UNISECO

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

Deliverable Report D3.1 Report on Environmental, Economic and Social Performance of Current AEFS, and Comparison to Conventional Baseline

AUTHORS (for affiliations, consult list of acronyms)	Jan Landert (FiBL), Catherine Pfeifer (FiBL), Johannes Carolus (TI), Fabrizio Albanito (UNIABDN), Adrian Müller (FiBL), Lukas Baumgart (FiBL), Johan Blockeel (FiBL), Gerald Schwarz (TI), Rainer Weisshaidinger (BOKU), Ruth Bartel-Kratochvil (BOKU), Alexander Hollaus (BOKU), Andrea Hrabalová (Bioinstitut), Janne Helin (LUKE), Jyrki Aakkula (LUKE), Kristina Svels (LUKE), Emmanuel Guisepelli (ISARA), Philippe Fleury (ISARA), Audrey Vincent (ISARA), Alexandra Smyrniotopoulou (AUA), George Vlahos (AUA), Yiannis Iordanidis (AUA), Alfréd Szilágyi (GEO), László Podmaniczky (GEO), Katalin Balázs (GEO), Francesco Galioto (CREA), Davide Longhitano (CREA), Letizia Rossignolo (CREA), Andrea Povellato (CREA), Andis Zīlāns (BEF-LV), Gražvydas Jegelevičius (BEF-LT), Mihaela Frățilă (WWF), Uxue Iragui Yoldi (GAN), Carlos Astrain Massa (GAN), Jon Bienzobas Adrian (INTIA), Kajsa Resare Sahlin (SLU), Elin Röös (SLU), Rebekka Frick (FiBL), Richard Bircher (FiBL), Inge Aalders (HUT), Katherine N. Irvine (HUT), Carol Kyle (HUT), David Miller (HUT), Jürn Sanders, (TI), Pete Smith (UNIABDN)
APPROVED BY WORK PACKAGE MANAGER OF WP3	Jan Landert (FiBL)
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ACRONYMS

AEFS	Agro-ecological farming system
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
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
MAP	Multi-Actor Platform
NA	Not applicable
RDP	Rural Development Programmes
SAFA	Sustainability Assessment of Food and Agriculture systems
SES	Socio-ecological System
SLU	Sveriges Lantbruksuniversitet
SMART	Sustainability Monitoring and Assessment RouTine
SNA	Social network analysis
TI	Johann Heinrich von Thuenen 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

The overall aim of the UNISECO project is to provide recommendations on how the sustainability of agro-ecological farming systems (AEFS) in Europe can be promoted. These recommendations build upon multi-actor engagement and practice-validated strategies. The project explores both of these approaches in 15 case studies across Europe. Every case study reflects an AEFS at a certain point of transition towards agro-ecological farming systems.

A first step in all of the case studies was to characterize the status quo of the farm systems. Along with other methods to describe the status quo, three decision support tools (DST) were applied in the case studies to provide information on the environmental, economic and social performance of current AEFS. The tools applied were COMPAS, an economic performance assessment tool, Cool Farm Tool, a greenhouse gas inventory tool, and SMART, a multidimensional sustainability tool. This deliverable presents the overall approach taken to assess the farms along the agro-ecological transition, describes the tools, and presents results from their application in the case studies.

In each case study area, the project partners defined pathways of agro-ecological transitions. Different stages of achievement of the agro-ecological transition characterized these pathways: stage 0 (not agro-ecological) served as the conventional baseline with which comparisons could be made. The subsequent stages defined represented states along the ecological transition pathway on a continuum from weak agro-ecological to strong agro-ecological (Prazan and Aalders, 2019), whereas strong agro-ecological represented a redesign of a system.

Preliminary results show that farms are highly diverse across Europe and that agro-ecological farms can perform well. Patterns identified suggest:

1. The environmental performance of farms generally increases along the agro-ecological transition pathway. Agro-ecological farms, therefore, provide more public goods and ecosystem services.
2. Mixed farms perform better than specialized farms, including specialized organic, implying that a combination of crops and relatively extensive livestock can be more sustainable with regard to the provision of public goods than a specialized farm.
3. Reduced chemically synthetized pesticides and mineral fertiliser use has a positive influence on biodiversity, soil health, and reducing greenhouse gas emissions in arable systems and water quality. Therefore, although being at the intermediate state of input-substitution on the transition pathway, chemically synthesized pesticides and mineral fertilisers are important levers in the AEFS.
4. The economic performance of agro-ecological farming is very heterogeneous. Although most of the farms were profitable, agro-ecological farms tend to be less productive and generate less income. This result is generally explained by the smaller size of the farm unit and the lower level of mechanisation of agro-ecological farms.
5. Yet, synergies exist between the public goods and economic performance. One example is that higher subsidies provide compensation for economic loss (e.g. in Latvia). Another example is that of short supply chains, through which the entire

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direct margin flows to the farmer directly (e.g. in Spain, Lithuania and France). However, this option is constrained by the relatively small market compared to mainstream value chains, and in some countries it was in decline (e.g. Spain). In the Italian case study, higher rationalization and economic success led to more ecological practices on the vineyards. Similarly, the adoption of innovations applied by conventional farms in the Swiss case study (share farming and higher levels of mechanisation) potentially could increase synergies for Swiss agro-ecological farms.

6. Lock-in situations exist in some contexts. Non-agro-ecological farms do not have sufficient returns and liquidity for the capital investment necessary for the agro-ecological transition as well as producing in an economic viable manner.
7. There is a high level of quality of life and satisfaction amongst all farmers regardless of the stage of agro-ecological transition.

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1. INTRODUCTION

The overall aim of the UNISECO project is to provide recommendations on how the sustainability of agro-ecological farming systems (AEFS) in Europe can be promoted. These recommendations build upon multi-actor engagement and practice-validated strategies. The project explores both of these approaches in 15 case studies across Europe. Every case study reflects an AEFS at a certain point of agro-ecological transition.

