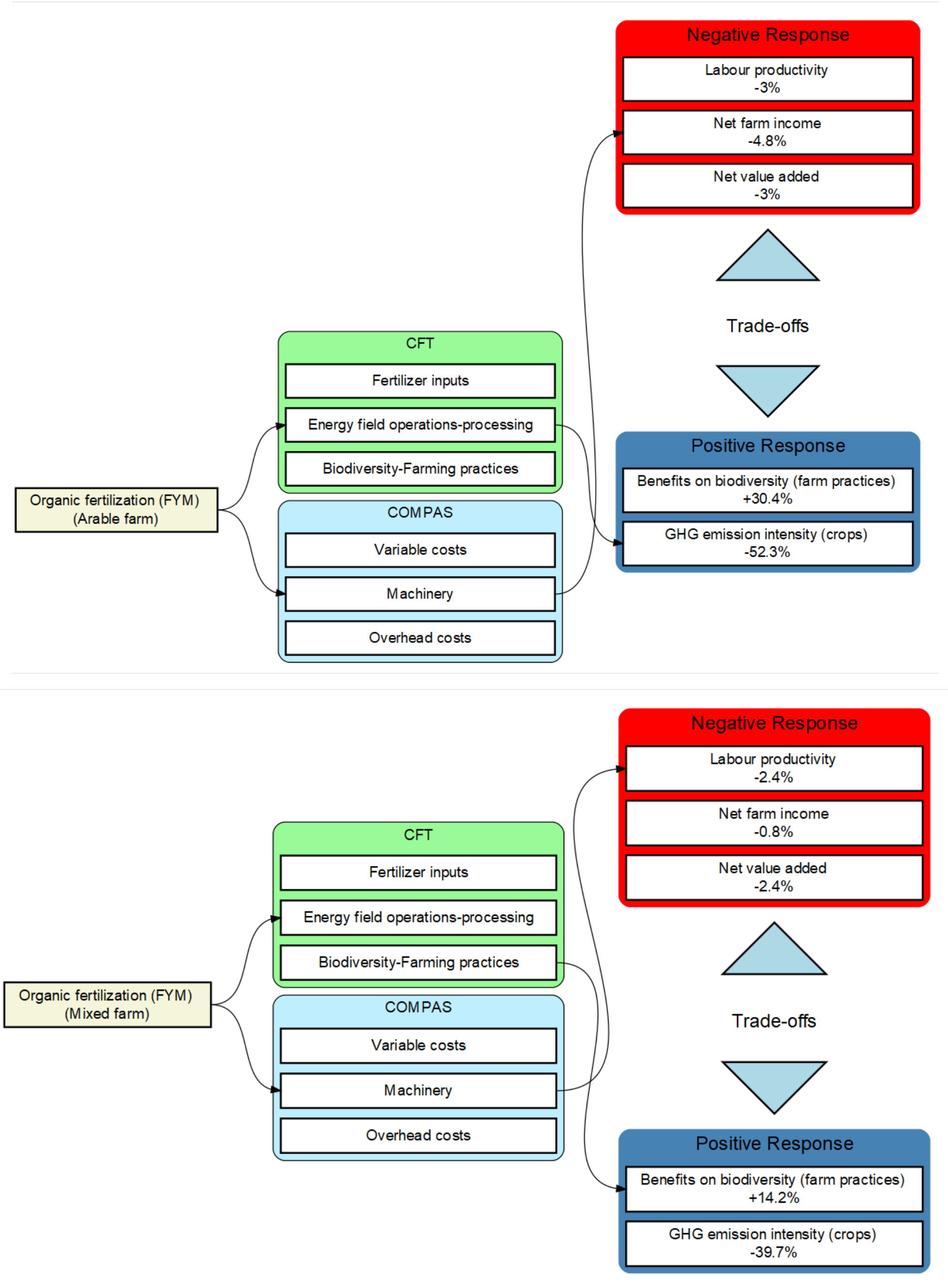

Figure 24: Sustainability results of the agro-ecological practice (AEP) analysed in the British case study. The boxes in the middle show the main sections of CFT and COMPAS managed to simulate the AEP. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.

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3.1.3. Synergies and trade-offs from farm re-design practices

The category "Farm re-design" included 16 AEPs across 7 case studies ranging from the simulation of individual to bundle of changes at farm level. As outlined in section 2.3, to avoid a direct comparison between different case studies, here we report the results by case study.

France: Inter-row green cover and no synthetic pesticides in conventional vineyard farms:

The sustainability analysis of this case study included the investigation of two AEPs, namely inter-row green cover and no synthetic pesticides, as a bundle using SMART and COMPAS (Figure 25). As expected, the implementation of these agro-ecological practices resulted in numerous synergies between ecosystem services. In the two farms included in the analysis, the ecosystem services of genetic, species, and habitat diversity increased by 48.8±21%, 57.7±3.3%, and 54.2±11% respectively (Figure 21). While, soil, water and life quality raised by 20.3±4.3%, 32.2±6.1%, and 2.4±3.4% respectively. Critically, the assumption made by the partners on the reduction of crop yield in the two farms (up to -49%), and the additional costs related to the field operations needed to implement and maintain inter-row green cover, caused important trade-offs between economic and environmental indicators.

The analysis from COMPAS, in particular, showed an average reduction of net farm income, net value added and labour productivity of -32.1±1.2%, -30.8±3.6% and -30.8±3.6, respectively. The trade-offs between economic and environmental indicators were explained by the partners of this case study as connected to higher costs of seeding for the inter-row green cover, yield losses of approximately 30% due to the suppression of fungicides, and the potential cost associated to the re-development of the vine rows (ranging between 12000 and 20000 euro/ha). The conversion to organic farming in French vineyard is in general associated with the disregarding of unfavourable plots located on steep slopes, and/or the implementation of tighter rows of vineyard in more suitable agricultural areas (less than 1.5m wide). In that respect, tight rows were reported to be very difficult to mechanise in current market conditions due to the increase of productivity costs for the farmers. Provided that the farmer can keep the same area of farmland, the economic valorisation of the organic product (between 30 and 40% compared to conventional farms) could potentially compensates for the potential drop in yield per hectare.

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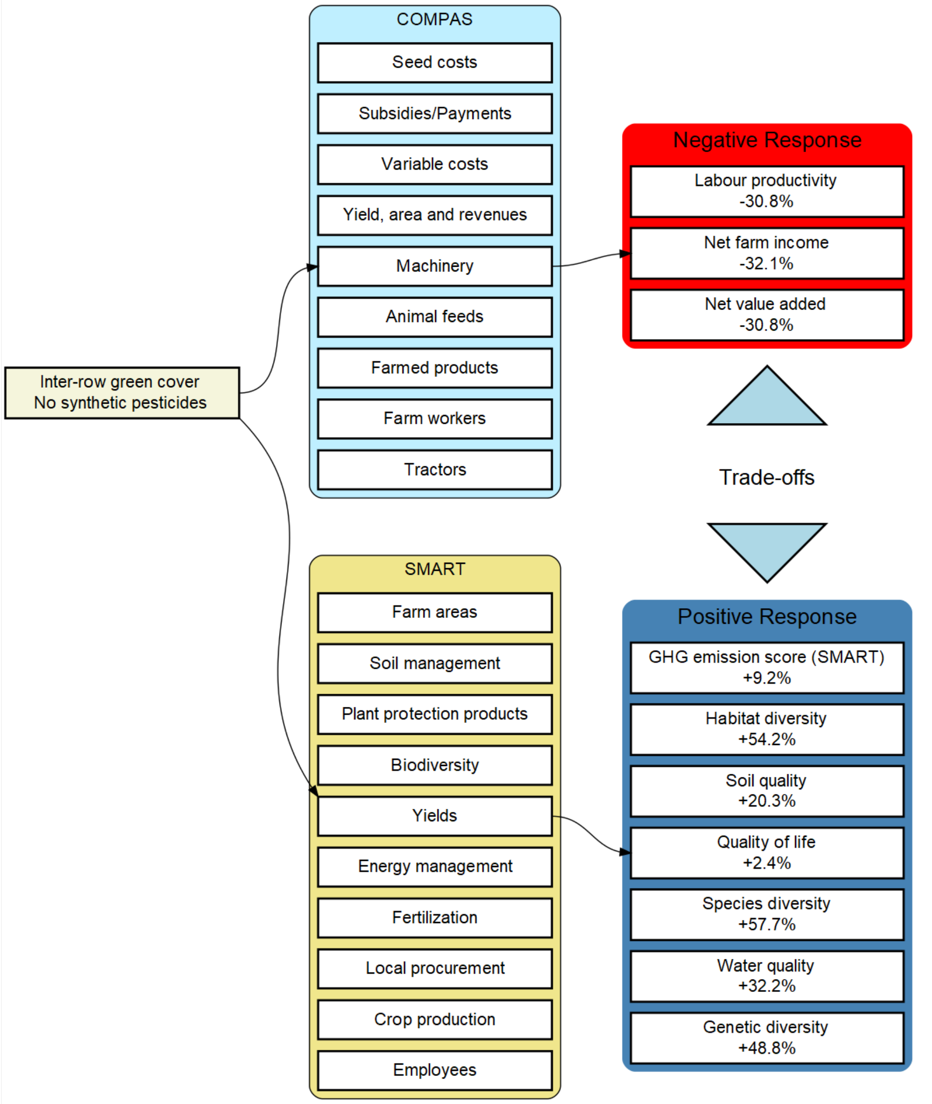

Figure 25: Sustainability results of the agro-ecological practices (AEPs) analysed in the French case study. The boxes in the middle show the main sections of COMPAS and SMART managed to simulate the AEPs. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEPs as a bundle.

Italy: Inter-row green cover in conventional vineyard farms

Similarly, to the French case study, the Italian case study analysed the sustainability of inter-row green cover on conventional vineyard farms. In this case study, however, this AEP was analysed as a stand-alone change in one vineyard farm, and including the assessment of the three DSTs. Interestingly, the Italian partners pointed out that inter-row green cover in vineyards should be implemented gradually and in combination with green manure. The lack of knowledge and trained advisory services are in general the main reasons behind the incorrect implementation of this AEP in the region.

Overall, the implementation of this AEP resulted in synergies between economic, environmental and social indicators, among which there is a substantial reduction of the

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carbon footprint of the farm, from the increase of soil carbon stock (-149.1%), and the benefits on farm biodiversity generated from green cover (+57.7%) (Figure 26). The synergies between the CFT-environmental indicators were also supported by the sustainability indicators of SMART on soil quality (+13.6%) and habitat diversity (+5.5%). These positive responses from environmental indicators could potentially be associated with negative responses from economic indicators during the first growth stages of the vine (from the 2 to the 6 year). These potential trade-offs between economic and environmental indicators could lead to a delayed application of the practice with the risk of undermining the potential positive long-term effects from the AEP. In this sustainability analysis, however, no reduction of crop yield was assumed which could have reduced the positive indicator response with regard to net farm income and labour productivity calculated in COMPAS. With respect to the economic assessment, any potential increase in labour costs for the farm were balanced by the lower costs from field operations, and the potential increase in the quality of the organic grapes which could results in about 10% increase in market prices.

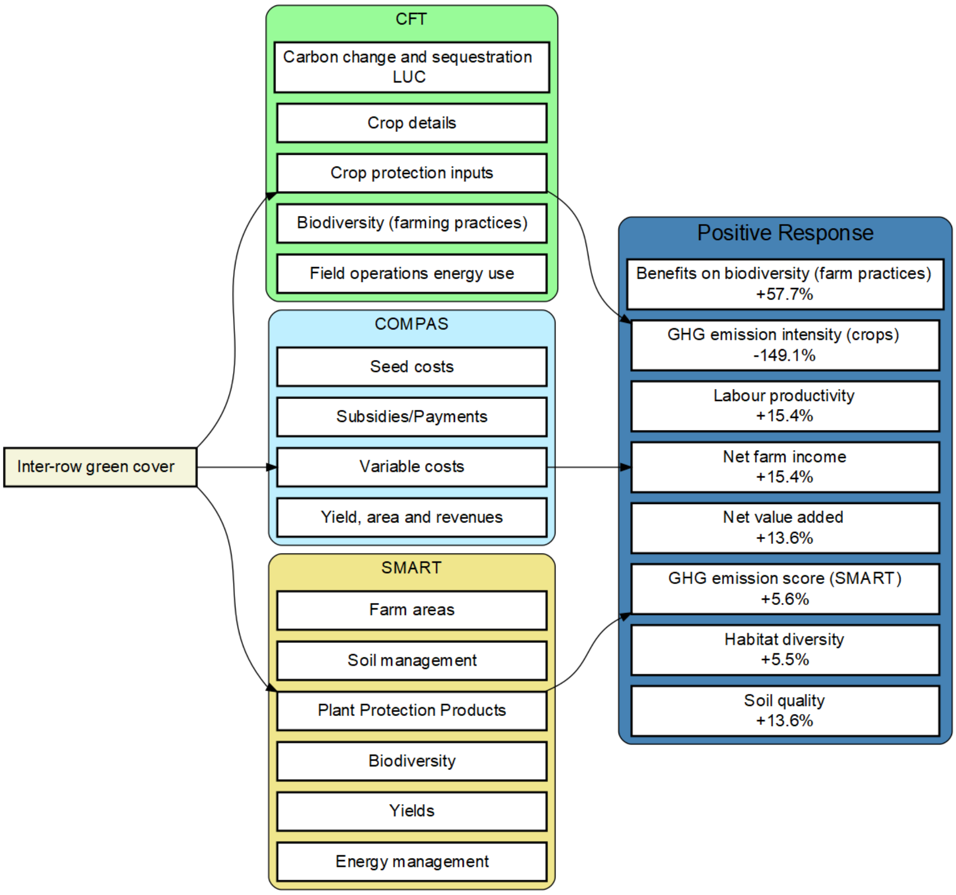

Figure 26: Sustainability results of the agro-ecological practice (AEP) analysed in the Italian case study. The boxes in the middle show the main sections of CFT, COMPAS and SMART managed to simulate the AEP. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.

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Germany: Reduced tillage, flower & buffer strips, and intercropping

The sustainability analysis of this case study was conducted by considering the simultaneous implementation of three AEPs to reach a practically feasible and generally accepted transitions towards a more sustainable agricultural system in conventional and market-oriented arable farms with and without pig husbandry. Figure 27 shows the overall sustainability results of the considered farms. The simultaneous implementation of all three AEPs contributed to reduce the GHG emissions from arable land by on average 26.5±22%, and improved soil and water quality in the farm by 10.4±0.5% and 5.7±2% respectively. In addition, they increased genetic, species, and habitat diversity in the farms by 26±8%, 16±4.6%, and 18.4±7% respectively. Notably, the environmental impact on biodiversity or water quality from AEP2 would be very dependent upon the precise designs of the measures, including their type and location. The results indicate that the environmental benefits of the joint implementation of the three AEPs come with trade-offs in the economic farm performance. On average, the labour productivity was reduced by 18±4.7%, while the amount of received subsidies increased by 25-30%. Given the already fairly low absolute farm income in the status quo scenario, the reduction in revenues but mostly constant costs led to a strong reduction in net farm income by 97.9±46%.

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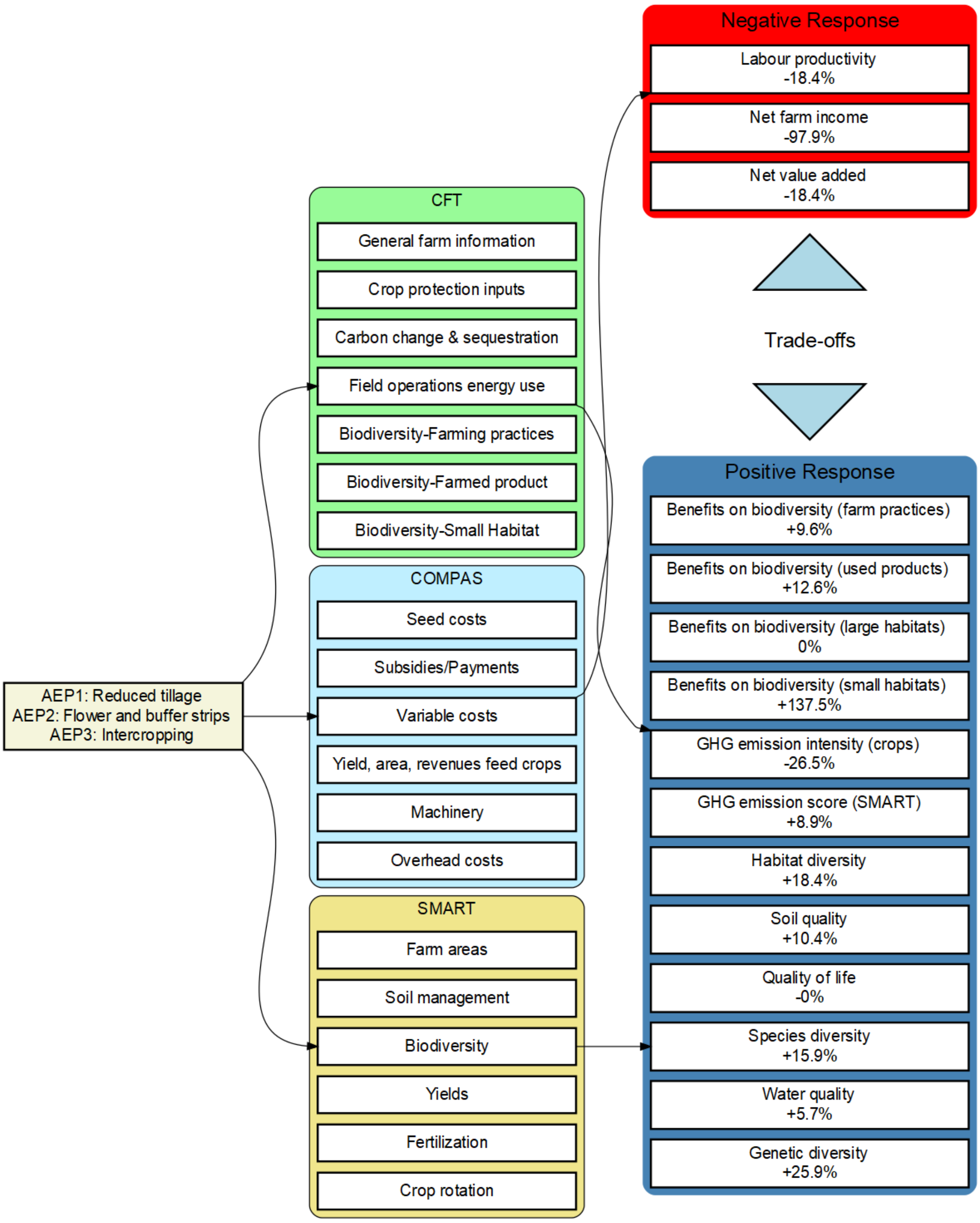

Figure 27: Sustainability results of the three agro-ecological practices (AEP1, AEP2 and AEP3) analysed in the German case study. The boxes in the middle show the main sections of CFT, COMPAS and SMART managed to simulate the AEPs. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEPs as a bundle.

The impact that AEP1 had on the economic farm performance was rather small yet affects farms in different ways. This, for instance, depended on whether or not farms already had the required equipment (the disc), owned a plough which was no longer needed, or whether or not the seedbed preparation was done by contract work. Generally, for AEP1, the slight increase in plant protection application (leading to an increase in the total intermediate consumption by between 0.7% and 1.4%) resulted in a decrease in the economic performance

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of farms (e.g., the net farm income is reduced by between 7.7% and 3.8%). Importantly, the German case study assumed that the crop yields of the farms would remain constant under AEP1 conditions. This assumption was confirmed by the majority of the consulted farm managers, and also observed in the database of the status quo assessment in Task 3.2 in which no clear differences between the yields of the differently operating farms can be observed. Rather, the differences of yields were perceived as being determined by the soil, water availability and production intensities. Still, limitations remain in terms of the long-term effects and possible impacts of reduced tillage practices, e.g., in respect to labour input, pest control and – ultimately – the yields.

As a consequence of contributing 10% of the arable land to agri-environmental measures of AEP2, namely flower (up to 10 ha) and buffer strips (filling up the rest of the 10%, between 0 ha and ca. 8 ha), the scores for biodiversity (both CFT and SMART) and water quality (SMART) went up. The direct economic consequences of AEP2, on the other hand, resulted to be largely negative, though with some distinctions. Overall, the additional cost for implementing AEMs were higher than the saved costs due to no longer cultivating the area (i.e., no fertiliser, seeds, etc). But in some farms, the received subsidies due to implementing the AEMs in general outweighed the potential losses of farm income from AEPs, which increased the net value added and the farm income.

Finally, the implementation of flower and buffer strip (AEP3) contributed to improve both the biodiversity scores of CFT and SMART and the water quality scores of farms. In one instance, where the environmental indicators go hand in hand with an improvement in the farm's economic performance, though this is only due to the additionally received subsidies. While biodiversity and water quality indicators improve (e.g. as a consequence of introducing legumes into the production system), lower prices for the sold product, a lower yield, and higher costs for seeds has substantial impacts on the farm performances.

Lithuania: Balancing grassland management (temporary vs permanent)

In the Lithuanian case study, the impact of different management strategies of permanent and temporary grassland was simulated for three farms to determine the best balance between environmental performance and farm economic sustainability. Additional details on the methodology and assumptions adopted in the analysis can be found in section 2.3.10. Given the complexity of the proposed agro-ecological practices, here we briefly summarize the approach applied on three farms, namely farm number 2, 5 and 7, which were initially assessed in the status quo assessment in Task 3.2. The sustainability analysis varied across the farms and, depending on the needs and grassland typology of the farms, comprised a conservative management of temporary and permanent grassland already present in the farms (farm 2 and farm 5), or a gradual conversion of temporary over permanent grassland (100% permanent, 50%-50% temporary-permanent, 100% temporary) in the organic dairy farm 7 (Figure 28).

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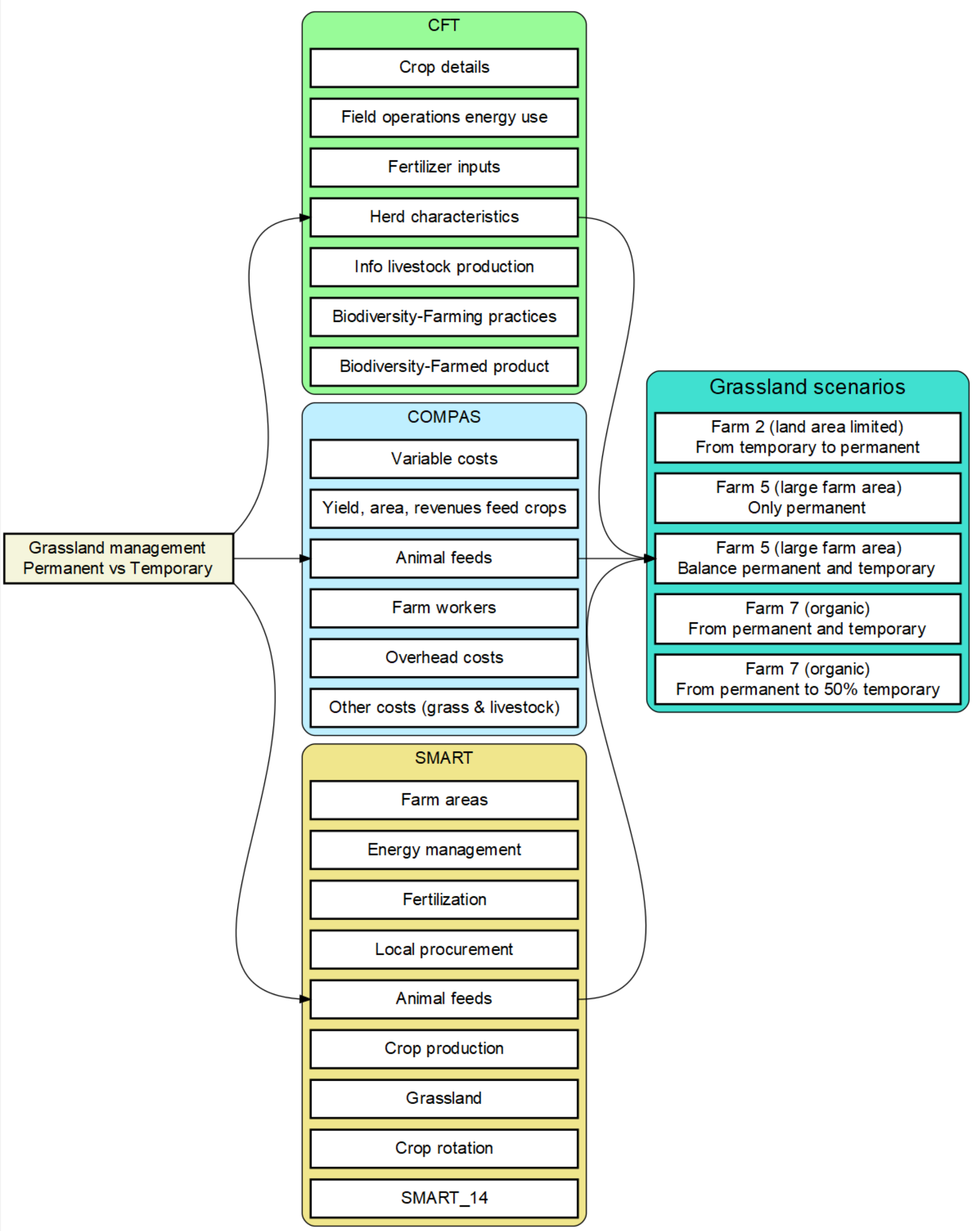

Figure 28: Chart-flow of the sustainability analysis carried out in the Lithuanian case study. The boxes in the middle show the main sections of CFT, COMPAS and SMART managed to simulate the agro-ecological practice (AEP). The box on the right summarises the grassland management transitions in the three dairy farms used in the analysis.

Figure 29 summarises the results of the sustainability analysis in the three farms. In farm 2, which originally had a larger proportion of temporary grasslands, the partial conversion to permanent grassland, to fulfil the farm dairy enterprise needs, provided only positive outcomes from the sustainability indicators of the three DSTs. Noticeable are the synergies between habitat diversity (+37.5%), species diversity (+14.3%) and genetic diversity (+12.8%) derived from the implementation of grass crop mixtures that enhance biodiversity and meadow longevity (i.e. 40% proportion of legume and a 5-year rotation). Consequentially,

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ecosystem services such as soil and water quality improved of approximately 9%, and GHG emissions from grassland was reduced by 7.5%. The positive economic indicator responses in farm 2, derived from the surplus and sale of roughage that the farm produce in the new grassland scenario.

In Farm 5 two alternative grassland scenarios were simulated. The first scenario included the transition to only permanent grassland to provide a sufficient production of hay for winter feed. This self-sufficiency in hay production went along with the assumption that 50% of the permanent grassland would need to be renewed. These assumptions resulted in negative responses of environmental indicators such as soil and water quality (-2.5% and -2.2% respectively), and GHG emissions in both CFT and SMART (up to +17.7%). On the other hand, the presence of only permanent grass for this cheese maker dairy farm permitted to improve by approximately 12% the labour productivity, net farm income, and net value added (Figure 23). The second scenario simulated in farm 5 aimed to balance permanent and temporary grassland, and showed a deterioration of all environmental indicators of SMART and CFT. This included negative responses of indicators relating to several ecosystem services such as GHG emissions (+28.6%), as well as genetic, habitat and species diversity in the farm. Among the potential synergies, the indicator of CFT on the benefits on biodiversity showed an improvement of just 4%, probably due to the diversification of grassland composition in the farm. In addition, the economic indicator of COMPAS remained positive, although the time and resources invested into preparation and exploitation of a temporary grassland resulted to be less efficient than the first scenario.

Finally, in the organic dairy farm 7 the conversion from permanent to temporary grassland resulted in an important increase in GHG emission (+67.9%) due to the more intensive management regime of the grassland. Other negative responses of indicators in the transition to temporary grassland were associated with the worsening of genetic and habitat diversity, as well as the overall benefits for biodiversity due to farming practices. On the other hand, however, this scenario showed some important positive responses of economic indicators for farm 7 (Figure 29) from the profits derived by the large surplus of roughage produces and sold by the farmer. These economic benefits, however, are only hypothetical for the farmer, as the analysis did not directly investigate if the surplus of roughage could be sold in the local market, and omitted to consider the costs for any process and storing facilities needed in the farm. Finally, the transition from permanent to 50% temporary grassland, resulted in the similar number of positive and negative indicator responses for farm 7. In that respect, the possibility to retain 50% of the permanent grassland on the farm did not change the trade-offs between environmental and economic dimension but lead to less extreme indicator responses in both directions, i.e. less economic benefits but also less negative environmental effect compared to a complete conversion to temporary grassland (Figure 29).

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Farm 2 (From temporary to permanent)	Farm 5 (only permanent)	Farm 5 (Balance permanent and temporary)	Farm 7 (from permanent to temporary)	Farm 7 (from permanent to 50% temporary grass)
Benefits on biodiversity (farm practices) +8.6%	Benefits on biodiversity (farm practices) 0%	Benefits on biodiversity (farm practices) +4.1%	Benefits on biodiversity (farm practices) -8.2%	Benefits on biodiversity (farm practices) -4.1%
GHG emission intensity (crops) -7.5%	GHG emission intensity (crops) +17.7%	GHG emission intensity (crops) +28.6%	GHG emission intensity (crops) +67.9%	GHG emission intensity (crops) +34.5%
Labour productivity +0.3%	Labour productivity +11.9%	Labour productivity +0.4%	Labour productivity +45.6%	Labour productivity +26.2%
Net farm income +0.3%	Net farm income +12%	Net farm income +5.5%	Net farm income +57.1%	Net farm income +34.8%
Net value added +0.3%	Net value added +11.9%	Net value added +5.4%	Net value added +52%	Net value added +31.7%
GHG emissions score (SMART) +13%	GHG emissions score (SMART) -1.7%	GHG emissions score (SMART) -6.7%	GHG emissions score (SMART) -10.5%	GHG emissions score (SMART) -5.3%
Habitat diversity +37.5%	Habitat diversity 0%	Habitat diversity -9.1%	Habitat diversity -10%	Habitat diversity -1.7%
Soil quality +9.1%	Soil quality -2.5%	Soil quality -3.7%	Soil quality 0%	Soil quality +1.4%
Quality of life 0%	Quality of life 0%	Quality of life 0%	Quality of life 0%	Quality of life 0%
Species diversity +14.3%	Species diversity 0%	Species diversity -3.8%	Species diversity 0%	Species diversity 0%
Water quality +8.2%	Water quality -2.2%	Water quality -3.3%	Water quality 0%	Water quality +1.3%
Genetic diversity +12.8%	Genetic diversity 0%	Genetic diversity -2.7%	Genetic diversity -7.7%	Genetic diversity -6.2%

Figure 29: Positive indicator responses (blue boxes) and negative indicator responses (red boxes) arising from the implementation of different grassland management strategies in the Lithuanian case study. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.

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HUNGARY: Reduced tillage, no plough and no tillage

As explained in section 2.3.5, the simulations of the case study were based on an economic model of a theoretical farm assessed in the participatory assessments of Task 3.2. Overall, the incremental impact of conservative soil management practices in the conventional tilled farm showed that the transition to reduced tillage (AEP1), no ploughing (AEP2), and no tillage (AEP3) could potentially provide synergies between environmental and economic indicators for the farmer (Figure 30, 31). The only potential negative indicator response in the three AEPs resulted from the modest worsening of biodiversity from the farming practices applied in no plough management. This case study did not apply CFT to assess the effect of these AEPs on the carbon footprint of the farm. It is plausible to expect, however, a reduction in GHG emissions from the increase of soil carbon stocks and lower energy consumption for field operations in arable land.

The positive economic indicator responses estimated by COMPAS were mostly driven by the economic savings applied in the model and described in section 2.3.5. It is worth mentioning here that the sustainability analysis considered only the positive and direct effects expected from the three AEPs. The suitability at farm level of conservative soil management should account for climate, soil and crops factors, and its implementation requires research on equipment choice and a high standard of crop and soil husbandry for the farmers. In that respect, the expected improvement of soil biodiversity, accounted in the analysis, is in general accompanied by an increase in organisms associated with plant diseases. In addition, the transition from tillage to reduced tillage, or no ploughing, or no-till need to carefully consider the management of crop residues. Under conservative soil management scenarios, crop residues left on the soil can increase fungal contamination in wet conditions, and delay seed germination as a result of poor seed-to-soil contact. To ensure that crop residues and planted seeds are not in close proximity, direct drilling and rolling should be considered to lessen the risk of crop failure. The above insights, however, were not included in the quantitative assessments with the DSTs.

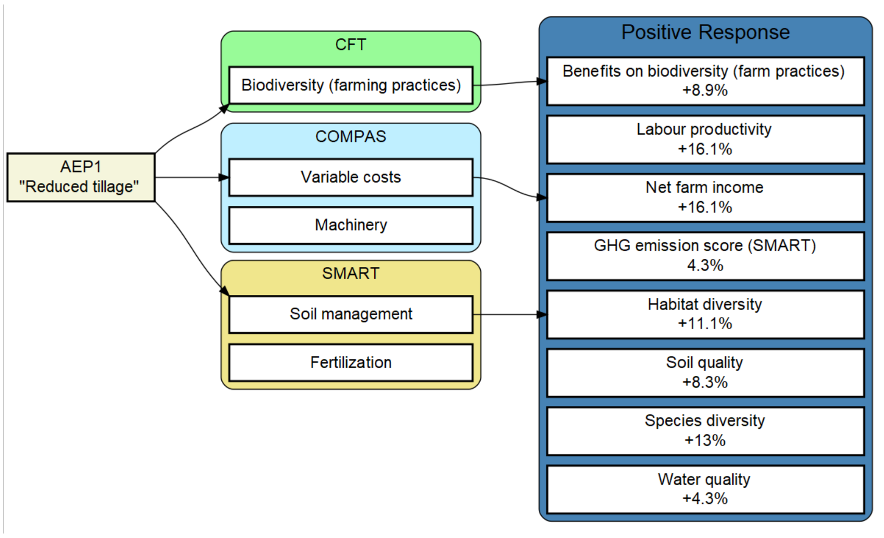
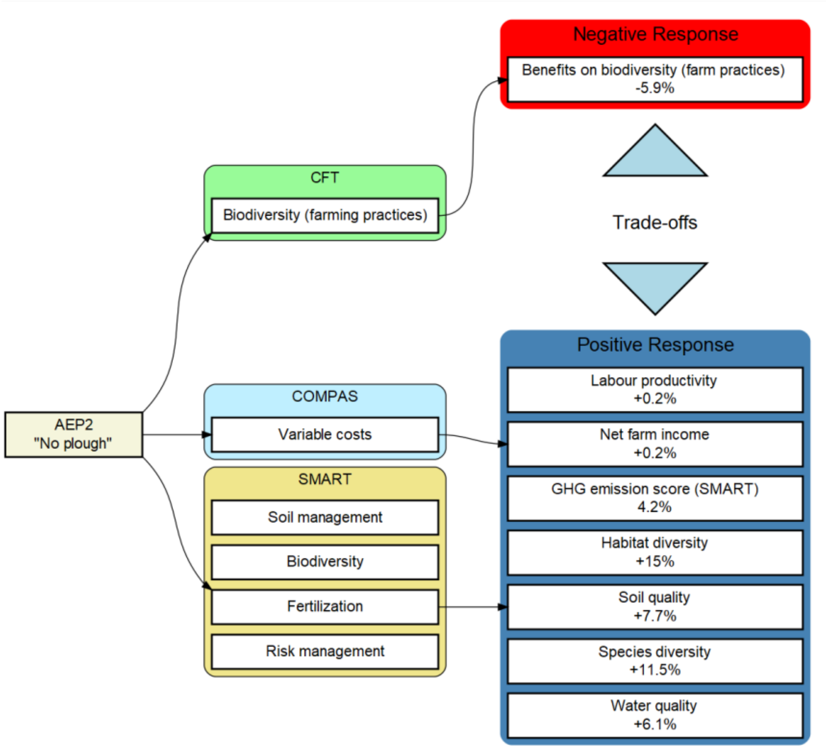


Figure 30: Sustainability results of the agro-ecological practice (AEP1) analysed in the Hungarian case study. The boxes in the middle show the main sections of CFT, COMPAS and SMART managed to simulate the AEP. The sustainability indicators in the blue box exhibit a positive response to the implementation of the AEP at farm level. The values represent the average relative change in

percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.



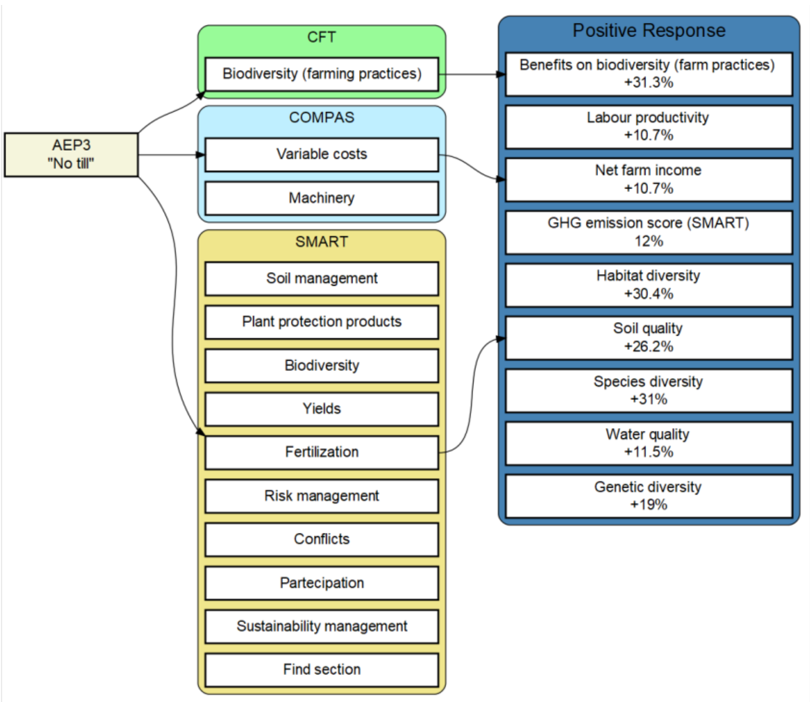


Figure 31: Sustainability results of the two agro-ecological practices (AEP2 and AEP3) analysed in the Hungarian case study. The boxes in the middle show the main sections of CFT, COMPAS and SMART managed to simulate the two AEPs. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the two AEPs.

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Switzerland: Extensification, increased direct marketing and fruit growing

As outlined in section 2.3.12, the extensification and increase of direct marketing (AEP1) was simulated in two conventional farms with dairy, pigs and some arable crops. On one farm, the pig breeding was completely abandoned, while on the second farm the breeding intensity was reduced to 14% of the original production. Considering the average results from the two farms, the synergies from AEP1 included a reduction of 10±19% of GHG emissions per ha of crop land, and a reduction of 48±72% of GHG emission from the pig breading enterprise (Figure 32). SMART showed only marginal improvement of ecosystem services such as soil and water quality. Despite the direct marketing, the extensification leads to trade-offs between environmental and economic indicators, such as lower labour productivity on both farms by 39±5%, 60.5±5% decrease of net farm income, and 49±7% decrease of net value added. The decrease in labour productivity was mainly explained by the reduction or abandoning of the pig breeding enterprise, and by the fact that the two farms would not be able to tab the full potential of direct marketing since they market mainly business to business products. Yet, the resulting labour productivity is still twice as high as the Swiss average.