A first step in all case studies was to characterize the status quo of the farm systems. The status quo was described using the socio-ecological system approach (SES, project Task 3.1) which aimed to describe the broad socio-economic environment in which the case study is embedded and to identify key process and drivers and barriers of agro-ecological transitions. Relationships between the relevant actors in the case study were described with the social network analysis approach (SNA, project Task 5.2). To assess the environmental, economic and social performance of the current AEFS (project Task 3.2), project partners analysed farms in the case study using three Decision Support Tools (DST). The three DST applied were COMPAS, Cool Farm Tool and SMART (see Section 2.1).

This report summarizes the results from these DST- assessments. The hypothesis of the core dilemma of AEFS between the provision of public goods and the economic viability of the farms framed the DST analyses.

The underlying basis for the performance assessments was the characterization of farms in the case studies into farm groups, and then the characterization of these groups (Section 2.3.1). Some project partners also defined new, case study specific indicators for the DST assessment with help of multi-actor engagement (Section 2.3.2). Prior to the data collection, all project partners received a tool to facilitate data collection and reduce the time required (Section 2.3.3). This report describes the process of data collection, verification and compilation in Section 2.4 and in Section 3 provides an overview of the case studies, their dilemmas and the investigated farm groups.

Sections 4 and 6 present summaries of the results, and conclusions per case study and across the case studies. The evaluation of the results focuses upon the components of the core dilemma of AEFS: the provision of public goods and the economic viability of farms.

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2. METHODS

The following sections describe the decision support tools applied in the study and the assessment process.

2.1. Description of the Sustainability Tools

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 rating of the whole farm, based on a multi-criteria assessment, similar to SMART.

2.1.1. 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 (Figure 2). 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 (**Figure 1**).

Figure 1. *Rating categories of SMART.*

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.

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GOOD GOVERNANCE				
CORPORATE ETHICS	Mission Statement	Due Diligence		
ACCOUNTABILITY	Holistic Audits	Responsibility	Transparency	
PARTICIPATION	Stakeholder Dialogue	Grievance Procedures	Conflict Resolution	
RULE OF LAW	Legitimacy	Remedy, Restoration & Prevention	Civic Responsibility	Resource Appropriation
HOLISTIC MANAGEMENT	Sustainability Management Plan	Full-Cost Accounting		

ENVIRONMENTAL INTEGRITY			
ATMOSPHERE	Greenhouse Gases	Air Quality	
WATER	Water Withdrawal	Water Quality	
LAND	Soil Quality	Land Degradation	
BIODIVERSITY	Ecosystem Diversity	Species Diversity	Genetic Diversity
MATERIALS & ENERGY	Material Use	Energy Use	Waste Reduction & Disposal
ANIMAL WELFARE	Animal Health	Freedom from Stress	

ECONOMIC RESILIENCE					
INVESTMENT	Internal Investment	Community Investment	Long-Ranging Investment	Profitability	
VULNERABILITY	Stability of Production	Stability of Supply	Stability of Market	Liquidity	Risk Management
PRODUCT QUALITY & INFORMATION	Food Safety	Food Quality	Product Information		
LOCAL ECONOMY	Value Creation	Local Procurement			

SOCIAL WELL-BEING				
DECENT LIVELIHOOD	Quality of Life	Capacity Development	Fair Access to Means of Production	
FAIR TRADING PRACTICES	Responsible Buyers	Rights of Suppliers		
LABOUR RIGHTS	Employment Relations	Forced Labour	Child Labour	Freedom of Association & Right to Bargaining
EQUITY	Non Discrimination	Gender Equality	Support to Vulnerable People	
HUMAN SAFETY & HEALTH	Workplace Safety and Health Provisions	Public Health		
CULTURAL DIVERSITY	Indigenous Knowledge	Food Sovereignty		

Figure 2. *Dimension, themes and subthemes of the Sustainability Assessment of Food and Agriculture guidelines.*

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2.1.2. 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 (Table 1). 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 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.

Table 1. *Overview of farm activities covered by COMPAS*

Crop activities		Livestock activities
Winter wheat	*Lentils*	*Dairy cow*
Summer wheat	*Linseeds*	*Dairy heifer*
Durum wheat	*Chickpeas*	*Dairy (breeding) bull*
Winter barley	*Coriander*	*Dairy calve*
Summer barley	*Cassava*	*Suckler cows*
Mating barley	*Cotton*	*Breeding bulls*
Spelt	*Carrots*	*Heifer*
Summer triticale	*Onions*	*Heifers < 12*
Winter triticale	*Spinage*	*Heifers 12-24*
Oat	*Fodder gras seed*	*Heifers 24*
Oaten hay	*Lawn gras seed*	*Male weaners*
Winter rye	*Grass on arable land*	*Female weaners*
Feeding rye	*Clover on arable land*	*Beef Finishing Steers*
Grain maize	*Lupines*	*Beef Finishing Bulls*
Grain maize	*Lucerne*	*Beef Finishing Cows*
Silage or Fodder maize	*Other types of legumes mixtures*	*Beef Finishing Calves*
Whole crop cereal silage	*Clover*	*Beef Finishing Heifers*
Rice	*Other arable crops*	*Breeding sow*
Spring rice	*Pasture*	*Gilts*
Summer rice	*Meadow (General)*	*Boar*
Autumn rice	*Intensive meadow (3-5 cuts)*	*Fattening pigs*
Sorghum	*Extensiv meadow (1-2 cuts)*	*Ewes*
Other cereals or mixed cereals	*Vineyard*	*Breeding rams*
Summer rape	*Fruits*	*Hoggets < 12*
Winter rape	*Berries*	*Hoggets 12-18*
Soya beans	*Other permanent crops*	*Hoggets > 18*
Late soya	*Fallow on gras land*	*Male lambs*
Sunflowers	*Fallow on arable land*	*Female lambs*
Palmoil	*Black fallow*	*Lamb Finishing Ewe*
Potatoes	*Summer fallow*	*Lamb Finishing Male lambs*
Industry potatoes	*Winter fallow*	*Lamb Finishing Female lambs*
Table potatoes	*Chemical fallow*	*Lamb Finishing Wether*
Sugar beets	*Intercrops Grain Legumes*	*Laying hens*
Fodder beets	*Intercrops Fine-seeded Legumes*	*Broiler*
Field peas	*Intercrops Cereals*	*other poultry fattening*
Field beans	*Intercrops Others*	*Hens raising*
Beans		

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The output of COMPAS consists of various economic indicators of which the following have been selected to meet the purpose of the farm assessment in the context of the UNISECO project. All of the indicators follow the FADN definition (FADN, 2018).

- *Annual Working Unit (SE010*[1]*)*
- *Family Working Unit (SE015)*
- *Total Output (SE131)*
- *Net Value Added (SE415)*
- *Labour productivity (SE425)*
- *Net Farm Income (SE420)*
- *Gross margins*
- *Total intermediate consumption (SE275)*

2.1.3. COOL FARM TOOL

The Cool Farm Tool (CFT) is an online decision support tool used to estimate the environmental impacts of food production (HTTPS://COOLFARMTOOL.ORG/). The tool estimates on-farm greenhouse gas (GHG) emissions from crops and livestock. 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.

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). In 2012 the on-line version of Cool Farm Tool was released, and more recently new metrics on biodiversity and water metrics were added to the tool. 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.)

[1] The abbreviations in the brackets correspond to each indicators' FADN ID.

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- Growing Area (area, characteristics of soil etc.)
- Field Treatment (crop protection, fertiliser use, residue management etc.)
- Management (land use and management, above ground biomass etc.)
- Energy and Processing (energy use, farm machinery, etc.)
- Transport (road, rail, air, ship).

Each section of Cool Farm Tool 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, yet comprehensive GHG footprint for a specific farm or product, whilst remaining generic across crops, livestock and geographies.

Global applicability has been a strong selling point of Cool Farm Tool, and has led to the adoption of the tool in several supply chains across the world, and by a variety of major businesses (e.g. NGOs, Unilever, PepsiCo, Nestle, Tesco, Yara, Fertilisers Europe, SAI platform, Solidaridad). Overall, Cool Farm Tool has been reported in over 30 scientific publications over the last 6 years, and has been used online by approximately 4,900 registered users. The scope of the different scientific uses ranged from model comparison (Camargo *et al*., 2013; Colomb *et al.*, 2013) to product assessments such as wheat, potatoes and coffee (Aryal *et al*., 2015; Haverkort *et al.*, 2014; Sapkota *et al.,* 2014), and investigation of mitigation strategies at a global scale (Hillier *et al*., 2012).

Figure 2. A screenshot of the Cool Farm Tool

Either for farmers or members, an online registration is a pre-requisite for using the tool (HTTPS://COOLFARMTOOL.ORG/COOLFARMTOOL/). The Cool Farm Tool is free for farmers but corporate and commercial or non-commercial entities need to affiliate to the non-profit

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organisation Cool Farm Alliance (CFA) and contribute with a fee according to their size. The fee required to join is not to buy software but to join the effort to measurable reduce agriculture greenhouse emissions and improve overall sustainability in global food supply chains, under no-commercial purposes. All of the revenues from membership fees go back into maintaining and improving the tool.

2.2. TRAINING ACTIVITIES AND DATA QUALITY ASSURANCE

Since the three DSTs were applied in each case study by the respective partners, centralised training was carried out to ensure data quality. These training activities comprised the following:

- 23rd January 2019: The lead partners of Task 3.2 introduced the task and the three DST to project partners
- 29th January 2019: SMART training webinar 1 for all project partners
- 13th February 2019: SMART training webinar 2 for all project partners to discuss the training exercises
- 18th to 23rd February 2019: **DST training days in Newbury, UK**: The lead partners of Task 3.2 presented the three DST to all project partners in more depth. Additionally, the training days included practical on-farm training for SMART.
- 27th March 2019: Webinar for project partners to discuss the assessment workflow with the three DSTs in Task 3.2
- 28th March 2019: SMART training webinar 3 for all project partners about the SMART method and on how to interpret SMART results
- 17th April 2019l: CFT/ COMPAS training webinar 1 for all project partners
- 23rd April 2019: CFT/ COMPAS training webinar 2 for all project partners

With the aim of informing partners, and for quality assurance, the lead partners of Task 3.2 provided the following guidelines to all the project partners:

- December 2018: Factsheet containing the most important cornerstones of Task 3.2
- March 2019: Guidelines on the involvement of stakeholders in Task 3.2
- April 2019: Guidelines on how to select farm for the DST assessments
- May 2019: Guidelines for the farm assessments with the three DST
- August 2019: Guidelines on data plausibility checks and how to evaluate the results of the DST assessments.

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Figure 3. UNISECO SMART Training near Newbury, UK

Since both, the workflow and the tools employed in Task 3.2, were complex, FiBL provided an online support forum for the project partners to ask questions. The forum was structured into a general section and tool-specific sections. The lead partners in the Task jointly answered questions in the forum with short response times. Additionally, a knowledge base hosted on the same platform provided general information for partners.

2.3. PREPARATION FOR DATA COLLECTION

The following sections characterize the general process of assessment for all case studies with the three DST for Task 3.2.