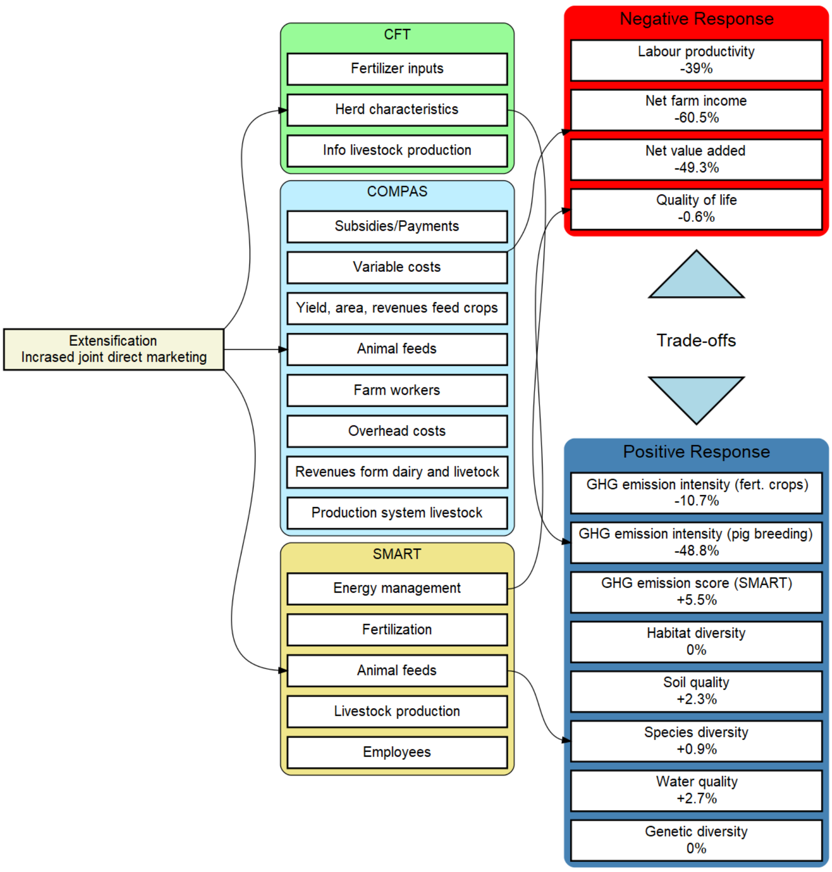

Figure 32: Sustainability results of the agro-ecological practices (AEPs) analysed in the Swiss case study. The boxes in the middle show the main sections of COMPAS and SMART managed to simulate the AEPs. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEPs as a bundle.

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As expected, the simulation of AEP2, which included the impact of AEP1, showed similar reduction in GHG emission from cropland and livestock (Figure 33). The conversion of 10% of permanent grassland to apricot plantation, however, increased the negative environmental impacts for the farms. In particular, soil and water quality decreased by 0.7% and 1.4% respectively. This negative effect on the SMART biodiversity rating can be attributed to higher pesticide use and a smaller share of permanent grassland. In the two farms, the apricots plantation substantially reduces the negative responses of economic indicators deriving from AEP1. The loss in net farm income went from -60.5±5% in AEP1 to -25±25% in case of AEP2. While, labour productivity changed from -39±5% in AEP1 to -5.9±17.8% in AEP2. The improvement of labour productivity was due to the increased work demand of the apricot growing which 100% was accounted for as seasonal workforce (costs) in the labour productivity figure. This simplification may have slightly improved the overall picture of changes in labour productivity.

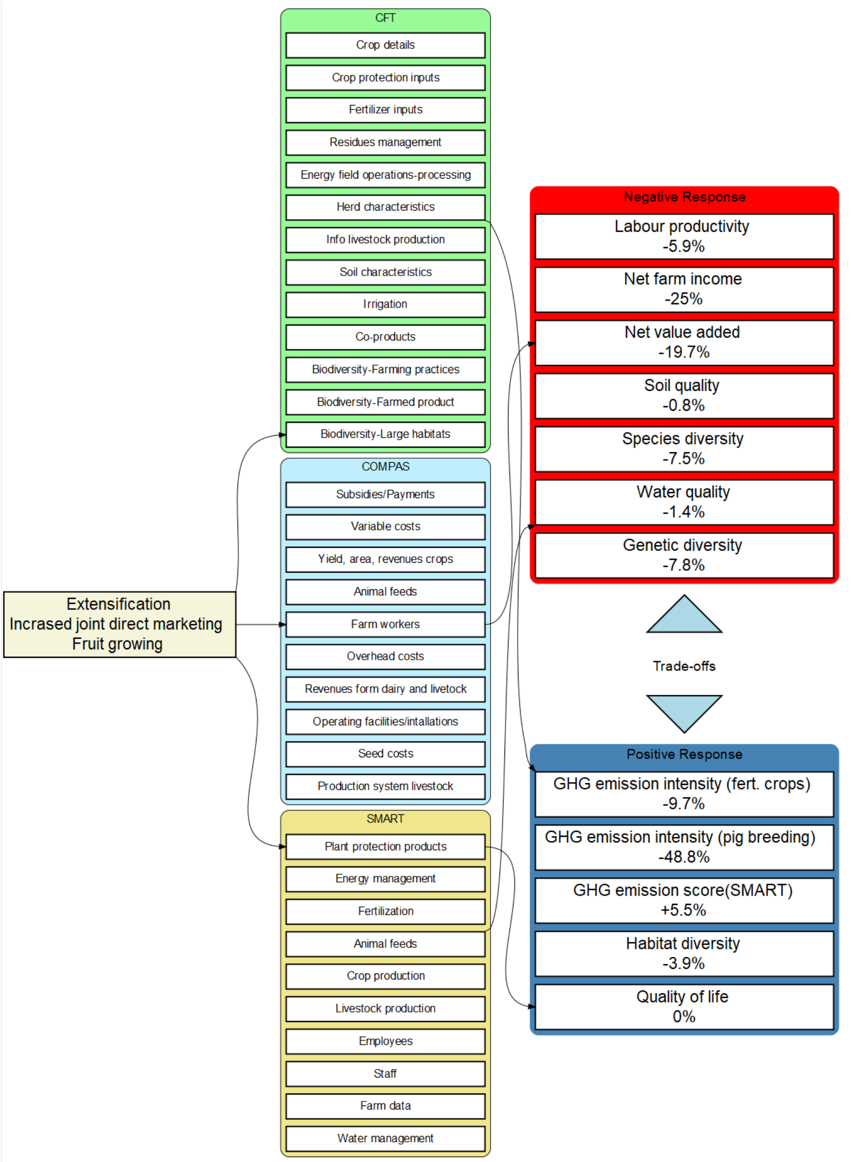

Figure 33: Sustainability results of the agro-ecological practices (AEPs) analysed in the Swiss case study. The boxes in the middle show the main sections of CFT, COMPAS and SMART managed to simulate the

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AEPs. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEPs as a bundle.

UNITED KINGDOM: No tillage and direct drilling in conventional farming

The sustainability of no tillage and direct drilling was assessed applying only COMPAS and CFT. Based on the agricultural recommendations on conservative soil management practices (Hillier et al., 2011), the impact of no-till was analysed in combination with practices such as direct drilling and rolling which are recommended to reduce risks of crop failure. Following the above approach, this case study assumed no change in crop yield from the AEP. The simulations involved a conventional arable farm producing cereal crops for human (e.g. whiskey) and animal consumption, and a conventional mixed farm producing beef meat, silage and cereal crops for human and animal consumption. The sustainability of the AEP, in particular, was assessed on the barley crop enterprise which represent the main cereal crop in the region of the case study.

The change of tillage practice is in general associated with the increase of soil carbon stock, which represent an important GHG removal (GGR) strategy in agriculture. Although, the conversion to no-till in the two farms resulted in similar number of positive and negative indicator responses on the two farms, their average effects were fairly different. In the conventional arable farm, characterised by low level of soil carbon stocks exclusively managed with mineral fertilizers, the AEP reduced GHG emission by 64.6%. While, in the conventional mixed farm where soils are managed with mineral and organic fertilization (FYM), the removal of soil tillage contributed to abate GHG emissions from barley by 340.8% (Figure 34). The higher environmental synergy from GHG emissions in the mixed farm was mainly linked to the initial soil conditions of the farm. The mixed farm in particular had higher soil organic carbon stock than the arable farm from the application of FYM. Regarding the benefit on farm biodiversity from the AEP, the arable farm resulted to have a higher net improvement on biodiversity compared to the mixed farm due to the initial lower biodiversity score of the intensively managed arable farm, which increased from 23% to 28% after the implementation of the AEP. While the biodiversity score of the mixed farm changed from 66% to 70% after the implementation of the AEP.

The implementation of no-tillage and direct drilling triggered weak trade-offs between environmental and economic indicators. As shown in Figure 34, these were generated by the additional costs for contractor work in the farm for direct drilling and rolling. The consumption of diesel for field operation remain overall unchanged as the removal of tillage practice was replace by a reconfiguration of the soil and crop protection regimes.

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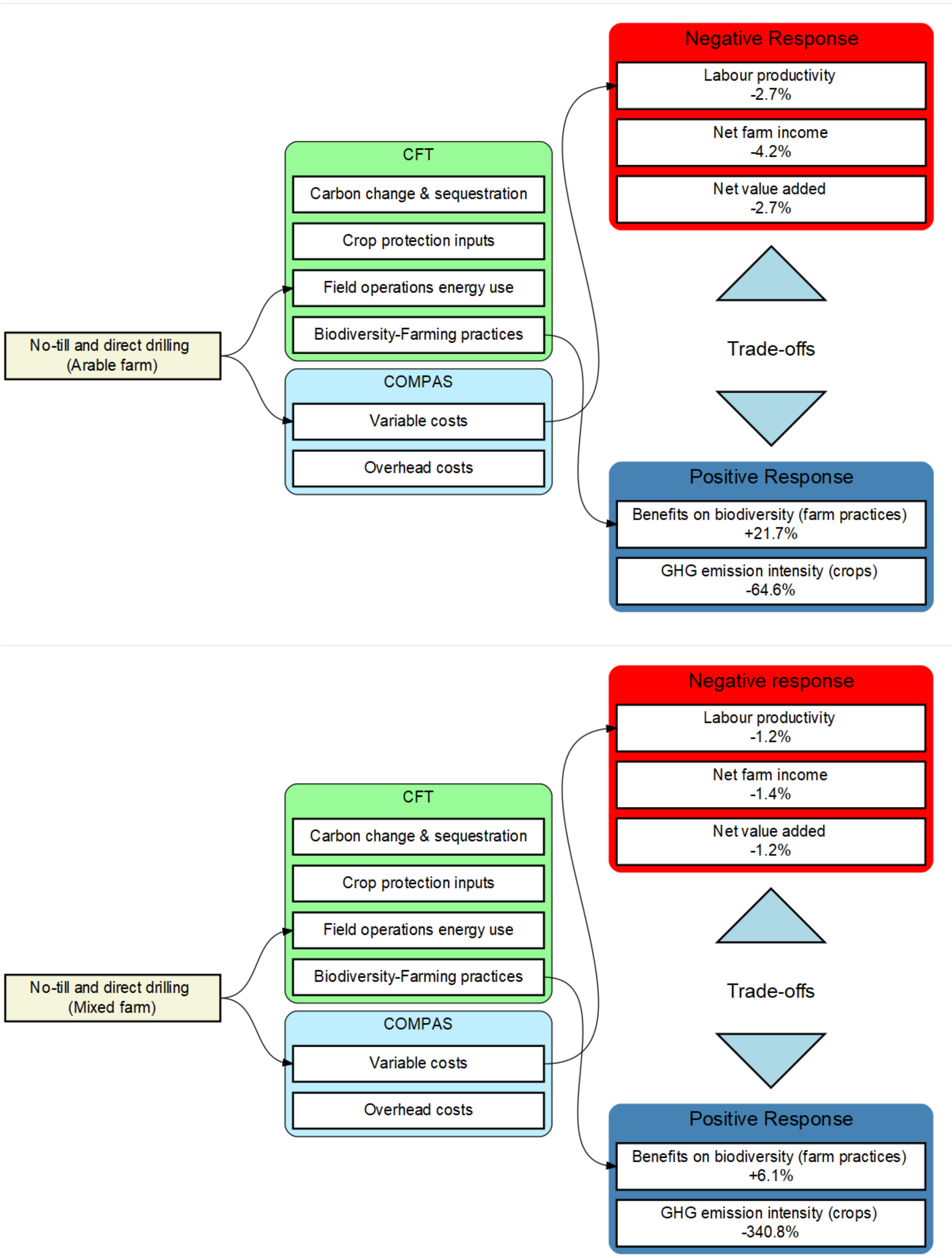

Figure 34: Sustainability results of the two agro-ecological practice (AEP) analysed in the British case study. The boxes in the middle show the main sections of CFT and COMPAS managed to simulate the AEP. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the two AEP.

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Sweden: More crop for food, increase payments and whole farm re-design

The AEP “more crop for food and increase payments” aimed to re-design 9 farms from the production of animal feed to crop for human consumption such as legumes and potatoes. This AEP reflects changes in the value chain and post farm-gate rather than changes to management practices on the farms. The sustainability analysis on more crop for food, in particular, were based on specific case study indicators such as energy content (Mkcal), protein content (ton), fat content (ton), and complete protein content (ton). While the analysis on increased payment was carried out in COMPAS and based on its sustainability indicators (Figure 35).

Being a net producer of calories, protein and fat depend on feeding high ratios of grass silage and having long grazing periods which in turn is beneficial both for biodiversity if the animals graze semi-natural pastures, and also for animal welfare. Increased cultivation of legumes can both increase the number of people that can be fed per hectare and reduce the need for bought in fertiliser. In addition, increased collaboration with a buyer (Oatly) has resulted in diversification; 3 out of 6 farms have added one more element to their crop rotation in year 2. The increased payment has also been beneficial for the economic situation at 5 out of 6 farms (the sixth being the farm that has undergone a large shift).

Milk production is a highly area efficient way of producing calories, protein and fat. For two farms, reduced milk production in year 2 has influenced the number of people that can be fed per hectare negatively. However, only a small increase in the crops for human consumption is required to compensate for the loss; for one farm that quit producing milk, the entire loss of calories would be compensated for by growing 6 ha of legumes or 3 ha of potatoes. Notably though without compensating for the loss of production of protein and fat per hectare.

Increased grazing and feeding with roughage free up arable land for cultivation of crops for human consumption but may increase emission intensities for milk and beef.

The price of oats decreased between the status quo assessment and year 2020 and thus, for some farmers, the additional payment for oats (+50%) did not provide sufficient monetary compensation for the increased risk of growing a new/additional crop. This highlights how difficult risk sharing between buyers and producers is in reality.

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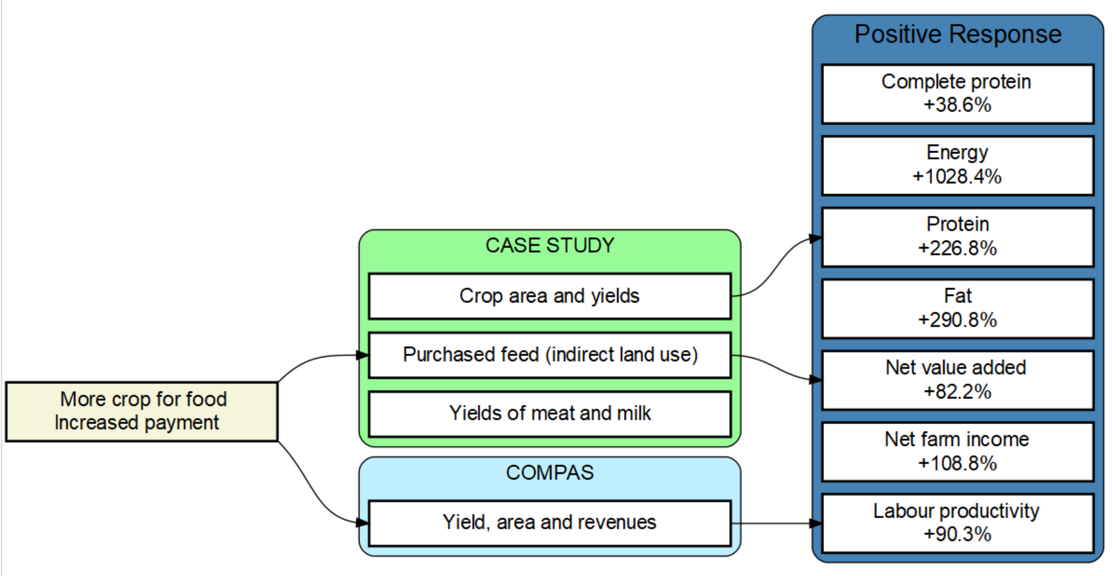

Figure 35: Sustainability results of the agro-ecological transition strategy analysed in the Swedish case study. The boxes in the middle show the main sections of COMPAS and specific case study indicators managed to simulate the transition strategy. The sustainability indicators in the blue box exhibit a positive response to the implementation of the several agro-ecological practices (AEPs) at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEPs as a bundle.

The sustainability analysis of AEP2 focuses on the whole transformation of a conventional livestock farm in organic cropping and extensive pasture rearing of beef, assuming the shift from 1200 intensively reared cattle to 300 extensively reared cattle integrated with crops. In the DSTs, this was achieved by changing the initial herd characteristics in the farm (from 1200 industrially reared bulls to 350 extensive heifers), the life cycle of the livestock in the farm (slaughter age from 17 to 30 moths), their feeding regime balance between grazing and feedstuff intake, and the management of manure and bedding in the farm.

Less dependence on input factors such as fertilisers and pesticides has positive impact both for biodiversity and reducing the costs on the farm (Figure 36). The extensive livestock rearing system is beneficial for both animal welfare and working conditions on the farm because stocking densities are lower, risks are fewer and the need to "intervene" with the herd (medical treatments, moving animals etc.) has been reduced. Despite lower yields from the cropping enterprise, abandoning the intensive livestock rearing that was heavily dependent on compound feed means that in total, the farm still feed (calories) as many people per hectare. The climate impact of the beef has been reduced thanks to fewer transports and reduced purchasing of compound feed which has also contributed to the lower costs of production. The shift to organic has lowered yields per hectare considerably, but the farm contributes with approximately the same quantity of calories. Stopping the intensive beef production has significantly reduced the protein, fat and complete protein the farm delivers despite a large reduction in the total area of arable land that the bought in feed for the intensive rearing required.

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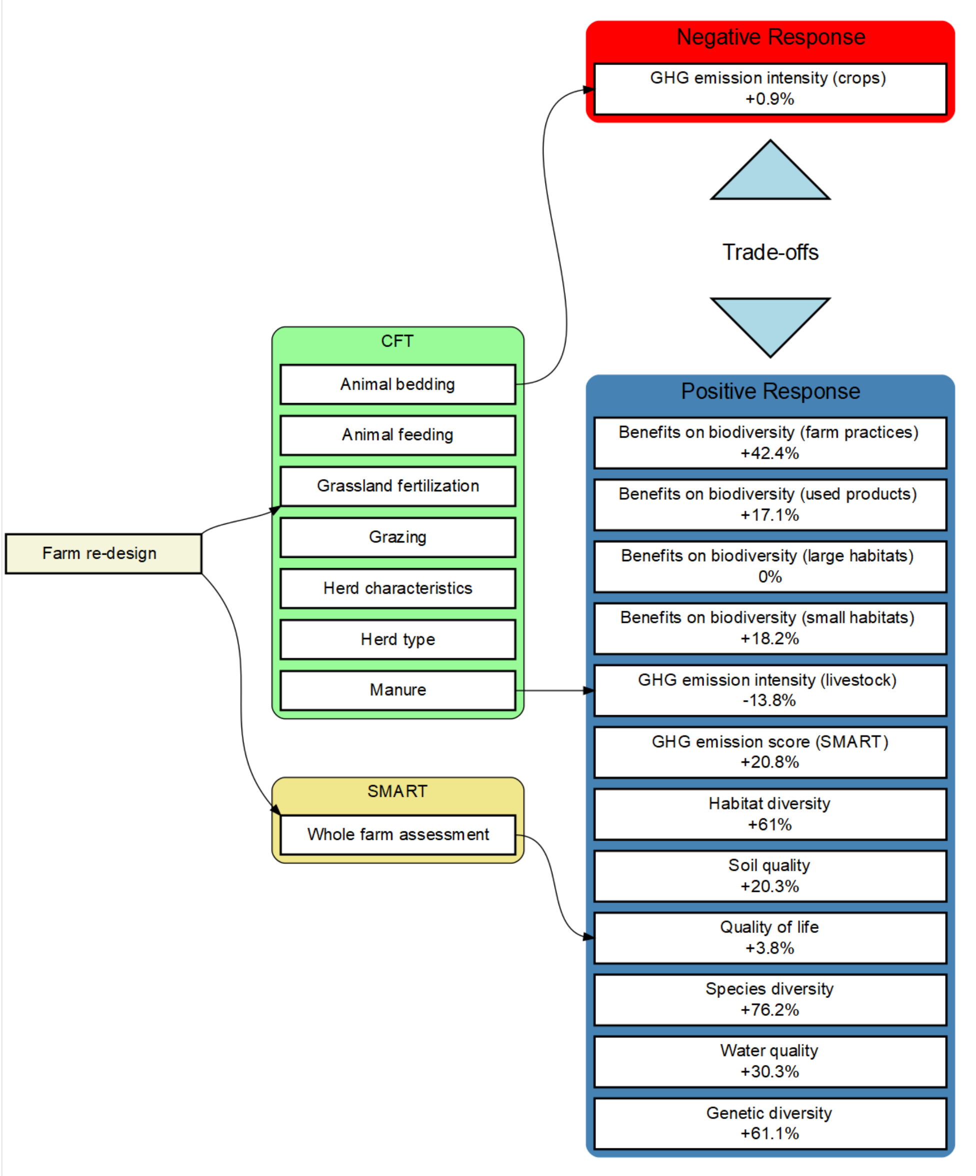

Figure 36: Sustainability results of the agro-ecological transition strategy analysed in the Swedish case study. The boxes in the middle show the main sections of CFT and COMPAS managed to simulate the transition strategy. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEPs as a bundle.