2.3.1. Farm Selection and Farm Survey

To ensure a common basis for the farm selection process in all case studies, the project partners received a guideline outlining the preferred workflow. The document aimed to base the farm selection in the case studies on the farm typology developed in the UNISECO project (Prazan and Aalders, 2019). The typology is based on three dimensions, the farm production system (dimension 1), the agro-ecological practices (dimension 2) and the socio-ecological system contest (dimension 3). The last dimension is drawn from a typology developed by Therond *et al.* (2017). For the farm selection in Task 3.2, the first two dimensions were used to group farms in the respective case study area by the following steps:

1. Defining agro-ecological transition pathways in the case study. The concept of the agro-ecological transition pathway was developed by Prazan and Aalders (2019), based on the work from Tittonell (2014). It arranges the agro-ecological practices (dimension 2) along the continuum of technological and institutional innovation (Figure 4).
2. In a second step, the project partners characterized the farms as part of the transition pathway by farm production type (e.g. specialist dairying).

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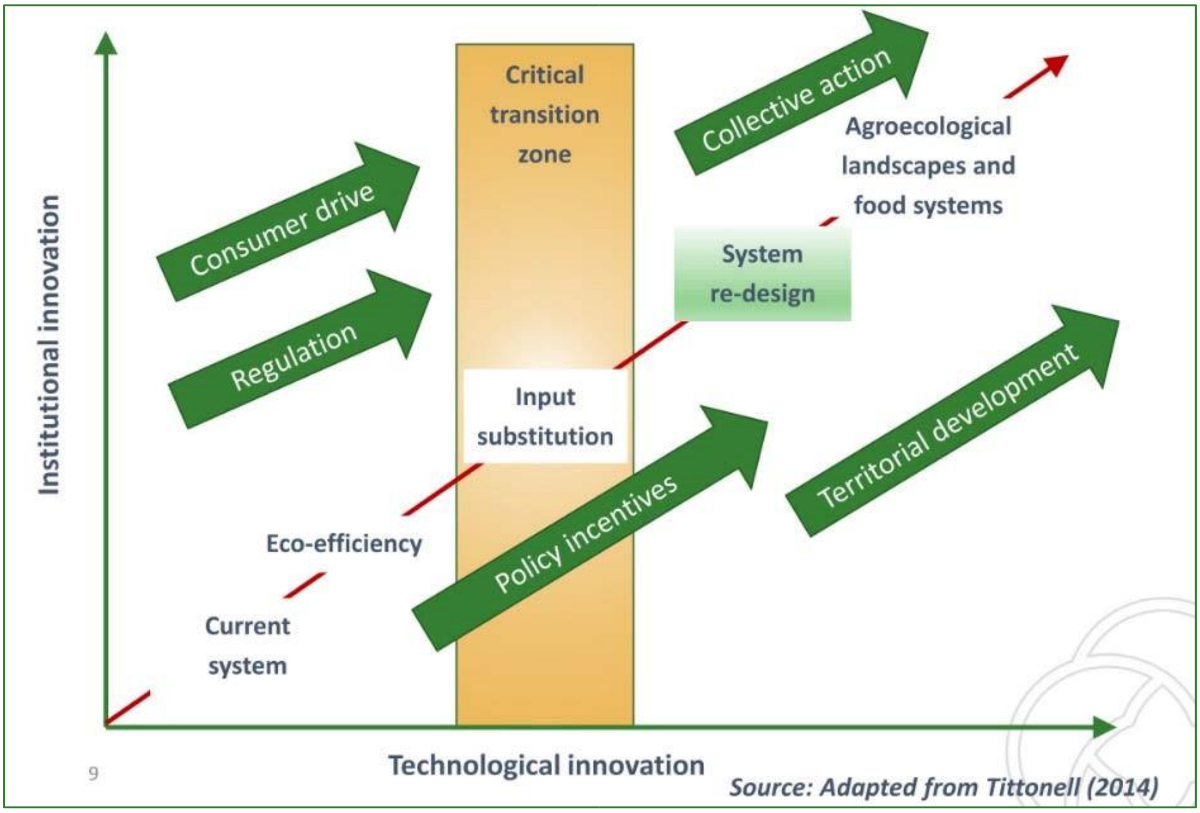

Figure 4. Representation of a transition pathway. Also see Prazan and Aalders (2019).

The result of the two steps above served as the conceptual framework to conduct the assessments with the three DST in the case studies. Figure 5 illustrates a grouping of farms in a case study.

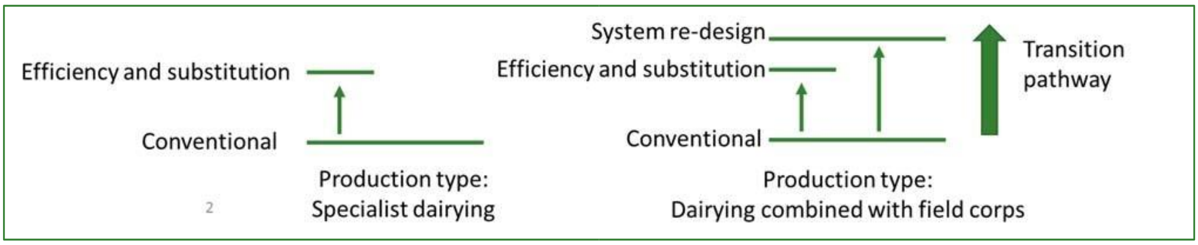

Figure 5. Example for two transition pathways for two farm production types defined in a case study (total of 5 farm groups)

For the further characterizing the different farm groups in the case studies, a set of attributes was defined. This definition was driven mainly by key modelling input parameters (e.g. based on Muller *et al.*, 2017) of:

- Agro-ecological practices, structured in accordance to Prazan and Aalders (2019)
- Utilized agricultural area (UAA) in ha
- N- and organic fertiliser source
- Fodder source
- Irrigation
- Plant protection
- Yields of main product case study

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- Crop rotation of the main crop
- Common crops
- Common livestock
- Broad socio- ecological contexts (dimension 3 from Prazan and Aalders, 2019).