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SPAIN: Strengthened farmer network (AEP1)

The simulation of AEP1 in SMART showed that a total of 20 indicators (Figure 37) resulted to be positively modified, which are related to a great variety of themes within the good governance, economic resilience and social wellbeing dimensions. The results indicate that AEP1 has the potential to generate synergies deriving from the predisposition and the behaviour of a farmer towards a more sustainable management of all the aspects of the farming activities.

13 of the 20 indicators affected the performance of only 1 or 2 farms at the same time, meaning that the strengthening of the farmers networks impacts diverse aspects of the socio-economic results of a farm depending on the starting point of each farmer. The other 7 indicators affect at least 3 of the 6 modelled farms, 4 of the indicators being encompassed in the dimension of good governance, and 3 in economic resilience. Due diligence (corporate ethics), holistic audits (accountability), transparency (accountability) and product information (within economic resilience) are the indicators that affect a higher number of farms (5 out of 6), followed by civic responsibility (rule of law) and community investment (investment), affecting 3 out of 6 farms.

A clear difference has been seen between the two groups of farms modelled (agro-ecological versus in transition), showing that even though there is still room for improvement in farmers who are already in a system redesign, the strengthening of farmers networks is particularly important in the transition stage. On one hand, the total improvement of the farm performance is 3 times higher in farms in agro-ecological transition compared to farms in an advanced stage of agro-ecology (improvement of 300 points in the transition stage versus 100 points in the system redesign). On the other hand, the diversity of the subthemes of SMART where improvements have been seen is also higher in farms in the transition stage (17 versus 12). Finally, the number of indicators that improve in a given farm is higher in farms in transition than in farms in an advanced stage of agro-ecology (10 indicators per farm versus 5).

In agro-ecological farms, the biggest differences between the status quo and the modelled scenario occur in the improvement of the product information (under the economic resilience dimension). The rest of the subthemes show rather small variations between the two scenarios, with the exception of capacity development and fair access to means of production (both under the social wellbeing dimension), with a noticeable increase but only in one particular farm.

In farms in the transition pathway, there is a very important improvement in civic responsibility, followed by the theme of responsibility and stakeholder dialogue, all under the dimension of good governance. Other significant changes have been seen in indigenous knowledge (social wellbeing dimension), grievance procedures, remedy, restoration & prevention, and resource appropriation (under the good governance dimension).

Finally, the application of AEP1 could back out those farmers who for different reasons are not willing to get more involved with their community. However, despite the great variety of changes found in the 6 farms analysed, there has not been a single indicator which value decreased in the modelled scenario.

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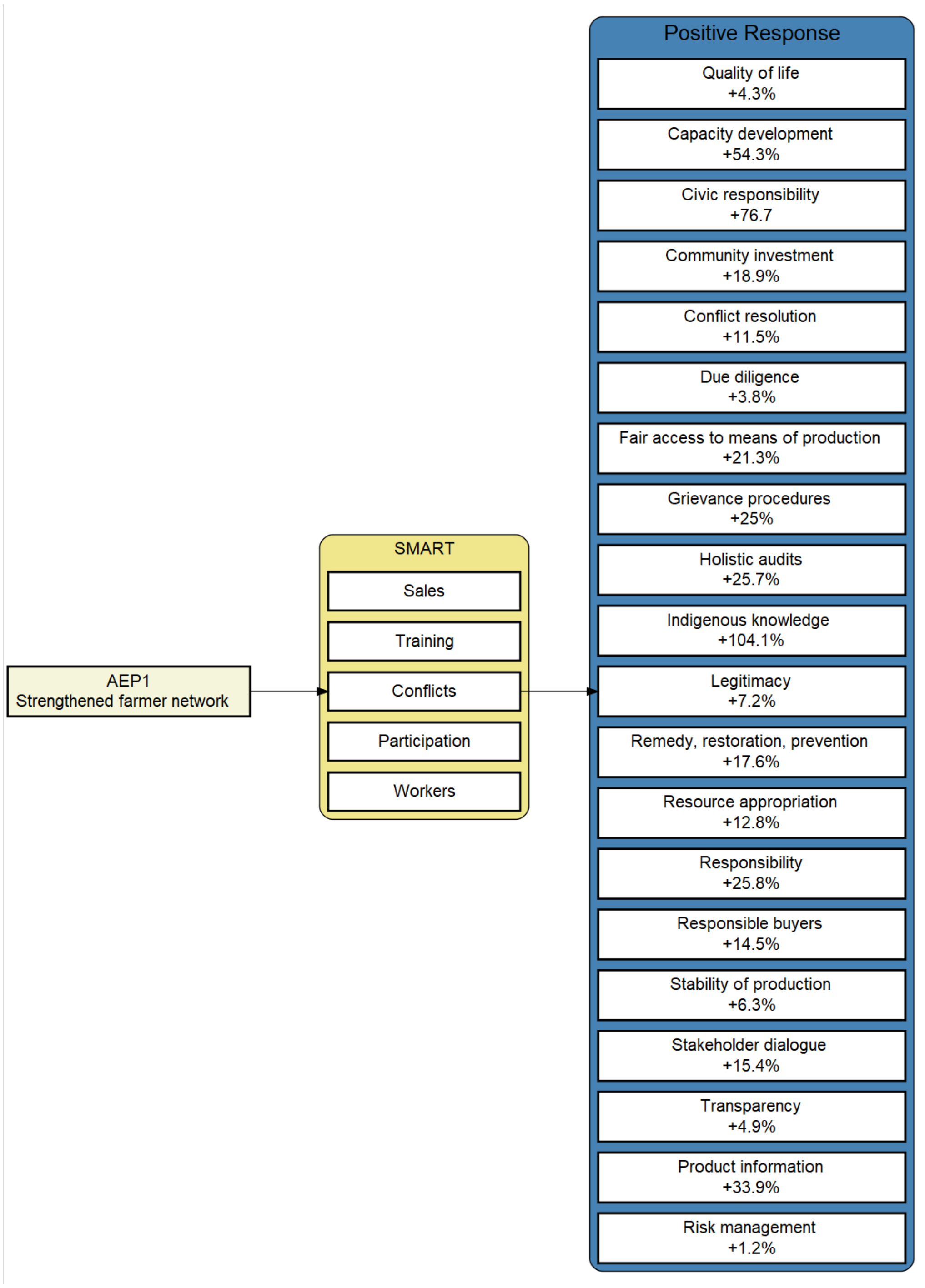

Figure 37: Sustainability results of the agro-ecological practice analysed in the Spanish case study. The box in the middle shows the main sections of SMART managed to simulate the AEP. The sustainability indicators in the blue box exhibit a positive response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP. The average relative change value of the indicator "civil responsibility" excludes the results of one farm which resulted to have value zero in the baseline scenario.

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SPAIN: Collective post-harvest activities (AEP2)

A number of indicators of SMART and COMPAS were positively affected by AEP2. The results showed that collective post-harvest activities have an impact in crucial aspects of any farming system, such as the farmers' net income and the economic sustainability of the farming system as a whole. Within SMART, collective post-harvest activities have a positive impact on 6 indicators, 4 of which are related to the economic resilience dimension, and 2 to social wellbeing (Figure 38). Profitability (investment), stability of market (vulnerability), value creation (local economy) and responsible buyers (fair trading practices) show a change in all the modelled farms. Risk management (vulnerability) and quality of life (decent livelihood) affect two of the three farms.

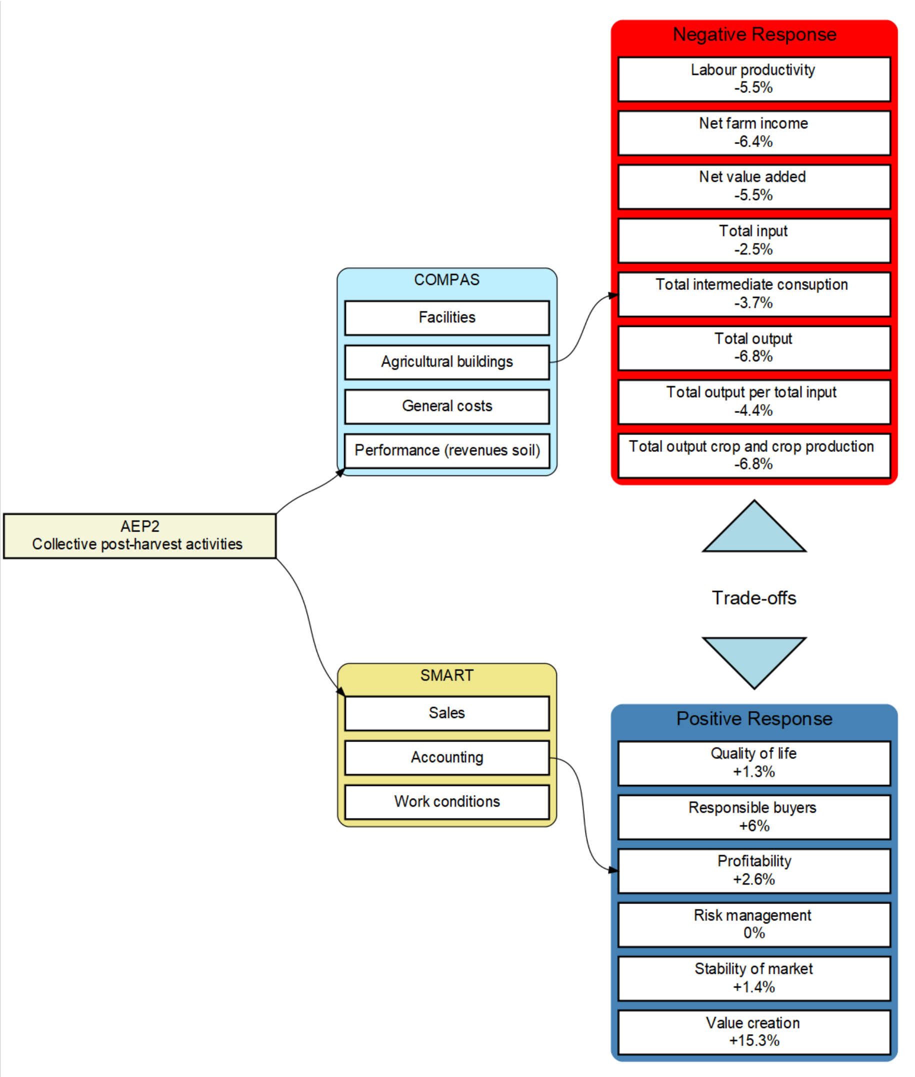

Figure 38: Sustainability results of the agro-ecological practice analysed in the Spanish case study. The boxes in the middle show the main sections of COMPAS and SMART managed to simulate the AEP. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.

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Although several SMART indicators showed a slight improvement in AEP2, in some cases the change was negative (stability of market and risk management in only one farm). Value creation and responsible buyers were on average the indicators in SMART with the highest change (15.3±5% and 6±0.8% of difference respectively). While, the average difference in the scores of the rest of the indicators was much lower (Figure 38).

Within COMPAS, rather negative responses were obtained in 8 different indicators in the modelled scenario: total input (with an average variation of -2.5±2.5% among the 3 farms analysed), total intermediate consumption (-3.7±3.3%), total output (-6.8±1.6%), total output crops & crop production (-6.8±1.6%), net value added (-5.5±2.4%), net farm income (-6.4±2.3%), total output per total input (-4.4±2.2%), and labour productivity (-5.5±2.4%). The results indicate a potential trade-off between improvements in the quality of life and value chain improvements on the one side and negative impacts on the economic performance of single farms on the other side. When farmers use EKOALDE's collective selling services, the net farm income decreased due to the reduced crop income. The selling prices of crops (euros per ton) went down when farmers sold their products through collective centres compared to selling them individually to other customers with whom they have more negotiating power. In addition, although farmers saved on farm building costs and rental fees, these savings were not enough to compensate the reduction on market prices for crops. This COMPAS result from the implementation of AEP2 seemed to contradict the slightly positive score obtained with SMART on profitability. This was due to the fact that, within the SMART tool, the decrease in the price of the products (question number 1.8.1.8) was compensated by the improvement of two other indicators: the farmer's involvement in collective marketing with other producers (1.8.1.7) and that part of the products sold are processed from the farm (1.8.1.10). Furthermore, the specific SMART indicator on net farm income (1.11.2.5) remained unchanged in AEP2 because the answer (closed type YES/NO) remained the same: "Yes, the income covered all expenses including a liveable wage". Farm income may have decreased but it is still sufficient to cover expenses, so this type of response does not lead to the measurement of this decrease.

SPAIN: Improved access to land (AEP3)

A number of indicators of SMART and COMPAS were positively affected by this AEP. In SMART, a total of 8 indicators showed positive trends in their scores, 1 related to the good governance dimension, 1 to environmental integrity, 4 to economic resilience and 2 to social wellbeing. The indicators affected by AEP3 belong to the 4 dimensions contained in SMART, which showed an impact in very varied topics (Figure 39). In particular, one of the 3 farms involved in the analysis of AEP3 did not suffer any changes in SMART since the answers given in the status quo are those sought in the new scenario. While, in the other 2 farms AEP2 positive influenced 7 key indicators of SMART (Land degradation (2.2±0.9%), internal investment (5.9%), long-ranging investment (10.2±1.6%), stability of production (4.7±2.2%), risk management (1.9±0.9%), fair access to means of production (16.9±3.9%), and food sovereignty (15.2±0.5%). One of the farmers additionally saw 7% increase in his sustainability management plan.

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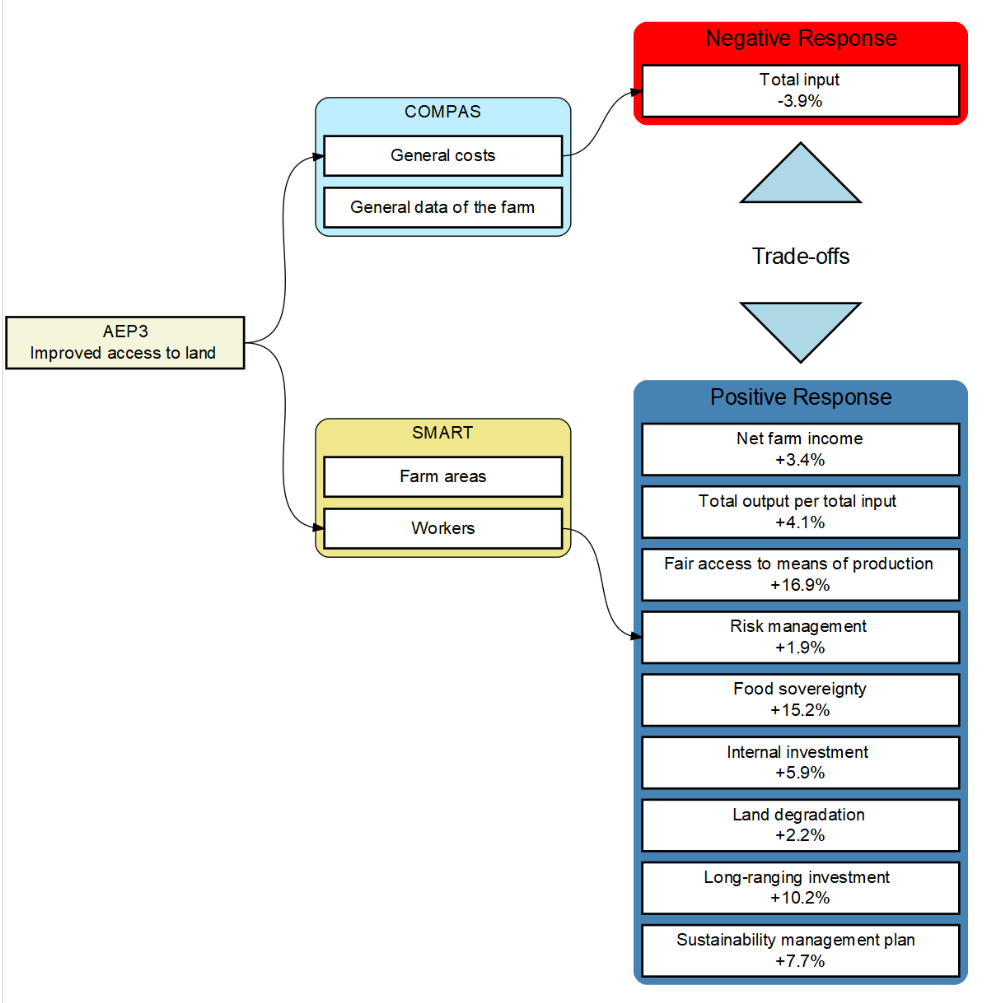

Figure 39: Sustainability results of the agro-ecological practice analysed in the Spanish case study. The boxes in the middle show the main sections of COMPAS and SMART managed to simulate the AEP. The sustainability indicators in the blue boxes exhibit a positive response while those in the red boxes show a negative response to the implementation of the AEP at farm level. The values represent the average relative change in percentage estimated from the pair-wise correlation of the sustainability indicators before and after the implementation of the AEP.

Improving the access to land offers farmers better property rights on the farm's land. The increase in guaranteed staff replacement also gives farmers more possibilities of securing the farm succession. Farmers would be willing to make more internal and long-ranging investments, seeking for long-term sustainability instead of the maximum benefit in the short-term, which would even be reflected in the improvement of an indicator of the dimension of environmental integrity, land degradation.

In general, improving access to land created more possibilities to farmers to buy land, which in turn created an increase in the owned land and a decrease in rented land. Within COMPAS, the total input of the three modelled farms decreased on average decrease by -3,9±1.4%. This had an impact on the total output per total input which increased by 4,1% which combined with the decrease in the average lease price and land rental expenses, resulted in a potential synergy derived from the increase in the net income of farmers (+3,4±2.2%).

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4. DISCUSSION AND CONCLUSIONS

Agro-ecological approaches are fundamental for sustainable food production in the future, and the overarching objective of UNISECO is to co-develop improved and practice-validated strategies and incentives for the promotion of improved agro-ecological approaches. The key dilemma how to produce public goods whilst maintaining viable production of private goods, securing economic and social sustainability at a farm level. This report explores the sustainability implications of a range of different AEPs selected in the specific context of the case study farming systems, identifying and assessing synergies and trade-offs that either mitigate or compound the dilemma. In that respect, the analysis of Task 3.4 emphasises the centrality of reducing the use of external inputs and the simultaneous improvement in the quality and use-efficiency of input at farm level.

Although the majority of the analysis are not directly comparable against each other, due to differences in the objectives and farming systems between the 13 case studies, the Latvian and Romanian case studies represent an exception. These case studies investigated the transition from conventional to organic dairy farming implementing very similar assumptions and farm management changes. In particular, they both assumed the substitution of mineral fertilizers with organic fertilizer, a decrease of 50% of feed crop yields due to the transition to organic farming, constant herd size and milk production, and the access to substantial organic farming subsidies for the farmers. Despite the above similarities, however, the Romanian case study showed significant economic implications due the use of external inputs to sustain the organic fertilization in arable land. The approach of the Romanian case studies tends to undermine the economic concept that is central to both agro-ecological principles and practice, which is based on the importance of natural resources produced on the farm (Wezel et al., 2020, Wezel et al., 2017). When most of the resources are produced within the farm, the agro-ecological transition does not appear as a monetary cost for the farmers, making the farm less susceptible than conventional farms to market price increases for factors of production (van der Ploeg et al., 2019). Based on the input changes in the three DSTs, the decline of crop yield assumed by these two cases studies seem to be related to the reduction of crop protection in organic farming. In this context, a trade-off in organic farming exists between organic weed control which leads to better environmental performance and the provision of yield (economic performance). Several studies indeed show that short-term yield declines on average between 19 and 25% lower on organic farms than in conventional agriculture (Sufert and Ramankutty, 2017, Ramankutty et al., 2019). Weed control in organic agriculture, however, can be positively managed using reduced tillage which may result in machinery and labour savings (Cooper et al., 2016). Furthermore, organic agriculture can be associated with the increase of rural employment and farmer incomes because of their access to a premium market price (Ramankutty et al., 2019). Ultimately, the magnitude of difference between organic and conventional production depends on whether conventional production within a given region is of an intensive or extensive nature (Lynch et al., 2011).