Project partners obtained the data from official statistics and expert interviews or, where data did not exist, estimated the missing values based on the first two sources.

The aim of the survey was to:

- gain a structured overview of the farm groups being assessed with the DST across all case studies
- deepen understanding how the chosen farm groups represent the whole farming system with regard to certain attributes in the whole case study area
- provide information for the case studies to WP4 which can be used for the upscaling process
- frame criteria for farm selection.

Based on the survey results of all case studies, the Task leader compiled a milestone report, which provided a first overview of the farm structure across all case studies (Milestone MS11).

Based on the farm survey, the project partners selected the farms for the assessment with the aim of covering each farm group with at least two farms. In some cases, the farm groups defined needed to be adapted later to account for the willingness of individual farmers in the farm groups initially selected to participate in the project.

In total, each case study partner should select 10 farms for the DST assessment. Most partners did not manage to recruit that number of farms in time for the Deliverable. This was due to the harvesting season in several countries, the amount of time which farmers were required to commit (approximately 1.5 days in total), and the time needed to identify and recruit suitable farms. However, all partners will assess the remaining farms by the end of 2019. The corresponding farm data will be used in subsequent tasks, such as Task 3.4.

2.3.2. Multi-Actor Engagement

The project partners contacted local stakeholders to verify if the three DST covered all of the indicators relevant to the case study. The Task Leaders recommended a workshop or interviews during which stakeholders could suggest new topics for the assessment. A guideline for the project partners contained the workflow for both forms of stakeholder involvement. Table 2 lists the additional topics resulting from the stakeholder involvement. These were included in the SMART questionnaires of respective case study and assessed during the field visits.

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Table 2. Additional sustainability aspects, raised by local stakeholders

Case Study	Farm Type	Additional Sustainability Aspects for the Case Study
Austria	Arable / fruit farms	Reasons for participation in the humus project, share of area in humus project, humus content, variable costs for building up humus in soils, regional marketing, interaction with local suppliers, impact of climate change, future climate smart farm enterprises, farm succession, digitalization, farm self-sufficiency, relevant topics of capacity building
Czech Republic	Mixed farms	Existence of an agro-ecological knowledge platform, societal estimation of agro-ecological practices, closing of material flows on the farm, soil quality models, quality of milk, share of subsidies of farm income, alternative marketing channels
Lithuania	Dairy farms	Feed origin, farmer- customer relationship, overgrazing, pasture productivity, maintenance of on-farm biodiversity, income fluctuations, hiring of local staff.
Finland	Dairy farms	Phosphorous content of soils
Germany	Arable farms	Land rental agreement conditions and high land prices, short rotation coppices, existence of multi-actor platforms for biodiversity measures
Romania	Mixed farms	Traditional cultural landscape, farmland mosaic, traditional practices
Sweden	Ruminant farms	Number of people fed per hectare, climate impact per calorie, work-life balance, work meaningfulness, threat and hatred, preservation of farmland, attractive landscapes
Switzerland	Livestock farms	Animal welfare certificates, rented land, cooperation, quality of biodiversity areas and ecological interconnection projects, phosphorous content of soils, work meaningfulness, uptake of loans for stables and their potential for conversion, promising future farm enterprises, alternative farm income sources, capacity building related to marketing of products, participation in phosphorous reduction programmes, enforcement of environmental legislation

2.3.3. Common Data Collection Tool

All three tools, SMART, COMPAS and Cool Farm Tool collect data on similar topics, yet different in detail. To simplify data collection, avoid irritating the farmers with similar questions, and avoid confusion of the auditor, a common data collection tool was developed that merges topics that were similar across the three tools. Each farm enterprise was tackled in a different way. Crop related questions were brought together relatively easily, with the tool enabling the auditor to ask one question of the farmer and immediately select the answer for each of the three tools.

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Merging livestock enterprises was more challenging for several reasons: 1) each tool made a different assumption on how to characterize a herd/flock; 2) data on feeding options were very different; 3) Cool Farm Tool works with feed in dry weight whereas COMPAS works with feed in fresh weight.

To address these challenges, and to insure that all case studies address these issues in a similar way, the common data collection tool contained information on the most detailed herd/flock model and the most detailed feed ratio, and automatically aggregated those to the level required by each of the three tools. To do this, the tool creates a conversion table that translates a feed ratio to the specific feed type a tool can handle. For example, if an animal is fed triticale, a cereal that is not found in the Cool Farm Tool, then it is automatically counted as wheat in Cool Farm Tool. A standard conversion factor between dry and fresh weight was used based on data taken from the animal feed resources information system (feedipedia.org). This approach enables a consistent conversion between the different feed types and their weights, making results from the different study sites comparable.

During the data collection, the tool was updated and these updates communicated to partners. The latter have been offered help in case of open questions.

2.4. DATA COLLECTION, VERIFICATION AND COMPILATION

The next sections describe the data collection and processing in Task 3.2.

2.4.1. Data Collection

The project partners received a guideline outlining the different steps of the data collection. Figure 6 provides an overview of the process.

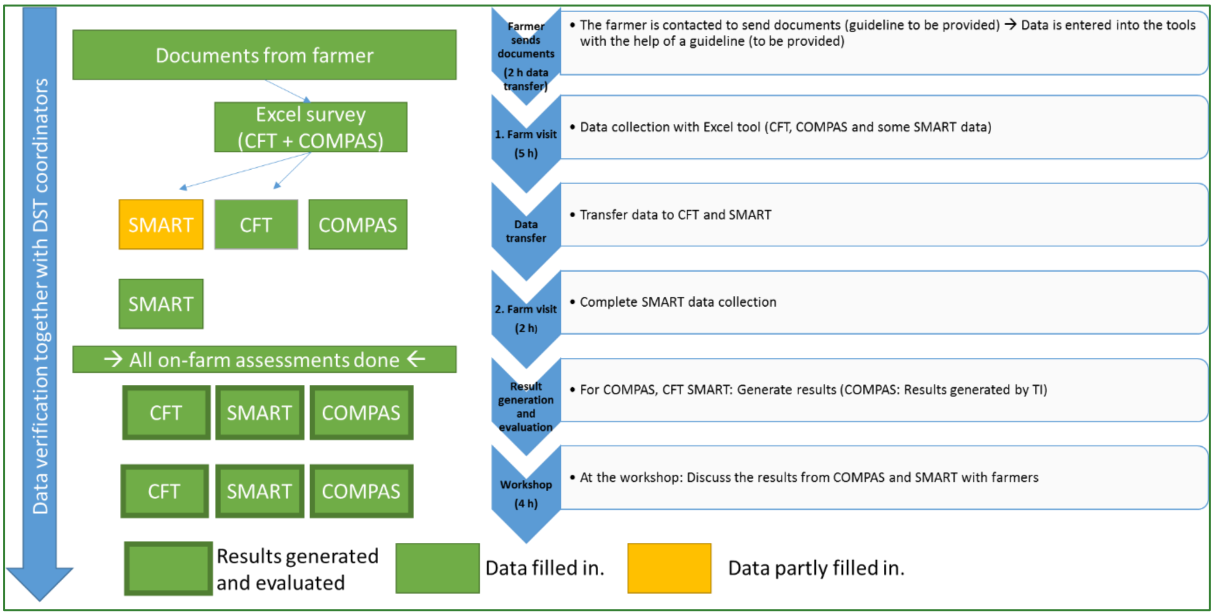

Figure 6. Workflow of steps of data collection and verification (the common data collection tool is referred to as "Excel survey")

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As the data collected with the DSTs comprised hundreds of variables, the guideline emphasised strategies on avoiding long interviews with farmers, with a consequence of potentially low data quality. The first step in the data collection procedure reflects this approach with project partners collecting existing documents from the farmers to pre-fill the three DST as much as possible already before the interview with the farmer.

In a second step, the Task leaders recommended that project partners use the common data collection tool ("Excel survey" in Figure 6) during an initial field visit and then transfer the data to Cool Farm Tool, and where relevant also to SMART. It was recommended that project partners visit the farm a second time to complete the SMART assessments.

During the data collection, project partners engaged in the online support forum and asked questions related to the tools and the general process.

2.4.2. Data Generation and Plausibility Checks

After the results were collected, the project partners generated the results for SMART and Cool Farm Tool (see Figure 6). The Thünen Institute (TI) calculated and provided the results of COMPAS to project partners. During the latter process, TI ran plausibility checks on the data and gave feedback to partners.

For SMART, FiBL checked at least one SMART questionnaire for plausibility in each case study and provided a list of common errors to partners to check. The same was the case for Cool Farm Tool for which UNIABND provided feedback to partners regarding data quality.

In addition, project partners received a guideline, which contained further suggestions for checking data plausibility.

2.4.3. Data Validation

The DST assessments targeted 10 farms in each case study. To increase the potential of generalization for a sample with a low number of farms, project partners validated the results together with farmers and / or experts in the case studies and explored the extent to which they could be generalized with regard to typical farms in the region. The Task lead partners recommended the validation to use either selected interviews or a workshop based on the key findings of the assessments which needed validation.

2.4.4. Compilation of Deliverable Report

All project partners sent a case study report and the aggregated DST data to FiBL, which summarized the case study reports if needed for the result section of the deliverable report. Cross-case analysis sections in the report highlight interesting patterns which were interpreted from across the summaries. Finally, overall conclusions were drawn from the case study results.

The underlying data for this report can be found in Deliverable 3.2 of the UNISECO project, the *Database on the performance of current AEFS as an input to the modelling in WP4.*

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3. CASE STUDIES AND FARM GROUPS

The following sections summarize the dilemmas and farm group structure for the case studies. More information on each of the case studies is available in the case study reports which are included in 0.

3.1. Description of the Case Study Dilemmas

Transforming agriculture towards more sustainability is never just a win-win. Often trade-offs between different sustainability dimension raise a dilemma on what to prioritize. Each of the case studies therefore hypothesized such a dilemma that results from agro-ecological practices to be assessed. These dilemmas are the basis for the research conducted in the UNISECO case studies.

In summary, all the case studies connect the provision of public goods with the economic viability of farms. Whereas project partners describe the latter similarly across all case studies, they further specify the provision of public goods in some cases to account for the prioritisation of issues in the area. The results from case studies in Section 0 focus on in these core components of case study dilemmas.

Austria (Ökoregion Kaindorf - mixed farm)

The key dilemma is to tackle impacts due to climate change (e.g. increasing water stress), increase carbon sequestration in soils, prevent soil degradation and reduce soil fertility loss from arable land whilst maintaining or improving the farm's social and economic sustainability and contributing to climate change mitigation.

Czech Republic (Vysočina region – dairy farms)

The case study dilemma for the Czech case is how to maintain good practices on arable land of dairy farms in the Vysočina region by applying organic farming practices with a positive impact on water quality and soil fertility whilst ensuring their economic viability.

Finland (Nivala region – dairy farms)

The key dilemma is how to reduce harmful climate, water and soil impacts of dairy farming in the Nivala region without sacrificing economic viability of the local dairy sector, by means of envisioning and implementing a multipurpose bio-product plant along the principles of circular bioeconomy, with the aim of producing bioenergy (mainly biogas) and organic fertilisers from manure.