The analysis based on the implementation of individual AEPs can facilitate the understanding of how specific farm management changes can generate synergies and trade-offs on the farms. Like the Latvian and Romanian case studies, the UK case study analysed the simulation of soil organic fertilization (FYM) on mixed farms, but outside the generic strategy of organic agriculture. Assuming no change in fertilization inputs for the crops, this case study

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highlighted how FYM application can generate trade-offs between the positive effects relating to soil biodiversity, carbon sequestration, energy use and labour savings, and the moderately negative effect on the economic performance when the FYM spreading needs to be carried out by contractors (Figure 34). Similar trade-offs were reported from the Italian partners for the simulation of composting in conventional vineyard farms. In a separate analysis, the Italian case studies also investigated the impact of inter-row green cover, which involved a certain degree of re-design of conventional vineyards. This AEP showed important synergistic loops from the improvement of biodiversity, soil health, and carbon footprint of the farm that strengthen the resilience against external disturbances. Interestingly, in the French case study this AEP was associated with a general reduction of crop yield due to the simultaneous removal of conventional plant protection practices which lead to significant trade-offs between the environmental performance and socio-economic benefits (Annex IV).

A number of case studies investigated the implementation of a bundle of AEPs which resulted in diversified farm systems. Diversified strategies can generate synergistic loops that strengthen resilience and help to build economies of scope (van der Ploeg et al., 2019). This outcome, however, depends on several external factors such as farm size, climate, and farm infrastructure (Rosa-Schleich et al., 2019). In this context, the Swiss case study simulated the agricultural extensification on conventional mixed farms (livestock, arable and grassland), increased direct marketing and even the removal of part of the livestock and grassland production. The latter was replaced by an apricot plantation. If we use the definition reported in Rosa-Schleich et al (2019), the diversified farming strategy simulated in the Swiss case study generates high-low relationships (trade-offs) driven by ecological benefits at the cost of economic benefits. Similarly, the German case study reported trade-offs from the simultaneous implementation of intercropping “Maize-Beans”, reduced soil tillage, and agri-environmental measures. Intercropping with nitrogen fixing crops can promote ecosystem functioning such as biodiversity, carbon sequestration and lower input requirements from fertilizer applications (Figure 27). The German case study showed that the opportunity costs from intercropping may depend on the requirements of the cultivated crop types regarding machinery and labour. Diversified farming strategies can also be based on the spatial and temporal integration of grassland with livestock. The Lithuanian case study, in particular, investigated the potential win-win (synergy) situations that derive from mixed permanent-temporary grassland in conventional dairy farms. By finding the right balance between permanent and temporary grasslands, farms can conserve ecological benefits of perennial pastures (e.g. improved soil and water resources, increased carbon sequestration and biodiversity, and lower GHG emissions) while increasing economic gains derived by the higher productivity of temporary grassland and the surplus of roughage for the farmer (Figure 29).

Several studies showed that soil conservation practices such as reduced tillage, no-till, direct seeding, and non-turning soil cultivation are associated to the increase of soil health, but only few studies identified synergy situation between environmental and economic benefits (Rosa-Schleich et al., 2019). In general, the potential economic driver to adopt soil conservation practices can derive from input savings from farm labour, lower fuel consumption, machinery repair costs and lower depreciation rates of equipment (Derpsch et al., 2010, Knowler and Bradshaw, 2007). Based on these pre-requisites, the Hungarian case study outlined only win-win (synergy) situations from the progressive implementation of different soil conservation practices. The UK case studies, reported no economic benefits from the simulation of no-till even if the simulations include soil management measures that aim to reduce crop failure in no–till regime.

The most robust and desirable approach to trade-off analysis is the direct measurement via primary data collection in the field before and after the implementation of AEPs. In Task 3.4 we defined the baseline farm scenarios using data collected at the farms in Task 3.2. In addition, the agro-ecological practices were investigated within a unique combination of local parameters, circumstances and actors that defined their decision context, their scope, and potential outcomes. Arguably the outcomes from this methodological approach can be influenced by assumption applied in the simulations, e.g. with regard to expected yields and the need for additional, external inputs to substitute for less inputs produced on the farm due to extensification. In addition, some case studies, such as the Swedish and Finnish, analysed agro-ecological practices which comprised a complex farm re-design that requires not only the reorganization of the resource-base at farms, but also a reshuffling of arrangements 'downstream' of farms (e.g. new markets and governance mechanisms) (Prove et al., 2016). Depending on the complexity of the practices implemented, ecological, social and economic processes can be influenced by phenomenon that are outside the system boundaries of the farm-level analysis targeted by Task 3.4. So by design, for some complex practices reported here, the results of the DSTs simulations did not provide sufficient information to understand the whole impacts arising from the implementation of the strategies.

In conclusion, the understanding of synergies and trade-offs from the implementation of agro-ecological practices goes beyond the assessment at farm level of productivity, nutrient losses, GHG emissions, energy consumption and other processes at farm level. It also needs to consider the social rules and social networks active within a community. In this context, the UNISECO project provides a system perspective within which some of the key findings of Task 3.4 are further evaluated in the context of wider transition strategies in each case study co-constructed in robust partnerships between researchers and stakeholders (i.e. producers, traders, consumers, ecologists and policy makers) as a prerequisite for strengthen the sustainability of European farming systems.

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ANNEX I: STRUCTURE OF CFT

Cropland assessment			
Sections	**Subsection**	**Factor**	
1 Crop	1.1 Details,	Type of crops (T):	
		Area:	
		Gross Yield:	
		Net Yield:	
		Dates (Planting/Harvest):	
	1.2 Residues management	Residue amount	
		Residue management	
	1.3 Co-products	Crop residues	
		Co-product (% of T):	
2 Soil		Texture:	
		Type	
		Soil Organic Matter %	
		Moisture	Overall average
			at sowing
		Drainage	
		pH	
3 Inputs	3.1 Fertilizer inputs	Fertilizer type	
		Fertilizer origin	
		Fertilizer rate	
		Fertilization method	
		Emission Inhibitor from fertilizer	
	3.2 Crop protection inputs	Category	
		Application doses	
5 Irrigation		Event numbers (only in "GHG")	
		Irrigation start (with "Water footprint")	
		Irrigation end (with ""Water footprint")	
		Method used	
		Water source	
		Pumping depth	
		Horizontal distance	
		Power source	
		Water used (E x quantity)	
		Water used per week	
		% of land irrigated	
4 Fuel & Energy/ Waste water emissions	4.1 Waste water emissions	Waste water volume	
		Oxygen demand	
		Type of oxygen demand	
		Water treatment type	
	4.2 Direct Energy Use	Energy source	
		Energy used	
		Category of energy use	
	4.3 Field operations energy use	Machine type	
		Fuel type	
		Fuel quantity	
		N. of operations	
6 Carbon	6.1 Carbon Change & Sequestration	Land Use Change type (LUC)	
		N. of years from change	
		Forest age (if LUC includes forest)	

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		% of field affected by LUC
		Change of tillage practice (TC)
		N. of years from TC
		% of field affected by TC
		Cover crop (CC)
		N. of years from CC
		% of field affected by CC
	6.2 Out of crop biomass change (i.e.Agroforestry)	Tree Species
		Density of the trees
		Diameter of the trees
		Annual growth in diameter
		Trees planted or lost?
7 Transport		Type of transport
		Weight
		Distance

Beef breeding/intermediate finishing assessment		
Section/subsection	**factor**	
1 Production	Production system	
	Type of farm	
	Reference period	
2 Herd	***Intermediate-Finishing Beef***	***Breeding Beef***
	Veal calves	Suckler cow
	Beef calves	Meat calves
	Younger beef heifer	Bulls
	Younger beef steer	Replacement heifers
	Older beef heifer	Beef heifers
	Older beef steer	Beef steers
2 Herd characteristics	Age first calving	
	Calving interval	
	Calving rate	
	Replacement rate	
	Time to slaughter	
3 Grazing	Days of grazing (per animal)	
	Hours per day of grazing (per animal)	
	Grazing type (per animal)	
	Grazing quality (per animal)	
3.1 Grassland fertilization	Type of fertilizer	
	Rate of fertilization	
	Unit of fertilizer applied	
	Origin of the fertilizer	
4 Feed	Feed type	
	Dry matter intake (per animal)	
	Percentage by type & by weight (average entire herd)	
5 Manure	Type of manure management (per animal)	
	Percentage of manure processed (per animal)	
5.1 Bedding	Type of bedding	
	Quantity of bedding	
6 Energy	Energy source	
	Energy usage	
7 Transport	Type of transport	

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	Weight
	Distance

Dairy assessment	
Section/Subsection	**factor**
1 Milk production	Main breed
	Total milk production
	Fat content
	True protein content
2 Herd	Dairy claves
	Meat calves
	Heifers
	Milk cows
	Dry cows
	Nursing/suckling cows
3 Grazing	Days of grazing (per animal)
	Hours per day of grazing (per animal)
	Grazing type (per animal)
	Grazing quality (per animal)
3.1 Grassland fertilization	Type of fertilizer
	Rate of fertilization
	Unit of fertilizer applied
	Origin of the fertilizer
4 Feeds	Feed type
	Dry matter intake (per animal)
	Percentage by type & by weight (average entire herd)
4.1 Manure	Type of manure management (per animal)
	Percentage of manure processed (per animal)
4.2 Bedding	Type of bedding
	Quantity of bedding
5 Energy & processing	Energy source
	Energy usage
6 Transport	Type of transport
	Weight
	Distance

Livestock assessment		
Section	**Subsection / factor**	
1 General Information	Livestock type	
	Weight finished product	
	Co-product type	
	% main value	
2 Herd & Feed	2.1 Herd	Juvenile phase
		Adult productive phase
		Adult non-productive phase
	2.2 Grazing	% of nutrition from grazing
		Grazing type
		Grazing quality
	2.3 Feeds	Feed type

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		% of nutrition from feed type
		Dry matter intake
	2.4 Manure Management	Type of manure management
		% of manure processed
		Days per year
3 Energy	3.1 Energy use	Energy source
		Energy used
		Category of energy use
	3.2 Water waste	Waste water volume
		Oxygen demand
		Type of oxygen demand
		Water treatment type
4 Transport	Type of transport	
	Weight	
	Distance	

STRUCTURE OF THE BIODIVERSITY QUESTIONNAIRE

Farmed Products	
Question / factor	**Answer**
1.1. How many different crops do you grow?	
I have 1-3 types of crop	a
I have 4-6 types of crop	b
I have more than 7 types of crop	c
I do not grow any crops	d
I grow at least one rare or heritage type of crop, namely…	e
1.2. Do you grow more than 1 variety of any of your crops?	
No, always 1 variety of each crop	a
Yes, for 1-2 of my crops I grow more than one variety	b
Yes, for at least 3 of my crops I grow more than one variety	c
Yes, for at least 1 of my crops I grow 4 or more varieties	d
1.3. Do you have any grassland? (at least 0.5Ha, including temporary grassland or leys, excluding grass margins)	
Yes, almost entirely perennial ryegrass	a
Yes, mixed grasses and less than 75% perennial ryegrass	b
Yes, grassland which includes clover and/or field flowers	c
No, I have no grassland	d
1.4. What farm livestock do you keep?	
I have one species of livestock	a
I have 2-3 species of livestock	b
I have 4 or more species of livestock	c
I have no livestock	d
1.5. Do you keep more than one breed - or crossbreeds or rare breeds - of any of your livestock?	
No, always just 1 breed per livestock species	a
Yes, for one species of livestock I keep several breeds	b
Yes, for 2-3 species of livestock I keep several breeds	c
Yes, for 4 or more species of livestock I have several breeds	d
I keep at least one rare breed of livestock, namely…	e

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I have a crossbreed or hybrid variety of livestock from 2 breeds	f
Farming Practices	
Question / factor	**Answer**
2.1. What type of crop protection products do you use?	
I use chemical crop protection products, including those approved for organic systems	a
I do not use any chemical crop protection products, either conventional or organic	b
2.2. What good practices do you use when applying crop protection products?	
I aim to reduce my use of pesticides to protect wildlife	a
I use GPS for precision spraying	b
I use specific technologies to reduce pesticide drift (such as low drift nozzles, or an air-assisted or wing sprayer)	c
I sometimes or always replace conventional crop protection products with biological pest control, UV light or crop protection products certified under organic agriculture	d
None of the above	e
2.3. What do you target with crop protection chemicals? (*fill-in the section selected*)	
Insect pests (*fill-in 2.4*)	a
Fungi and diseases (*fill-in 2.5*)	b
Nematodes (*fill-in 2.6*)	c
Weeds (*fill-in 2.7*)	d
Potato haulms (*fill-in 2.8*)	e
Other targets, namely...	f
2.4. What good practices do you use when controlling pest insects?	
I never spray preventatively. I base my decision to spray on thresholds for observed damage in the field	a
I never spray preventatively. I base my decision to spray on the number of pest insects, either measured in the field or based on a decision support system	b
I only spray affected areas	c
I target my spraying on pest insect species only, avoiding beneficial insects (predators or pollinators)	d
I choose selective crop protection products to spare beneficial insects	e
I have semi-natural habitats located near crops, so beneficial insects can help with pest control	f
None of the above	g
2.5. What good practices do you use when controlling fungi or other diseases?	
Where relevant to the crop, I do not leave crop residues in such a way fungi can develop	a
I make use of decision support systems for fungal diseases	b
None of the above	c
2.6. What good practices do you use when controlling nematodes?	
I consider the risk of nematode infestation when selecting crop varieties and planning crop rotations	a
I use a non-chemical method of soil treatment against nematodes (e.g. covering, compaction or flooding to create anaerobic conditions)	b
I only treat nematodes where they occur within fields or rows	c
I look for the risk of nematodes and check for infestation using soil analysis or a decision support system	d
I base my decision for treatment on a nematodes advisory programme	e
I treat soils using granulates rather than sprays	f
None of the above	g
2.7. What good practices do you use when controlling weeds?	
I use a band sprayer instead of broadcast or full-field spraying	a
I identify weed species and select the most effective crop protection product against these species	b
I practice mechanical weed control	c
I control weeds manually or using a hand-held sprayer	d

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None of the above	e
2.8. What good practices do you use when destroying potato haulms?	
Mechanical haulm destruction	a
Defoliation of potato plants by flame weeder	b
None of the above	c
2.9. What good practices do you use to improve soil health in crop fields?	
Include legumes or grass-clover in the crop rotation	a
Grow cover crops	b
Grow mixtures of at least 3 species of cover crop	c
Keep soil covered between the main crops by growing cereal, grass or cover crops	d
The main method of cultivation is shallow tillage (non-inversion)	e
The main method of cultivation is no-tillage	f
The main method of cultivation is conventional tillage (soil inversion)	g
None of the above	h
2.10. What good practices do you use to improve soil health in grassland fields?	
Soil and grass root stock left intact for more than 10 years (no cultivation and re-seeding) on up to half the farm	a
Soil and grass root stock left intact for more than 10 years (no cultivation and re-seeding) on over half the farm	b
Soil and grass root stock never left intact for more than 10 years	c
Livestock grazed and manure retained on the land (avoiding soil compaction, poaching and runoff)	d
None of the above	e
2.11. What measures do you take to provide flower resources in your productive fields (excluding non-productive areas such as field margins, scored as 'small habitats')?	
One or more flowering crop such as peas, clover or herbs are grown	a
Cover crops are allowed to flower	b
None of the above	c
2.12. Do you add organic matter to your fields?	
Solid manure	a
Compost	b
Straw or crop residues are not removed from the field	c
Cut grass/grass-clover mix is incorporated into the soil	d
Organic fertilizers (including manure or compost) are only added in response to demand for nutrients such as nitrogen or phosphorus, quantified as part of a nutrient management plan.	e
None of the above	f
2.13. Do you grow cereal crops?	
No	a
Yes (*fill in 2.14*)	b
2.14. What wildlife-friendly measures do you carry out in all or part of your cereal fields?	
I do not carry out mechanical or chemical weed control during the cropping period	a
I leave the stubble in the field over winter until the next spring	b
I leave an area of the field unharvested to provide food (seed) for animals	c
I leave areas of the field cultivated, but unsown, to support ground-nesting birds such as lapwing and skylark	d
Bird nests are marked or protected to prevent damage by machinery	e
None of the above	f
2.15. What wildlife-friendly measures do you carry out in all or part of your grass fields?	
Slurry and mineral fertiliser are not used	a
Bird nests are marked or protected to prevent damage or trampling by livestock	b
Extensive grazing only (no more than 2 livestock units/ha at any time)	c
Mowing and grazing delayed until at least 1 June on at least 1 ha	d
Strips at least 6 m wide are left unmown as refuge areas	e
None of the above	f

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Small Habitats	
Question / factor	**Answer**
3.1. Do you have areas of grass and flowering plants that are not for production?	
Yes, verges along roads or tracks	a
Yes, field corners	b
Yes, field margins or areas left uncultivated, with naturally occurring grasses and flowering plants	c
Yes, field margins or areas cultivated annually to encourage annual flowering plants and grasses (annual flowering plants could be sown)	d
Yes, field margins or areas sown with perennial flowering seed mixes (nectar and pollen for beneficial insects)	e
Yes, field margins or areas sown with perennial grasses	f
Yes, sown with seed-rich plants as food and cover for birds	g
No, none of the above	h
3.2. What management do you carry out in perennial grassy or flower-rich areas (not suitable for annual flowers or wild bird mixes)?	
Grassy or flower-rich areas are mown only between mid-July and September	a
Grassy or flower-rich areas are mown in phases, so there is always some longer vegetation available	b
If mown, cuttings are removed	c
Grassy or flower-rich areas are grazed, but not between March and June	d
None of the above	e
3.3. Do you have hedgerows?	
I have hedgerows	a
Hedgerows are pruned no more than once every 3 years (or every 2 years during dormancy), with gaps filled by re-planting or laying	b
I have no hedgerows	c
3.4. Do you have small patches of woodland or trees?	
Yes, solitary trees or widely spaced avenues of trees	a
Yes, small areas (less than 1 ha) of forest, including coppice and short shrub trees	b
Yes, traditional orchard	c
None of the above	d
3.5. What wildlife-friendly management measures do you carry out along water courses?	
I have water courses, including rivers, streams or ditches. Please enter the number of ha or length and average width from outer edges of banks	a
Bank vegetation is mown after 1 June, at least every two years but no more than twice a year	b
When mowing banks, some vegetation left standing or banks are mown in phases	c
If next to a productive crop or grass field, water course is buffered with a woody or grass margin	d
If water courses are open field drains, they are regularly cleared (plant growth in water removed every 1-3 years)	e
Dredged material and bank cuttings are removed promptly	f
I have no water courses	g
3.6. What wildlife-friendly management do you carry out in pools and ponds on your land (including in your farmyard)?	
I have pools and ponds (enter number of ha or length and width)	a
Pool/pond bank vegetation is mown once every 1-2 years.	b
When mowing, some patches of vegetation are left standing	c
Plants are cleared from the water every 1-3 years	d
Bank cuttings and cleared aquatic plants are promptly removed	e
Pools or ponds are dredged once or twice every 5 years, and dredged material is removed	f
Trees and shrubs on the banks are regularly pruned, pollarded or coppiced to prevent shading	g
I have no pools and ponds	h
3.7. What wildlife habitats do you provide in and around your farm buildings?	