France (Auvergne-Rhône-Alpes – winegrowers)

The key dilemma in this case study is the reduction in the dependency on external fertilisers and pesticides use (especially glyphosate) through agro-ecological practices while increasing soil ecological services (soil biology) and maintaining the economic profitability of farms.

Germany (Nienburg in Lower Saxony – arable farms)

The key dilemma in the German case study area is the integration of agro-ecological practices on arable land in highly market-oriented farming systems to reduce biodiversity loss and water pollution threats without significant negative impacts on the economic viability of farms.

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Greece (Imathia region of Central Macedonia – fruit farms)

The key dilemma is to sustain the long-term economic viability of farms and to improve the competitiveness of products and their market access whilst protecting natural resources.

Hungary (Belső Somogy region – arable farms)

The dilemma in the case study is how to integrate agro-ecological practices on arable land in highly market-oriented arable farming systems to maintain and improve soil quality without significant negative impacts on the economic viability of farms.

Italy (Chianti region – winegrowers)

To develop a more diversified cropping system in a highly specialised and market-oriented winegrowing area while maintaining the profitability of farming is the dilemma of the Chianti Case Study. Several environmental issues are addressed in the case study, including soil degradation, water pollution, biodiversity loss, landscape degradation and the number of wild animals (ungulates) threatening arable crop production.

Latvia (countrywide – dairy farming)

The Latvian case study investigates the dilemma of increasing the economic viability of conventional and organic, largely grass-based, dairy farms while preserving biodiversity in grasslands and water resource quality.

Lithuania (countrywide – dairy farming and cheese making)

Lithuanian case study dilemma addresses the current tendencies in the country of the loss in small dairy farms and intensifying agriculture in general with a negative effect on the environment. The two main questions raised are: How to maintain and encourage extensive management (grazing) of grassland habitats? How to become (or remain) competitive for dairy farms in the market without intensifying the farming practice?

Romania (Transylvania and Maramures region – mixed farms)

The case study dilemma for the Romanian Case Study is to investigate how to increase the economic viability of small-scale farming that is representative of Romania's food production system, while preserving the cultural landscape and biodiversity through agro-ecological principles.

Spain (Basque Country and Navarra – cereal farms)

In Spain, agro-ecological farms, defined as farms with high diversity, organic and implementing biodiversity practices and all member of the EHKO organisation, are economically fragile. The dilemma in this case study is to increase economic resilience without compromising on the agro-ecological practices.

Sweden (countrywide – ruminant farms)

The case study dilemma for the Swedish case is to investigate 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.

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Switzerland (Lucerne Central Lakes region – livestock farms)

The intensive agricultural area in the Lucerne Central Lakes region is of high economic importance. The high animal densities and the related emissions cause important environmental problems. Additionally, the economic situation of farmers will most likely worsen with future regional effects of climate change. The key dilemma is therefore to overcome the negative effects of high animal densities while maintaining the economic performance of the farms.

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

The dilemma being addressed in the United Kingdom (UK) case study is the production of public goods whilst maintaining viable production of private goods, and securing economic and social sustainability at a farm level. The farming production systems represented by this case study are relevant across the European Union (i.e. Mixed farming with livestock, and General cropping). Examples of the agro-ecological farming practices used to address issues of sustainability are biodiversity support practices, nutrient budgeting, organic farming, permaculture and agroforestry.

3.2. Investigated Farm Groups

To assess the different dilemmas, each of the partners defined pathways of agro-ecological transitions (see section 2.3.1). Different stages of achievement of the agro-ecological transition characterized these pathways: stage 0 (not agro-ecological) served as the conventional baseline to compare with. The subsequent stages defined represented states along the ecological transition pathway on a continuum from weak agro-ecological to strong agro-ecological (Prazan and Aalders, 2019), whereas strong agro-ecological represented a redesign in system. However, in many countries system redesign was difficult to find and therefore represents an improved situation of the previous stage on the transition pathway (namely for Greece, Hungary, Spain).

Table 3. Overview of agro-ecological practices in the case studies and their classification along the transition pathway. [The main agro-ecological practices are distinguished between field level (green background) and farm level (orange background) according to Prazan und Aalders (2019)].

Country	Main agro-ecological practices, based on Prazan and Aalders (2019)	Farm typology for each case study, ordered in stages along the agro-ecological transition pathway		
		Stage 0: Not agro-ecological / conventional baseline	**1st stage on the agro-ecological transition pathway in the case study**	**2nd stage on the agro-ecological transition pathway in the case study**
Austria	Soil management (humus formation)	Conventional perennial (fruit)	Conventional mixed perennial (fruit) arable farms –humus project	Organic mixed perennial farms -humus project
		Conventional mixed livestock (pig) arable farms	Conventional mixed livestock (pig) arable farms –humus project	Diversified mixed livestock (pig, poultry, cattle) arable farms –humus project
Czech Republic	Livestock density / soil management	Conventional specialized dairy farms	Organic specialized dairy farms	
Finland	Livestock density/ livestock diversity	Conventional specialized dairy farms	Organic (incl. some more diversified dairy farms)	
			Conventional specialized dairy farms-biogas project	