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Three or more nest boxes for songbirds	a
One or more nest box for owls or birds of prey, such as kestrels	b
Farm buildings are accessible for swallows, birds and bats	c
Nesting opportunities for wasps and bees (e.g. blocks of wood, piles of sand, brick walls)	d
Pile of dead wood (sticks or logs), or wattle fencing	e
Pile of stones	f
Grass snake brood pile	g
Bat box or other bat shelter	h
Straw or grass cuttings collected in piles, in the farmyard or in a field margin	i
None of the above	l
Large Habitats	
Question / factor	**Answer**
4.1. Do you own or manage larger areas (at least 1 ha) of natural habitat that are designated or managed solely for nature conservation?	
Yes, natural grassland or heathland (do not include areas of grass and flowering plants recorded as small natural habitats in a previous question)	a
Yes, wetland (bog, mire, marsh, reed bed or open water)	b
Yes, forest	c
Some natural habitats on the farm are designated as protected areas, nationally or internationally (includes Natura 2000 sites, Special Areas of Conservation)	d
No, none of the above	e
4.2. How would you describe the landscape surrounding your farm?	
A diverse landscape, with small fields, traditional farming practices and frequent patches of natural habitat	a
An intermediate landscape, with a mix of traditional and modern farming practices and some patches of natural habitat	b
A landscape dedicated to modern, technological food production, with large, productive fields and little natural habitat	c

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ANNEX II: STRUCTURE OF SMART

Section	Subsection	Factor (|Table column|)
01.02: General Information	01.02.03: Farm Data	01.02.03.04: Hectares of arable land
01.02: General Information	01.02.03: Farm Data	01.02.03.05: Hectares of permanent grassland
01.02: General Information	01.02.03: Farm Data	01.02.03.06: Hectares of temporary grassland
01.02: General Information	01.02.03: Farm Data	01.02.03.08: Hectares of permanent crops
01.02: General Information	01.02.03: Farm Data	01.02.03.09: Hectares of agroforestry area
01.02: General Information	01.02.03: Farm Data	01.02.03.10: Hectares of woodland
01.02: General Information	01.02.03: Farm Data	01.02.03.16: Hectares of total farm area
01.02: General Information	01.02.03: Farm Data	01.02.03.17: Yearly water consumption
01.02: General Information	01.02.03: Farm Data	01.02.03.18: Yearly water consumption for irrigation
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.1: Loose housing system
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.10: Light in livestock housing
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.11: Technical noise in livestock housing
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.12: Maternity pen
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.13: Quarantine space (pens) for sick animals
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.14: Pig keeping: quarantine section
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.15: Injuries of pigs
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.16: Protection from heat and cold for animals
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.17: Poultry: cover of vegetation at open air access
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.18: Condition of farm infrastructure
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.2 : Stocking density
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.4 : Materials to keep animals busy
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.5 : Hardness of the lying area
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.6 : Size of the lying area
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.7 : Cleanness of livestock / housing
01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.8 : Air quality in livestock housing

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01.03: Tour Of Farm Page	01.03.01: Livestock Housing & Welfare	01.03.01.9 : Number and quality of drinking points
01.03: Tour Of Farm Page	01.03.02: On Farm Mechanization	01.03.02.2 : Mechanization: Milking
01.03: Tour Of Farm Page	01.03.02: On Farm Mechanization	01.03.02.3 : Mechanization: Feeding roughage
01.03: Tour Of Farm Page	01.03.02: On Farm Mechanization	01.03.02.4 : Mechanization: Feeding concentrated fodder
01.03: Tour Of Farm Page	01.03.02: On Farm Mechanization	01.03.02.5 : Mechanization: Mucking out
01.03: Tour Of Farm Page	01.03.02: On Farm Mechanization	01.03.02.6 : Mechanization: harvesting
01.03: Tour Of Farm Page	01.03.03: Emissions and Storage	01.03.03.1 : Contamination through emissions: exhaust emissions, factories or airports
01.03: Tour Of Farm Page	01.03.03: Emissions and Storage	01.03.03.2 : Covered slurry stores (or stable natural crust)
01.03: Tour Of Farm Page	01.03.03: Emissions and Storage	01.03.03.3 : On farm point sources of nutrients and pollutants
01.03: Tour Of Farm Page	01.03.03: Emissions and Storage	01.03.03.4 : Distance manure heap to waters
01.03: Tour Of Farm Page	01.03.03: Emissions and Storage	01.03.03.5 : Storage of other hazardous substances
01.03: Tour Of Farm Page	01.03.03: Emissions and Storage	01.03.03.6 : Silage storage
01.03: Tour Of Farm Page	01.03.03: Emissions and Storage	01.03.03.7 : Storage of feed concentrate
01.04: Crop Production	<no subsection>	Table: Crops | Column: Area |
01.04: Crop Production	<no subsection>	Table: Crops | Column: Average regional yields (farmer's estimation)
01.04: Crop Production	<no subsection>	Table: Crops | Column: Crop selection |
01.04: Crop Production	<no subsection>	Table: Crops | Column: Erosion Measure |
01.04: Crop Production	<no subsection>	Table: Crops | Column: Fungicides Share |
01.04: Crop Production	<no subsection>	Table: Crops | Column: Herbicides Share |
01.04: Crop Production	<no subsection>	Table: Crops | Column: Insecticides Share |
01.04: Crop Production	<no subsection>	Table: Crops | Column: Intercrops share
01.04: Crop Production	<no subsection>	Table: Crops | Column: Legumes Share |
01.04: Crop Production	<no subsection>	Table: Crops | Column: On farm crop yield (farmer's estimation)|
01.04: Crop Production	<no subsection>	Table: Crops | | Column: Share of farm income higher than 10%
01.04: Crop Production	<no subsection>	Table: Crops | Column: Yield losses over the past 5 years |
01.04: Crop Production	01.04.01: Farm Areas	01.04.01.1: Land ownership

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01.04: Crop Production	01.04.01: Farm Areas	01.04.01.10: Agroforestry systems: Number of sold products.
01.04: Crop Production	01.04.01: Farm Areas	01.04.01.11: Agroforestry systems: Number of layers
01.04: Crop Production	01.04.01: Farm Areas	01.04.01.12: Agroforestry systems: Share of native tree species
01.04: Crop Production	01.04.01: Farm Areas	01.04.01.15: Share green cover on perennial crop land
01.04: Crop Production	01.04.01: Farm Areas	01.04.01.5 : Arable land: Gradients > 15 %
01.04: Crop Production	01.04.01: Farm Areas	01.04.01.7 : Woodlands: Deforestation
01.04: Crop Production	01.04.01: Farm Areas	01.04.01.8 : Woodlands: Method of deforestation
01.04: Crop Production	01.04.01: Farm Areas	01.04.02.14: Number of plots
01.04: Crop Production	01.04.02: Grasslands	01.04.02.05: Size of the drained permanent grassland area on peatland
01.04: Crop Production	01.04.02: Grasslands	01.04.02.05: Size of the undrained permanent grassland area on peatland
01.04: Crop Production	01.04.02: Grasslands	01.04.02.06: Area of waterlogged permanent grassland which is not on moorland
01.04: Crop Production	01.04.02: Grasslands	01.04.02.1: Permanent grasslands: Mowing frequency
01.04: Crop Production	01.04.02: Grasslands	01.04.02.2: Permanent grasslands Extensively managed
01.04: Crop Production	01.04.02: Grasslands	01.04.02.3: Permanent grasslands: Conversion
01.04: Crop Production	01.04.02: Grasslands	01.04.02.4: Permanent grasslands: Renewal
01.04: Crop Production	01.04.03: Crop Rotation	01.04.03.1: Number of elements in crop rotation
01.04: Crop Production	01.04.03: Crop Rotation	01.04.03.10: Humus Formation: Catch Crops
01.04: Crop Production	01.04.03: Crop Rotation	01.04.03.11: Arable land: Share of green cover outside growing period
01.04: Crop Production	01.04.03: Crop Rotation	01.04.03.12: Rare or endangered agricultural crops
01.04: Crop Production	01.04.03: Crop Rotation	01.04.03.13: Hybrid cultivars
01.04: Crop Production	01.04.03: Crop Rotation	01.04.03.14: Use of GMO crops
01.04: Crop Production	01.04.03: Crop Rotation	01.04.03.15: Crop resistance
01.04: Crop Production	01.04.03: Crop Rotation	01.04.03.2: Number of perennial crops
01.04: Crop Production	01.04.03: Crop Rotation	01.04.03.3: Weed management
01.04: Crop Production	01.04.03: Crop Rotation	01.04.03.6 : Use of clean planting materials
01.04:	01.04.03:	01.04.03.7:

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Crop Production	Crop Rotation	Production of bioenergy crops
01.04: Crop Production	01.04.04: Soil Management	01.04.04.1: Agricultural area: Share of mulching
01.04: Crop Production	01.04.04: Soil Management	01.04.04.10: Arable land: Green cover > 30 %
01.04: Crop Production	01.04.04: Soil Management	01.04.04.11: Soil degradation: Measures taken to counter
01.04: Crop Production	01.04.04: Soil Management	01.04.04.12: Soil degradation: Severe soil compaction
01.04: Crop Production	01.04.04: Soil Management	01.04.04.13: Soil degradation: Compaction due to heavy machinery
01.04: Crop Production	01.04.04: Soil Management	01.04.04.14: Plough less soil management
01.04: Crop Production	01.04.04: Soil Management	01.04.04.15: Steaming on open ground
01.04: Crop Production	01.04.04: Soil Management	01.04.04.16: Steaming in the greenhouse
01.04: Crop Production	01.04.04: Soil Management	01.04.04.17: Soil disinfection
01.04: Crop Production	01.04.04: Soil Management	01.04.04.18: Size of the drained arable land area on peatland
01.04: Crop Production	01.04.04: Soil Management	01.04.04.19: Size of the agricultural area (without permanent grassland) on peatland
01.04: Crop Production	01.04.04: Soil Management	01.04.04.2 : Humus Formation: Crop residues
01.04: Crop Production	01.04.04: Soil Management	01.04.04.21: Size of the agricultural area (without permanent grassland; excl. peatland) which is waterlogged.
01.04: Crop Production	01.04.04: Soil Management	01.04.04.22: Landslides and mudslides on agricultural area
01.04: Crop Production	01.04.04: Soil Management	01.04.04.23: Humus Formation: Humus balance
01.04: Crop Production	01.04.04: Soil Management	01.04.04.24: Substrate (Soilless) production
01.04: Crop Production	01.04.04: Soil Management	01.04.04.25: Use of synthetic aggregates for soil and substrate
01.04: Crop Production	01.04.04: Soil Management	01.04.04.26: Utilization of peat
01.04: Crop Production	01.04.04: Soil Management	01.04.04.3: Arable land: Share of direct seeding
01.04: Crop Production	01.04.04: Soil Management	01.04.04.4: Arable land: Under sown crops
01.04: Crop Production	01.04.04: Soil Management	01.04.04.5: Soil degradation: Share of agricultural area
01.04: Crop Production	01.04.04: Soil Management	01.04.04.6: Soil improvement
01.04: Crop Production	01.04.04: Soil Management	01.04.04.8: Arable land: Erosion control > 15 %
01.04: Crop Production	01.04.05: Water Management	01.04.05.1: Information on water availability
01.04: Crop Production	01.04.05: Water Management	01.04.05.10: Use of rainwater

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01.04: Crop Production	01.04.05: Water Management	01.04.05.11: Soil water harvesting
01.04: Crop Production	01.04.05: Water Management	01.04.05.12: Irrigation: Precipitation measurement
01.04: Crop Production	01.04.05: Water Management	01.04.05.13: Water use efficiency
01.04: Crop Production	01.04.05: Water Management	01.04.05.14: Water saving cleaning: Harvested products
01.04: Crop Production	01.04.05: Water Management	01.04.05.15: Waste water: Reuse
01.04: Crop Production	01.04.05: Water Management	01.04.05.16: Waste water: Disposal
01.04: Crop Production	01.04.05: Water Management	01.04.05.17: Water storage capacity
01.04: Crop Production	01.04.05: Water Management	01.04.05.2 : Information on water quality
01.04: Crop Production	01.04.05: Water Management	01.04.05.5 : Use of non renewable (fossil) water resources
01.04: Crop Production	01.04.05: Water Management	01.04.05.8 : Irrigation: Low energy technology and pumps
01.04: Crop Production	01.04.06: Fertilisation	01.04.06.05: Ha Fertilised with mineral and organic fertilisers
01.04: Crop Production	01.04.06: Fertilisation	01.04.06.10: Soil analyses for heavy metals
01.04: Crop Production	01.04.06: Fertilisation	01.04.06.11: Mineral K fertilizers
01.04: Crop Production	01.04.06: Fertilisation	01.04.06.15: Slurry application with drag hose system or by injection
01.04: Crop Production	01.04.06: Fertilisation	01.04.06.16: Measures to prevent pathogen contamination of vegetables
01.04: Crop Production	01.04.06: Fertilisation	01.04.06.17: Precise fertilisation
01.04: Crop Production	01.04.06: Fertilisation	01.04.06.6 : Antibiotics from livestock in fertilizers
01.04: Crop Production	01.04.06: Fertilisation	01.04.06.7 : Heavy Metals, Compost, Sewage, Sludge
01.04: Crop Production	01.04.06: Fertilisation	01.04.06.8 : Harmful substances P fertilisers
01.04: Crop Production	01.04.06: Fertilisation	01.04.06.9 : Determining fertilizer requirements
01.04: Crop Production	01.04.06: Fertilisation	Table: Mineral Fertilizer | Column: Amount |
01.04: Crop Production	01.04.06: Fertilisation	Table: Mineral Fertilizer | Column: Fertilizer selection |
01.04: Crop Production	01.04.06: Fertilisation	Table: Organic Fertilizers | Column: Amount imported on farm |
01.04: Crop Production	01.04.06: Fertilisation	Table: Organic Fertilizers | Column: Amount spread on farm |
01.04: Crop Production	01.04.06: Fertilisation	Table: Organic Fertilizers | Column: Dry matter |
01.04:	01.04.06:	Table:

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Crop Production	Fertilisation	Organic Fertilizers | Column: N content |
01.04: Crop Production	01.04.06: Fertilisation	Table: Organic Fertilizers | Column: Organic Fertilizer selection |
01.04: Crop Production	01.04.06: Fertilisation	Table: Organic Fertilizers | Column: P content |
01.04: Crop Production	01.04.07: Plant Protection Products	01.04.07.2 : Pesticides: Knowledge about active substances
01.04: Crop Production	01.04.07: Plant Protection Products	01.04.07.3 : Growth regulation
01.04: Crop Production	01.04.07: Plant Protection Products	01.04.07.4 : Use of chem. synth. seed dressings
01.04: Crop Production	01.04.07: Plant Protection Products	01.04.07.5 : Flowering regulation
01.04: Crop Production	01.04.07: Plant Protection Products	Table: Pesticides | Column: Pesticides selection |
01.04: Crop Production	01.04.08: Biodiversity	01.04.08.01: Areas for biodiversity promotion on agricultural area
01.04: Crop Production	01.04.08: Biodiversity	01.04.08.02: Areas for biodiversity promotion off agricultural area
01.04: Crop Production	01.04.08: Biodiversity	01.04.08.4 : Ecological compensation areas: Valuable landscape elements Interconnection
01.04: Crop Production	01.04.08: Biodiversity	01.04.08.5 : Management of riparian strips
01.04: Crop Production	01.04.08: Biodiversity	01.04.08.6 : Promotion of beneficial organisms
01.04: Crop Production	01.04.09: Yields	01.04.09.1 : Yield tendency
01.04: Crop Production	01.04.09: Yields	01.04.09.4 : Yield decreases resulting from lack of water
01.05: Livestock Production	<no subsection>	Table: Livestock | Column: Livestock selection |
01.05: Livestock Production	<no subsection>	Table: Livestock | Column: Losses |
01.05: Livestock Production	<no subsection>	Table: Livestock | Column: Number |
01.05: Livestock Production	<no subsection>	Table: Livestock | Column: Share antibiotics treatment |
01.05: Livestock Production	<no subsection>	Table: Livestock | Column: Share dual purpose |
01.05: Livestock Production	<no subsection>	Table: Livestock | Column: Share prophylactic treatment |
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.1 : Locally adapted livestock breeds
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.10: Mutilation: Use of anaesthetics and analgesics
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.11: Waiting period for milk deliveries after usage of antibiotics
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.12: Use of antibiotic drying agents
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.13: Outdoor access for poultry: Hours per day
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.14: Average number of lactations

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01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.2 : Rare and endangered livestock breeds
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.3 : Hybrid livestock (poultry, pigs)
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.4 : Alpine pasturage and shepherding
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.5 : Daily outdoor access for animals
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.6 : Access to pasture: Months per year
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.7 : Outdoor access for pigs: Hours per day
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.8 : Share of dehorned ruminants
01.05: Livestock Production	01.05.01: Animal Welfare	01.05.01.9 : Poultry: Beak trimming
01.05: Livestock Production	01.05.01: Animal Welfare	01.14.15: Measures for hoof care
01.05: Livestock Production	01.05.01: Animal Welfare	01.14.16: Proportion of lameness animals
01.05: Livestock Production	01.05.01: Animal Welfare	01.14.17: Livestock health: Hormonal treatment for problems with livestock in heat
01.05: Livestock Production	01.05.01: Animal Welfare	01.14.18: Pigs: Docking/use of nose rings
01.05: Livestock Production	01.05.01: Animal Welfare	01.14.19: Buying new animals
01.05: Livestock Production	01.05.01: Animal Welfare	01.14.20: Polishing teeth of piglets
01.05: Livestock Production	01.05.01: Animal Welfare	01.14.21: Animal welfare standards slaughter
01.05: Livestock Production	01.05.01: Animal Welfare	01.14.22: Duration of transport to abattoir
01.05: Livestock Production	01.05.02: Feeding	01.05.02.1 : Proportion bought in roughage
01.05: Livestock Production	01.05.02: Feeding	01.05.02.2 : Bought in concentrated feed
01.05: Livestock Production	01.05.02: Feeding	01.05.02.3 : Feed No Food: grazing livestock
01.05: Livestock Production	01.05.02: Feeding	01.05.02.4 : Feed No Food: non grazing animals
01.05: Livestock Production	01.05.02: Feeding	01.05.02.5 : Use of GMO feedstuff
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.1 : Correct waste disposal
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.10: Waste disposal: cadaver livestock
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.11: Production materials: Use of problematic elements
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.12: Reusable packaging materials
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.13: Open burning of farm or household wastes and bushes
01.06:	01.06.01:	01.06.01.14:

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Materials & Energy	Waste Management	Biogas plant: share organic residues
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.15: Disposal of food losses or waste over the past five years
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.2 : Waste disposal: pesticides and veterinary medicines
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.3 : Recycling of paper/cardboards
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.4 : Recycling of waste oil
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.5 : Recycling of used tyres
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.6 : Recycling of used batteries
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.7 : Recycling of plastic waste
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.8 : Recycling of metal waste
01.06: Materials & Energy	01.06.01: Waste Management	01.06.01.9 : Recycling of waste glass
01.06: Materials & Energy	01.06.02: Energy Management	01.06.02.2: Renewables electricity
01.06: Materials & Energy	01.06.02: Energy Management	01.06.02.3 : Settings of combustion motors
01.06: Materials & Energy	01.06.02: Energy Management	01.06.02.5 : Energy efficient driving (EcoDrive)
01.06: Materials & Energy	01.06.02: Energy Management	01.06.02.6 : Plants for energy production instead of human consumption
01.06: Materials & Energy	01.06.02: Energy Management	01.06.02.7 : Insulation of heated farm buildings
01.06: Materials & Energy	01.06.02: Energy Management	01.06.02.8 : Isolation of heated greenhouses
01.06: Materials & Energy	01.06.02: Energy Management	01.06.02.9 : Heating need of plants
01.06: Materials & Energy	01.06.02: Energy Management	Table: Energy | Column: Amount |
01.06: Materials & Energy	01.06.02: Energy Management	Table: Energy | Column: Share own production |
01.07: Inputs & Suppliers	01.07.01: Local Procurement	01.07.01.6 : Local procurement: strategy
01.07: Inputs & Suppliers	01.07.01: Local Procurement	Table: Externally Sourced Input | Column: Cost of input: | Of the inputs within this table, what are their costs?
01.07: Inputs & Suppliers	01.07.01: Local Procurement	Table: Externally Sourced Input | Column: External input selection based on environmental conditions |
01.07: Inputs & Suppliers	01.07.01: Local Procurement	Table: Externally Sourced Input | Column: External input selection based on social conditions |
01.07: Inputs & Suppliers	01.07.01: Local Procurement	Table: Externally Sourced Input | Column: Name of the social certificate of the external input |
01.07: Inputs & Suppliers	01.07.01: Local Procurement	Table:

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		Externally Sourced Input | Column: Point of origin: domestically (non locally) | (0%100%)
01.07: Inputs & Suppliers	01.07.01: Local Procurement	Table: Externally Sourced Input | Column: Point of origin: | Origin of input is known |
01.07: Inputs & Suppliers	01.07.01: Local Procurement	Table: Externally Sourced Input | Column: Point of Purchase: domestic (nonlocal) supplier | (0%100%)
01.07: Inputs & Suppliers	01.07.01: Local Procurement	Table: Externally Sourced Input | Column: Proportion Inputs Local Supplier
01.07: Inputs & Suppliers	01.07.01: Local Procurement	Table: Externally Sourced Input | Column: Proportion Locally Produced |
01.07: Inputs & Suppliers	01.07.03: Cooperation With Suppliers	01.07.03.1 : Quality of cooperation with suppliers
01.07: Inputs & Suppliers	01.07.03: Cooperation With Suppliers	01.07.03.2 : Secure supply of farm inputs
01.07: Inputs & Suppliers	01.07.03: Cooperation With Suppliers	01.07.03.3 : Farm inputs from countries with problematic social conditions
01.07: Inputs & Suppliers	01.07.03: Cooperation With Suppliers	01.07.03.4 : Forced labour at suppliers
01.07: Inputs & Suppliers	01.07.03: Cooperation With Suppliers	01.07.03.5 : Child labour at suppliers
01.08: Products & Sales	01.08.01: Sales	01.08.01.1 : Diversification of sales
01.08: Products & Sales	01.08.01: Sales	01.08.01.10: On farm processing
01.08: Products & Sales	01.08.01: Sales	01.08.01.11: Transparency of production
01.08: Products & Sales	01.08.01: Sales	01.08.01.12: Customer relationship
01.08: Products & Sales	01.08.01: Sales	01.08.01.2 : Dependency on main customer
01.08: Products & Sales	01.08.01: Sales	01.08.01.3 : Length of customer relationships
01.08: Products & Sales	01.08.01: Sales	01.08.01.4 : Proportion of environmentally certified products
01.08: Products & Sales	01.08.01: Sales	01.08.01.5 : Proportion of products meeting social standards
01.08: Products & Sales	01.08.01: Sales	01.08.01.6 : Direct sales
01.08: Products & Sales	01.08.01: Sales	01.08.01.7 : Collective marketing
01.08: Products & Sales	01.08.01: Sales	01.08.01.8 : Producer price vs. market price level
01.08: Products & Sales	01.08.01: Sales	01.08.01.9 : Availability of alternative markets
01.08: Products & Sales	01.08.02: Product Quality	01.08.02.1 : Harvesting methods
01.08: Products & Sales	01.08.02: Product Quality	01.08.02.2 : Storage facilities
01.08:	01.08.02:	01.08.02.3 :

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Products & Sales	Product Quality	Product returns
01.08: Products & Sales	01.08.02: Product Quality	01.08.02.4 : Food safety standard
01.08: Products & Sales	01.08.02: Product Quality	01.08.02.5 : Contaminated products
01.08: Products & Sales	01.08.02: Product Quality	01.08.02.6 : Complaints regarding exceeded cell counts
01.08: Products & Sales	01.08.02: Product Quality	01.08.02.7 : Cases of contamination: Measures
01.08: Products & Sales	01.08.02: Product Quality	01.08.02.8 : Residues of antibiotics in milk
01.08: Products & Sales	01.08.02: Product Quality	01.08.02.9 : Use of nanotechnology based products
01.09: Employees	<no subsection>	Table: Workers | Column: Actual weekly working hours |
01.09: Employees	<no subsection>	Table: Workers | Column: Agreed weekly working hours |
01.09: Employees	<no subsection>	Table: Workers | Column: Agreed working weeks |
01.09: Employees	<no subsection>	Table: Workers | Column: Compensation |
01.09: Employees	<no subsection>	Table: Workers | Column: Duration |
01.09: Employees	<no subsection>	Table: Workers | Column: Number of workers |
01.09: Employees	<no subsection>	Table: Workers | Column: Number of workers with financed training |
01.09: Employees	<no subsection>	Table: Workers | Column: Worker Category |
01.09: Employees	01.09.01: Staff	01.09.01.10: Guaranteed staff replacement: Farm succession
01.09: Employees	01.09.01: Staff	01.09.01.6 : Staff shortages
01.09: Employees	01.09.01: Staff	01.09.01.7 : Number of jobs created/removed
01.09: Employees	01.09.01: Staff	01.09.01.8 : Staff turnover
01.09: Employees	01.09.01: Staff	01.09.01.9 : Availability of adequate replacement of farm manager
01.09: Employees	01.09.02: Work Conditions	01.09.02.1 : Employees: Legally binding contracts
01.09: Employees	01.09.02: Work Conditions	01.09.02.10: Availability of regular meals, beverages and toilet facilities
01.09: Employees	01.09.02: Work Conditions	01.09.02.11: Employees: Regular breaks
01.09: Employees	01.09.02: Work Conditions	01.09.02.12: Employees: Incidences of harassment and mobbing
01.09: Employees	01.09.02: Work Conditions	01.09.02.14: Clear ownership rights / social protection for partners in the event of divorce / death
01.09: Employees	01.09.02: Work Conditions	01.09.02.15: Lowest wage paid on the farm

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01.09: Employees	01.09.02: Work Conditions	01.09.02.16: Forced labour at the farm
01.09: Employees	01.09.02: Work Conditions	01.09.02.17: Access to medical care
01.09: Employees	01.09.02: Work Conditions	01.09.02.18: Employees: Nutritional meals
01.09: Employees	01.09.02: Work Conditions	01.09.02.19: Household food security
01.09: Employees	01.09.02: Work Conditions	01.09.02.2 : Employees: Social protection
01.09: Employees	01.09.02: Work Conditions	01.09.02.20: Child labour: Impairment of school performance
01.09: Employees	01.09.02: Work Conditions	01.09.02.21: Child labour: Hazardous forms of work
01.09: Employees	01.09.02: Work Conditions	01.09.02.3 : Employees: Work permits
01.09: Employees	01.09.02: Work Conditions	01.09.02.4 : Employees: Freedom of assembly and collective bargaining rights
01.09: Employees	01.09.02: Work Conditions	01.09.02.5 : Employees: Freedom of joining unions
01.09: Employees	01.09.02: Work Conditions	01.09.02.7 : Instruction temporary workers/visitors in handling animals
01.09: Employees	01.09.02: Work Conditions	01.09.02.8 : Employees: Overtime compensation
01.09: Employees	01.09.02: Work Conditions	01.09.02.9 : Work Life Balance family workers (holiday)
01.09: Employees	01.09.03: Employee Safety	01.09.03.1 : Systematic identification of potential safety hazards
01.09: Employees	01.09.03: Employee Safety	01.09.03.2 : Employees: Use of protective gear
01.09: Employees	01.09.03: Employee Safety	01.09.03.3 : Technical noise in production
01.09: Employees	01.09.03: Employee Safety	01.09.03.4 : Certification for the use of plant protection and animal treatment products
01.09: Employees	01.09.03: Employee Safety	01.09.03.5 : Employees: Training for use of plant protection and animal treatment products
01.09: Employees	01.09.03: Employee Safety	01.09.03.6 : Days of absence due to occupational injuries and work related illnesses
01.09: Employees	01.09.03: Employee Safety	01.09.03.7 : Management system for workplace safety and health
01.09: Employees	01.09.04: Equality	01.09.04.1 : Antidiscrimination measures
01.09: Employees	01.09.04: Equality	01.09.04.2 : Proactive support of disadvantaged groups
01.09: Employees	01.09.04: Equality	01.09.04.3 : Commitment against discrimination
01.09: Employees	01.09.04: Equality	01.09.04.4 : Equal pay
01.09:	01.09.04:	01.09.04.5 :

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Employees	Equality	Disabled employees/inhabitants
01.09: Employees	01.09.05: Training	01.09.05.2 : Training on sustainability
01.09: Employees	01.09.05: Training	01.09.05.6 : Access to advisory services
01.10: Social Responsibility	01.10.01: Conflicts	01.10.01.1 : Cooperation with other farms
01.10: Social Responsibility	01.10.01: Conflicts	01.10.01.10: Infringements of the law
01.10: Social Responsibility	01.10.01: Conflicts	01.10.01.11: Recognition/payment for traditional or indigenous knowledge
01.10: Social Responsibility	01.10.01: Conflicts	01.10.01.2 : Prevention of resource conflicts
01.10: Social Responsibility	01.10.01: Conflicts	01.10.01.3 : Communication with stakeholder groups
01.10: Social Responsibility	01.10.01: Conflicts	01.10.01.4 : Negative social/environmental impacts
01.10: Social Responsibility	01.10.01: Conflicts	01.10.01.5 : Food security measures for local communities
01.10: Social Responsibility	01.10.01: Conflicts	01.10.01.7 : Fair resolution of conflicts
01.10: Social Responsibility	01.10.01: Conflicts	01.10.01.8 : Conflicts over water quantity
01.10: Social Responsibility	01.10.01: Conflicts	01.10.01.9 : Conflicts over water quality
01.10: Social Responsibility	01.10.02: Participation	01.10.02.1 : Social involvement outside the farm: Costs
01.10: Social Responsibility	01.10.02: Participation	01.10.02.2 : Environmental involvement outside the farm: Costs
01.10: Social Responsibility	01.10.02: Participation	01.10.02.3 : Involvement in improving laws and regulations
01.10: Social Responsibility	01.10.02: Participation	01.10.02.4 : Public health measures
01.10: Social Responsibility	01.10.02: Participation	01.10.02.5 : Dispossession of smallholders / local communities
01.10: Social Responsibility	01.10.02: Participation	01.10.02.6 : Subsistence farming
01.10: Social Responsibility	01.10.03: Sustainability Management	01.10.03.1 : Written commitment to sustainability
01.10: Social Responsibility	01.10.03: Sustainability Management	01.10.03.2 : Publication of written commitment to sustainability
01.10: Social Responsibility	01.10.03: Sustainability Management	01.10.03.3 : Verbal commitment to sustainability
01.10: Social Responsibility	01.10.03: Sustainability Management	01.10.03.4 : Sustainability report (based on SAFA)
01.10: Social Responsibility	01.10.03: Sustainability Management	01.10.03.5 : Sustainability report publicly available
01.10: Social Responsibility	01.10.03: Sustainability Management	01.10.03.6 : Explicit sustainability plan
01.10: Social Responsibility	01.10.03: Sustainability Management	01.10.03.7 : Oral information sustainability improvements
01.11: Financial Management	01.11.01: Risk Management	01.11.01.1 : Market challenges

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01.11: Financial Management	01.11.01: Risk Management	01.11.01.2 : Political / Policy challenges
01.11: Financial Management	01.11.01: Risk Management	01.11.01.3 : Knowledge of climate change problems
01.11: Financial Management	01.11.01: Risk Management	01.11.01.4 : Climate change adaptation measures
01.11: Financial Management	01.11.01: Risk Management	01.11.01.5 : Insurance: Fire
01.11: Financial Management	01.11.01: Risk Management	01.11.01.6 : Insurance: Natural disasters
01.11: Financial Management	01.11.02: Accounting	01.11.02.1 : Professional agricultural accounts
01.11: Financial Management	01.11.02: Accounting	01.11.02.2 : Consideration of external environmental and social costs in the accounting procedure
01.11: Financial Management	01.11.02: Accounting	01.11.02.3 : Profit stability
01.11: Financial Management	01.11.02: Accounting	01.11.02.4 : Long term investments
01.11: Financial Management	01.11.02: Accounting	01.11.02.5 : Farm net income
01.11: Financial Management	01.11.02: Accounting	01.11.02.6 : Diversification of income
01.11: Financial Management	01.11.03: Credit	01.11.03.1 : Debt
01.11: Financial Management	01.11.03: Credit	01.11.03.2 : Farm savings
01.11: Financial Management	01.11.03: Credit	01.11.03.3 : Access to Credit
01.11: Financial Management	01.11.03: Credit	01.11.03.4 : Problems with loan providers
01.11: Financial Management	01.11.03: Credit	01.11.03.5 : Cooperation with ethical financial institutions

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ANNEX III: STRUCTURE OF COMPAS

Wholefarm	Farm workers	Labour input (AWU) and work allocation to farm enterprises (sheet 0001)
Wholefarm	Farm workers	Yearly salary (sheet 0001)
Wholefarm	Tractors	Costs [Depreciation, maintenance and assurance costs of machinery/equipment, fuel costs (sheet 0008) OR detailed information in 0004]
Wholefarm	Machinery	Costs [Depreciation, maintenance and assurance costs of machinery/equipment, fuel costs (sheet 0008) OR detailed information in 0005]
Wholefarm	Farm buildings	Costs [Depreciation, maintenance and assurance costs of farm buildings (sheet 0008) OR detailed information in 0007]
Wholefarm	Operating facilities/Installations	Costs [Depreciation, maintenance and assurance costs of operating facilities/installations (sheet 0008) OR detailed information in 0006]
Wholefarm	Subsidies/Payments	Direct payments (total)
Wholefarm	Subsidies/Payments	Basic premium
Wholefarm	Subsidies/Payments	Greening premium
Wholefarm	Subsidies/Payments	Redistribution premium
Wholefarm	Subsidies/Payments	Young farmer premium
Wholefarm	Subsidies/Payments	Investment grants
Wholefarm	Subsidies/Payments	Agricultural diesel refunds
Wholefarm	Subsidies/Payments	Other grants for plant products
Wholefarm	Subsidies/Payments	Other grants for animal productions
Wholefarm	Subsidies/Payments	Other operating grants
Wholefarm	Subsidies/Payments	Area payments for organic farming
Wholefarm	Subsidies/Payments	Payments for agri-environmental measure 1
Wholefarm	Subsidies/Payments	Payments for agri-environmental measure 2
Wholefarm	Subsidies/Payments	Payments for agri-environmental measure 3
Wholefarm	Subsidies/Payments	Compensatory payments for environmental requirements
Wholefarm	Subsidies/Payments	Other environmental-related payments
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	General cost of materials: Heating material (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	General cost of materials: Electricity (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	General cost of materials: Water, waste water (without irrigation) (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	General cost of materials: Diesel fuels (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	General cost of materials: Other fuels and lubricants (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	General cost of materials: Contract work and machine rental (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Assurance: Building insurances (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Assurance: Motor vehicle insurances (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Assurance: Hail insurance (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Assurance: Animal insurances (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Assurance: Liability insurance (yearly costs)

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Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Assurance: Other insurances (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Other operating expenses: Soil analyses (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Other operating expenses: Lease expenditure for agricultural land (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Other operating expenses: Advisory costs (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Other operating expenses: Certification costs (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Other operating expenses: Accounting or office costs (yearly costs)
Wholefarm	Overhead costs (material, depreciation, maintenance & reparations, assurance)	Other operating expenses: Other costs (yearly costs)
Crop	Yield, area and revenues	Area (ha)
Crop	Yield, area and revenues	Yield (t or t/ha)
Crop	Yield, area and revenues	Sold product (t)
Crop	Yield, area and revenues	Sold product (EUR/t)
Crop	Yield, area and revenues	Sold seeds (t)
Crop	Yield, area and revenues	Sold seeds (EUR/t)
Crop	Yield, area and revenues	Own use feedstuff (t)
Crop	Yield, area and revenues	Own use energy (t)
Crop	Yield, area and revenues	Revenues due to selling other products (EUR/ha)
Crop	Seed costs	Seeds costs (EUR/ha or EUR/year)
Crop	Seed costs	Re-seeding fees (EUR/ha)
Crop	Seed costs	Seeds for intercrops (EUR/ha or EUR/year)
Crop	Variable costs	Mineral fertiliser (EUR/ha or EUR/year)
Crop	Variable costs	Organic fertiliser (EUR/ha or EUR/year)
Crop	Variable costs	Plant protection (EUR/ha or EUR/year)
Crop	Variable costs	Water (EUR/ha or EUR/year)
Crop	Variable costs	Assurance (EUR/ha or EUR/year)
Crop	Variable costs	Labour input (working hours/ha)
Crop	Variable costs	Diesel/fuel (l/ha)
Crop	Variable costs	Diesel/fuel (EUR/ha)
Crop	Variable costs	Machinery cost (EUR/ha or EUR/year)
Crop	Variable costs	Contract cost (EUR/ha or EUR/year)
Dairy	Production system (dairy)	Number dairy cows (Animal places)
Dairy	Production system (dairy)	Number heifers (Animal places)
Dairy	Production system (dairy)	Number calves (Animal places)
Dairy	Production system (dairy)	Number breeding bulls (Animal places)
Dairy	Production system (dairy)	Millk performance (kg/Yr)
Dairy	Production system (dairy)	Protein content (%)
Dairy	Production system (dairy)	Fat content (%)
Dairy	Production system (dairy)	Utlilisation period of breeding bulls (Yr)
Dairy	Production system (dairy)	Calving intervall (Days)
Dairy	Production system (dairy)	First calving age (Months)
Dairy	Production system (dairy)	Replacement rate (%)
Dairy	Production system (dairy)	Natal death rate (%)
Dairy	Production system (dairy)	Rearing losses (%)
Dairy	Revenues milk	Sold milk quantity (kg/Yr)
Dairy	Revenues milk	Revenues (dairy) (EUR/Yr)
Dairy	Revenues milk	Milk EUR (dairy) (ct/kg)
Dairy	Revenues milk	Milk quantity (on-farm processing) (kg/Yr)
Dairy	Revenues milk	Revenues (processing) (EUR/Yr)
Dairy	Revenues milk	Milk EUR (processing) (ct/kg)
Dairy	Revenues milk	Milk quantity (feeding calves) (kg/Yr)
Dairy	Revenues milk	Internal milk EUR (ct/kg)
Dairy	Revenues milk	Other milk revenues (EUR/Yr)
Dairy	Revenues calves	Calves born (Number)

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Dairy	Revenues calves	Calves sold (Number)
Dairy	Revenues calves	Calves used for breeding on the farm (Number)
Dairy	Revenues calves	Calves used for fattening on the farm (Number)
Dairy	Revenues calves	EUR calves (EUR/Head)
Dairy	Revenues cows	Sold culled stock (Head)
Dairy	Revenues cows	EUR (culled stock) (EUR/Head)
Dairy	Revenues cows	Sold breeding cattle (Number)
Dairy	Revenues cows	EUR (breeding cattle) (EUR/Head)
Dairy	Other revenues (dairy)	Revenues by-products (EUR/year)
Dairy	Costs (dairy)	Purchased dairy cows (Number)
Dairy	Costs (dairy)	Price dairy cow (EUR/Head)
Dairy	Costs (dairy)	Purchased dairy heifers (Number)
Dairy	Costs (dairy)	Price dairy heifer (EUR/Head)
Dairy	Costs (dairy)	Purchased dairy calves (Number)
Dairy	Costs (dairy)	Price dairy calf (EUR/Head)
Dairy	Costs (dairy)	Purchased breeding bulls (EUR/Head)
Dairy	Costs (dairy)	Price (breeding bulls) (Years)
Dairy	Other costs (dairy)	Insemination (EUR/Yr)
Dairy	Other costs (dairy)	Veterinary service (EUR/Yr)
Dairy	Other costs (dairy)	Medical products (EUR/Yr)
Dairy	Other costs (dairy)	Contract work (EUR/Yr)
Dairy	Other costs (dairy)	Pedigree records or milk recording (EUR/Yr)
Dairy	Other costs (dairy)	Animal insurances (EUR/Yr)
Dairy	Other costs (dairy)	Other (EUR/Yr)
Dairy	Feedingstuff	Own production (t/Yr)
Dairy	Feedingstuff	Bought-in (t/Yr)
Dairy	Feedingstuff	Price (EUR/t)
Dairy	Feedingstuff	Total cost (EUR/Yr)
Beef	Production system (beef)	Number calves (Animal places)
Beef	Production system (beef)	Number weaners (Animal places)
Beef	Production system (beef)	Number finishing cattle (Animal places)
Beef	Production system (beef)	Weight start (kg)
Beef	Production system (beef)	Weight end (kg)
Beef	Production system (beef)	Daily weight gain (g)
Beef	Production system (beef)	Slaughtered weight (kg)
Beef	Production system (beef)	Feeding period (weaner) (days)
Beef	Production system (beef)	Feeding period (finishing) (days)
Beef	Production system (beef)	Mortality (%)
Beef	Production system (beef)	Annual stocking rate (Animals per animal place)
Beef	Revenues finishing cattle	Carcass sold to slaughter (kg/Yr)
Beef	Revenues finishing cattle	Price (slaughter) (EUR/kg SW)
Beef	Revenues finishing cattle	Meat sold via direct marketing (kg/Yr)
Beef	Revenues finishing cattle	Price (direct marketing) (EUR/kg SW)
Beef	Revenues finishing cattle	Meat processed on-farm (kg/Yr)
Beef	Revenues finishing cattle	Own consumption (kg/Yr)
Beef	Revenues finishing cattle	Price (internal use) (EUR/kg SW)
Beef	Revenues finishing cattle	Other revenues (EUR/Yr)
Beef	Revenues Others	Revenues By-Products (EUR/Yr)
Beef	Costs of livestock changes	Purchased calves (Number)
Beef	Costs of livestock changes	Price calve (EUR/Head)
Beef	Costs of livestock changes	Purchased weaner (Number)
Beef	Costs of livestock changes	Price weaner (EUR/Head)
Beef	Other costs	Veterinary service (EUR/Yr)
Beef	Other costs	Medical products (EUR/Yr)
Beef	Other costs	Contract work (EUR/Yr)
Beef	Other costs	Fees (EUR/Yr)
Beef	Other costs	Animal insurances (EUR/Yr)
Beef	Other costs	Other (EUR/Yr)
Beef	Feedingstuff	Own production (t/Yr)
Beef	Feedingstuff	Bought-in (t/Yr)
Beef	Feedingstuff	Price (EUR/t)
Beef	Feedingstuff	Total cost (EUR/Yr)
Chicken (meat)	Production system (chicken/meat)	Number of birds (animal places)
Chicken (meat)	Production system (chicken/meat)	Fattening end weight (kg)
Chicken (meat)	Production system (chicken/meat)	Daily weight gain (g)

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Chicken (meat)	Production system (chicken/meat)	Fattening period (days)
Chicken (meat)	Production system (chicken/meat)	Mortality (%)
Chicken (meat)	Production system (chicken/meat)	Annual turnover rate (number per animal place)
Chicken (meat)	Revenues (chicken/meat)	Meat sold to slaughter (kg/Yr)
Chicken (meat)	Revenues (chicken/meat)	Price (EUR/kg slaughter weight)
Chicken (meat)	Revenues (chicken/meat)	Meat sold via direct marketing (kg/Yr)
Chicken (meat)	Revenues (chicken/meat)	Price (direct marketing) (EUR/kg SW)
Chicken (meat)	Revenues (chicken/meat)	Meat processed on-farm (kg/Yr)
Chicken (meat)	Revenues (chicken/meat)	Price (on-farm processing) (EUR/kg SW)
Chicken (meat)	Revenues (chicken/meat)	Revenues By-Products (EUR/Yr)
Chicken (meat)	Costs (chicken/meat)	Purchased chicks (Number)
Chicken (meat)	Costs (chicken/meat)	Price (EUR/chick)
Chicken (meat)	Other costs (chicken/meat)	Veterinary service (EUR/Yr)
Chicken (meat)	Other costs (chicken/meat)	Medical products (EUR/Yr)
Chicken (meat)	Other costs (chicken/meat)	Contract work (EUR/Yr)
Chicken (meat)	Other costs (chicken/meat)	Fees (EUR/Yr)
Chicken (meat)	Other costs (chicken/meat)	Animal insurances (EUR/Yr)
Chicken (meat)	Other costs (chicken/meat)	Other (EUR/Yr)
Chicken (meat)	Other costs (chicken/meat)	Insemination (EUR/Yr)
Chicken (meat)	Other costs (chicken/meat)	Littering material (EUR/Yr)
Chicken (meat)	Feeding stuff	Own production (t/Yr)
Chicken (meat)	Feeding stuff	Bought-in (t/Yr)
Chicken (meat)	Feeding stuff	Price (EUR/t)
Chicken (meat)	Feeding stuff	Total cost (EUR/Yr)
Chicken (egg)	Production system (chicken/egg)	Number of laying hens (animal places)
Chicken (egg)	Production system (chicken/egg)	Meat of laying hens used for human consumption (yes/no)
Chicken (egg)	Production system (chicken/egg)	Age of bought-in pullets (days)
Chicken (egg)	Production system (chicken/egg)	Laying period (days)
Chicken (egg)	Production system (chicken/egg)	Group size (number)
Chicken (egg)	Production system (chicken/egg)	Annual turnover rate (number per animal place)
Chicken (egg)	Production system (chicken/egg)	Mortality (%)
Chicken (egg)	Revenues Eggs	Number of Eggs per Year
Chicken (egg)	Revenues Eggs	Price (EUR/egg)
Chicken (egg)	Revenues Others	Revenues By-Products (EUR/Yr)
Chicken (egg)	Costs (chicken/egg)	Purchased pullets (Number)
Chicken (egg)	Costs (chicken/egg)	Price (EUR/pullet)
Chicken (egg)	Other costs (chicken/egg)	Veterinary service (EUR/Yr)
Chicken (egg)	Other costs (chicken/egg)	Medical products (EUR/Yr)
Chicken (egg)	Other costs (chicken/egg)	Contract work (EUR/Yr)
Chicken (egg)	Other costs (chicken/egg)	Fees (EUR/Yr)
Chicken (egg)	Other costs (chicken/egg)	Animal insurances (EUR/Yr)
Chicken (egg)	Other costs (chicken/egg)	Other (EUR/Yr)
Chicken (egg)	Other costs (chicken/egg)	Insemination (EUR/Yr)
Chicken (egg)	Other costs (chicken/egg)	Littering material (EUR/Yr)
Chicken (egg)	Feeding stuff	Own production (t/Yr)
Chicken (egg)	Feeding stuff	Bought-in (t/Yr)
Chicken (egg)	Feeding stuff	Price (EUR/t)
Chicken (egg)	Feeding stuff	Total cost (EUR/Yr)
Fattening pigs	Production system (fattening pigs)	Number fattening pigs (Animal places (AP))
Fattening pigs	Production system (fattening pigs)	Weight start (kg)
Fattening pigs	Production system (fattening pigs)	Weight end (kg)
Fattening pigs	Production system (fattening pigs)	Daily weight gain (g)
Fattening pigs	Production system (fattening pigs)	Fattening period (Days)
Fattening pigs	Production system (fattening pigs)	Losses (%)
Fattening pigs	Production system (fattening pigs)	Annual stocking rate (Number/AP)
Fattening pigs	Revenues (fattening pigs)	Meat sold to slaughter (kg/Yr)
Fattening pigs	Revenues (fattening pigs)	Price (slaughter) (EUR/kg SW)
Fattening pigs	Revenues (fattening pigs)	Meat sold via direct marketing (kg/Yr)
Fattening pigs	Revenues (fattening pigs)	Price (direct marketing) (EUR/kg SW)
Fattening pigs	Revenues (fattening pigs)	Meat processed on-farm (kg/Yr)
Fattening pigs	Revenues (fattening pigs)	Price (on-farm processing) (EUR/kg SW)
Fattening pigs	Revenues (fattening pigs)	Other revenues (EUR/Yr)
Fattening pigs	Costs (fattening pigs)	Purchased piglets (EUR/Head)
Fattening pigs	Costs (fattening pigs)	Price (piglets) (Years)
Fattening pigs	Other costs (fattening pigs)	Veterinary service (EUR/Yr)

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Fattening pigs	Other costs (fattening pigs)	Medical products (EUR/Yr)
Fattening pigs	Other costs (fattening pigs)	Contract work (EUR/Yr)
Fattening pigs	Other costs (fattening pigs)	Fees (EUR/Yr)
Fattening pigs	Other costs (fattening pigs)	Animal insurances (EUR/Yr)
Fattening pigs	Other costs (fattening pigs)	Other (EUR/Yr)
Fattening pigs	Feeding stuff	Own production (t/Yr)
Fattening pigs	Feeding stuff	Bought-in (t/Yr)
Fattening pigs	Feeding stuff	Price (EUR/t)
Fattening pigs	Feeding stuff	Total cost (EUR/Yr)
Breeding pigs	Production system (breeding pigs)	Number breeding sows (Animal places)
Breeding pigs	Production system (breeding pigs)	Number gilts (Animal places)
Breeding pigs	Production system (breeding pigs)	Number boars (Animal places)
Breeding pigs	Production system (breeding pigs)	Weaners per sow (Number)
Breeding pigs	Production system (breeding pigs)	Weaner sale/transfer (Days)
Breeding pigs	Production system (breeding pigs)	Weaner mortality (%)
Breeding pigs	Production system (breeding pigs)	Replacement rate (Number)
Breeding pigs	Production system (breeding pigs)	Annual stocking rate (Number/AP)
Breeding pigs	Revenues (weaner)	Weight of sold weaners (kg)
Breeding pigs	Revenues (weaner)	Sold / transferred weaner per sow (Number)
Breeding pigs	Revenues (weaner)	Price (weaner) (EUR/Head)
Breeding pigs	Revenues (Sow)	Slaughter weight culled stock (kg SW)
Breeding pigs	Revenues (Sow)	Sold culled stock (Head)
Breeding pigs	Revenues (Sow)	Price (culled stock) (EUR/kg SW)
Breeding pigs	Revenues (others)	Revenues By-Products (EUR/Yr)
Breeding pigs	Costs (breeding pigs)	Purchased gilts (Head)
Breeding pigs	Costs (breeding pigs)	Price (gilts) (EUR/Head)
Breeding pigs	Costs (breeding pigs)	Purchased boars (Head)
Breeding pigs	Costs (breeding pigs)	Price (boars) (EUR/Head)
Breeding pigs	Other costs (breeding pigs)	Insemination (EUR/Yr)
Breeding pigs	Other costs (breeding pigs)	Veterinary service (EUR/Yr)
Breeding pigs	Other costs (breeding pigs)	Medical products (EUR/Yr)
Breeding pigs	Other costs (breeding pigs)	Contract work (EUR/Yr)
Breeding pigs	Other costs (breeding pigs)	Fees (EUR/Yr)
Breeding pigs	Other costs (breeding pigs)	Animal insurances (EUR/Yr)
Breeding pigs	Other costs (breeding pigs)	Littering material (EUR/Yr)
Breeding pigs	Other costs (breeding pigs)	Other (EUR/Yr)
Breeding pigs	Feeding stuff	Own production (t/Yr)
Breeding pigs	Feeding stuff	Bought-in (t/Yr)
Breeding pigs	Feeding stuff	Price (EUR/t)
Breeding pigs	Feeding stuff	Total cost (EUR/Yr)
Other livestock	Production system (others)	Species
Other livestock	Production system (others)	Juvenile: Number of animal (Number / year)
Other livestock	Production system (others)	Adult productive: Number of animal (Number / year)
Other livestock	Production system (others)	Adult non-productive: Number of animal (Number / year)
Other livestock	Production system (others)	Juvenile: average numbers of days the animal is on farm (Days)
Other livestock	Production system (others)	Adult productive: average numbers of days the animal is on farm (Days)
Other livestock	Production system (others)	Adult non-productive: average numbers of days the animal is on farm (Days)
Other livestock	Production system (others)	Juvenile: Average weight (kg)
Other livestock	Production system (others)	Adult productive: Average weight (kg)
Other livestock	Production system (others)	Adult non-productive: Average weight (kg)
Other livestock	Production system (others)	Mortality (%)
Other livestock	Production system (others)	Annual turnover rate (Number)
Other livestock	Revenues (other livestock)	Product sold (kg/Yr)
Other livestock	Revenues (other livestock)	Farm gate price (EUR/kg SW)
Other livestock	Revenues (other livestock)	Revenues (EUR/Jahr)
Other livestock	Revenues (other livestock)	Other revenues (EUR/Yr)
Other livestock	Revenues (other livestock)	Revenues By-Products (EUR/Yr)
Other livestock	Costs (other livestock)	Purchased animals (Number)
Other livestock	Costs (other livestock)	Price (EUR/Head)
Other livestock	Costs (other livestock)	Purchase costs (EUR/Yr)
Other livestock	Other costs (other livestock)	Insemination (EUR/Yr)
Other livestock	Other costs (other livestock)	Veterinary service (EUR/Yr)
Other livestock	Other costs (other livestock)	Medical products (EUR/Yr)
Other livestock	Other costs (other livestock)	Contract work (EUR/Yr)
Other livestock	Other costs (other livestock)	Fees (EUR/Yr)

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Other livestock	Other costs (other livestock)	Animal insurances (EUR/Yr)
Other livestock	Other costs (other livestock)	Littering material (EUR/Yr)
Other livestock	Other costs (other livestock)	Other (EUR/Yr)
Other livestock	Feeding stuff	Own production (t/Yr)
Other livestock	Feeding stuff	Bought-in (t/Yr)
Other livestock	Feeding stuff	Price (EUR/t)
Other livestock	Feeding stuff	Total cost (EUR/Yr)

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ANNEX IV: RESULTS

In Table A4-1 Annex IV provides an overview of the average sustainability indicator responses deriving from the implementation of individual and bundles of agro-ecological practises (AEPs) analysed in the 13 case studies. Due to the specific character and focus of the Spanish case studies additional socio-economic indicators were assessed. The results of the Spanish case study are provided in a separate Table A4-2.

In Table A4-1 positive responses in sustainability indicators are highlighted in green and negative responses in red indicating synergies and trade-offs between the sustainability indicators emerging from the implementation of the different AEPs. Table A4-1 uses the following abbreviations for the case study countries and sustainability indicators:

Case studies:
CH – Switzerland; DE – Germany; ES – Spain; FI – Finland; FR – France; GR - Greece; HU – Hungary; IT – Italy; LT – Lithuania; LV – Latvia; RO – Romania; SE – Sweden; UK – United Kingdom

Sustainability indicators (as explained in section 2.1.3 and Table 1):
SD – Species diversity; **HD** – Habitat diversity; **GD** – Genetic diversity; **WQ** – Water quality; **SQ** – Soil quality; **GHG** – GHG emission score (SMART); **GHG.C** – GHG emission intensity cropland; **GHG.L** - GHG emissions intensity livestock; **GHG.D** - GHG emissions intensity dairy; **BFPR** - Benefits to biodiversity farming products; **BFP** - Benefits to biodiversity farming practices; **BSH** - Benefits to biodiversity small farm habitats; **BLH** - Benefits to biodiversity large farm habitats; **QL** – Quality of life; **NVA** – Net value added; **NFI** – Net farm income; **LP** – Labour productivity.

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Table A4-1 Average sustainability indicator response deriving from the implementation of individual and bundles of agro-ecological practises (AEPs)

AEP category	Agro-ecological practice (AEP)	Case study	Sustainability indicators: Environmental													Sustainability indicators: Socio-economic			
			SD	HD	GD	WQ	SQ	GHG	GHG.C	GHG.L	GHG.D	BFPR	BFP	BSH	BLH	QL	NVA	NFI	LP
Efficiency increase	Increase of compound feed	LT	-1.3%			-2.2%		3.6%									-8.0%	-2.9%	-8.0%
	2D fruit orchards and reduced chemical inputs & water consumption	GR	16.3%	42.95%	30.1%	7.8%		5.5%	-4.4%				2.5%				8.3%	84.9%	8.3%
	Pest monitoring	IT		2.7%				2.8%					17.3%				1.5%	1.4%	0.8%
Substitution	Composting	IT					2.3%	1.5%	-35.9%				18.7%				-1.2%	-10.0%	-10.0%
	FYM application	UK							-46.0%				22.3%				-2.7%	-2.8%	-2.7%
	From conventional to organic farming	LV	10.0%	5.1%	9.0%	3.7%	1.5%		-22.5%				21.4%				21.6%	29.7%	21.6%
	From conventional to organic farming	RO	50.4%	47.7%	16.2%	20.5%	17.3%	2.2%	-47.3%				23.8%				-77.6%	-87.8%	-77.6%
	Biofertilizer production	FI	-11.4%	-12.5%	-11.0%	-10.9%	4.7%	-4.3%											
	Biofertilizer production - biofuel use	FI	0.9%	0.5%		1.9%	3.4%	2.5%											
Re-design	From permanent to 50% temp. grass	LT		-1.7%	-6.2%	1.3%	1.4%	-5.3%	34.5%		-1.4%		-4.1%				31.7%	34.8%	26.2%
	From permanent to temporary grass	LT		-10.0%	-7.7%			-10.5%	67.9%		-1.4%		-8.2%				52.0%	57.1%	45.6%
	From temporary to permanent grass	LT	14.3%	37.5%	12.8%	8.2%	9.1%	13.0%	-7.5%				8.6%				0.3%	0.3%	0.3%
	Only permanent grass	LT				-2.2%	-2.5%	-1.7%	17.7%								11.9%	11.9%	11.9%
	Balancing permanent and temporary grassland	LT	-3.8%	-9.1%	-2.7%	-3.3%	-3.7%	-6.7%					4.1%				5.4%	5.5%	0.4%
	Inter-row green cover	IT		5.5%			13.6%	5.6%	-149.1%				57.7%				13.6%	15.4%	15.4%
	Inter-row green cover - no synthetic pesticides	FR	57.7%	54.2%	48.8%	32.2%	20.3%	9.2%									-30.8%	-32.1%	
	Reduced till - Flower and buffer strips - Intercropping	DE	15.9%	18.4%	25.9%	5.7%	10.4%	8.9%	-26.5%			12.6%	9.6%	95.7%	4.0%		-18.4%	-97.9%	-18.4%
	Reduced tillage	HU	13.0%	11.1%		4.3%	8.3%	4.3%									16.1%		16.1%
	No plough	HU	11.5%	15.0%		7.7%	6.1%	4.2%									0.2%		0.2%
	No till	HU	31.0%	30.4%	19.0%	11.5%	26.2%	12.0%									10.7%		10.7%
	No Till & direct drilling	UK							-202.7%				13.9%				-2.0%	-2.8%	-2.0%
	Extensification - increased direct marketing	CH	0.9%			2.7%	2.3%	5.5%	-10.7%	-48.8%						-0.6%	-49.3%	-60.5%	-39.0%
	Extensification - increased direct marketing - fruit growing	CH	-7.5%	-3.9%	-7.8%	-1.4%	-0.8%	5.5%	-9.7%	-48.8%							-19.7%	-25.0%	-5.9%
	Farm re-design	SE	76.2%	61.0%	61.1%	30.3%	20.3%	20.8%	0.9%	-13.8%		17.1%	42.4%	18.2%		3.8%			
	More food crops - increase payment	SE															82.2%	108.8%	90.3%
	Collective post - harvest activities	ES														1.3%	-5.5%	-6.4%	-5.5%
	Improved access to land	ES																3.4%	
	Strengthened farmer network	ES														4.3%			

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Table A4-2 Results of the Spanish case study

AEP	Sustainability Indicator	Positive Response	Negative Response
Collective post-harvest activities (Spain)	Labour productivity		-5.5%
	Net farm income		-6.4%
	Net value added		-5.5%
	Profitability	2.6%	
	Quality of Life	1.3%	
	Total input		-2.5%
	Total output per total input		-4.4%
	Total intermediate consumption		-3.7%
	Total output		-6.8%
	Total output crops & crop production		-6.8%
Improved access to land (Spain)	Fair Access to Means of Production	16.9%	
	Food Sovereignty	15.2%	
	Internal Investment	5.9%	
	Land Degradation	2.2%	
	Net farm income	3.4%	
	Responsible Buyers	6.0%	
	Risk Management	0.0%	
	Stability of Market	1.4%	
	Total input		-3.9%
	Total output per total input	4.1%	
	Value Creation	15.3%	
Strengthened farmer network (Spain)	Capacity Development	54.3%	
	Civic Responsibility	64.8%	
	Community Investment	18.9%	
	Conflict Resolution	11.5%	
	Due Diligence	3.8%	
	Fair Access to Means of Production	21.3%	
	Grievance Procedures	25.0%	
	Holistic Audits	25.7%	
	Indigenous Knowledge	104.1%	
	Legitimacy	7.2%	
	Product Information	33.9%	
	Quality of Life	4.3%	
	Remedy, Restoration & Prevention	17.6%	
	Resource Appropriation	12.8%	
	Responsibility	25.8%	
	Responsible Buyers	14.5%	
	Risk Management	1.2%	
	Stability of Production	6.3%	
	Stakeholder Dialogue	15.4%	
	Transparency	4.9%	

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