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France	Weed, pest and disease control	Conventional perennial (wine)	Organic perennial (wine)	Organic-Demeter perennial (wine)
Germany	Fertiliser and soil management (e.g. precision application of fertiliser, cover/catch crops, flower/buffer strips, tillage practices), crop diversification	Conventional specialized arable farms (with minor pig systems)	Specialized arable farms (with minor pig systems) (with some agro-ecological practices and/or certified as organic)	Diversified arable farms
Greece	Fertiliser and soil management (Integrated Crop Management)	Conventional fruit producing farms	Integrated fruit producing farms	Agro-ecological (integrated + biodiversity) fruit producing farms
	Pest control (insect sexual confusion)		Biodiversity fruit producing farms	
Hungary	Soil management (erosion control)	Conventional arable farms	Reduced tillage arable farms	No- till arable farms
Italy	Fertiliser Management / Soil Management	Intense perennial (wine)	Organic perennial (wine)	Organic perennial (wine) with advanced soil management
Latvia	Livestock diversity	Conventional specialized dairy	Organic specialized farms	
Lithuania	Livestock diversity	Conventional specialized dairy farms	Extensive specialized dairy farms	Extensive mixed dairy
			Organic specialized dairy farms	
Romania	Livestock density / Fertiliser Management / Weed, pest and disease control	Conventional specialized dairy farms	Organic specialized dairy farms	
		Conventional cattle rearing and fattening	Transitional[2] cattle rearing and fattening	
			Transitional[2] mixed perennial (fruit) arable farms	Organic mixed perennial (fruit) arable farms
Spain	Crop spatial diversity	Conventional arable farms	Transitional arable farms	Organic arable farms
Sweden	Livestock diversity / density	Conventional, specialised beef farms	Organic and/or more diversified dairy farms	Organic diversified production of beef or lamb and crops
			Organic and/or more diversified beef or lamb farms (FADN 834)	
Switzerland	Livestock diversity / density	Conventional specialized livestock farms (pigs, dairy)	Organic specialized livestock farms (pigs and dairy)	Organic mixed special crop – livestock farms
				Organic extensive mixed livestock farms
United Kingdom	Fertiliser Management / Weed, pest and disease control	Conventional mixed farms	Transitional[2] mixed farms	Organic arable farms

[2] The term “transitional” is used to characterize conventional farms, which apply some practices used in organic agriculture.

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Austria (Ökoregion Kaindorf - mixed farm)

The project partner in Austria focused on the bottom-up initiative *Ökoregion Kaindorf* the objective of which it is to establish an ecological circular-flow economy in the region, targeting different sectors to combat climate change and develop mitigation strategies. Agro-ecological practices implemented aim at increasing humus content of soil through adapted cultivation techniques such as reduced tillage, compost, green cover. Austria explores these practices by comparing "humus farmers" that implement these practices comparing to conventional farmers. Within the humus farmers, the agro-ecological transition is explored by comparing farms that only do soil interventions (weak agro-ecological) with those that have redesigned their whole farming system, by being organic or highly diversified (strong agro-ecological).

Czech Republic (Vysočina region – dairy farms)

The Czech case study focused on the comparison of two farm groups to assess the agro-ecological transition pathway: conventional and organic dairy farms with a significant share of milk sales (code FADN 450) in the Vysočina region.

Finland (Nivala region – dairy farms)

The Finish case study focused on three farm groups along the agro-ecological transition pathway: Conventional dairy farms (FADN 450), conventional dairy farms active in the proposed biogas project and organic dairy farms with some of the latter being more diversified (FADN 832).

France (Auvergne-Rhône-Alpes – winegrowers)

The project partner in France selected wine producers in Auvergne-Rhône-Alpes Region (FADN 192/193) in different departments of the region Auvergne-Rhône-Alpes to explore agro-ecological practice related to the reduction of fertiliser and pesticide use. Agro-ecological transition was assessed along the gradient of organic certification, comparing conventional, organic and organic Demeter farms. It is important to note that even the conventional farms are striving towards reducing the use of highly contested pesticides.

Germany (Nienburg in Lower Saxony – arable farms)

The case study area selected comprises an intensive agricultural area with particular sustainability issues regarding biodiversity loss and water pollution threats. The case study area is adjacent to intensive livestock regions with severe issues of manure management and impacts on land (rental) prices. The German case study provides an example for the analysis of what is required to initiate the transition process to agro-ecological farming in cases of highly market-oriented farming with relatively low level of agro-ecological innovation. Thus, the different agro-ecological levels consist of farms which implement no or 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.

Greece (Imathia region of Central Macedonia – fruit farms)

The project partner Greece investigated two agro-ecological practices in the fruit production, namely integrated crop management and insect sexual confusion methods for pest control. Integrated crop management consists of the limited use of fertiliser, pesticides

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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.

The assessment of the current situation of agro-ecological transitions included the comparison of conventional farmers, who do not apply any of the two practices, with farmers that apply one of the two practices, with farmers that apply both practices at the same time.

Hungary (Belső Somogy region – arable farms)

The Hungarian case study focused on different tillage practices with the aim to control erosion. Three different levels of agro-ecological transition were considered, namely conventional, reduced (tillage every 2 to 3 years in line with crop rotation) and no tillage. Others were more innovative and used a no-till system, but neither applied direct seeding nor planted cover crops or exhibited a complex crop rotation. A few other farmers applied one or more of these latter techniques, or modern Geographic Information System based precision tools to reduce pesticide and fertiliser use. Otherwise, with respect to market position, economic strength, social impacts, the farms had considerable similarities.

Italy (Chianti region – winegrowers)

The baseline consists of mainly conventional winegrowers with intensive production methods. The second farm group along the agro-ecological transition pathway is organic winegrowers. The third group consists of organic wine producers but with advanced soil management techniques such as grass cover between the rows.

Latvia (countrywide – dairy farming)

In Latvia, the focus was to explore the diversity of dairy farmers as an agro-ecological pathway, i.e. to what extent the farms combine arable and grassland-based farm enterprises. The project partner in Latvia grouped the farms along the agro-ecological transition pathway into conventional specialized dairy farms and organic specialized dairy farms.

Lithuania (countrywide – dairy farming and cheese making)

Similar to Latvia, the agro-ecological transition was based on the diversity of the farming systems. The Lithuanian case study grouped the farms slightly different into specialized dairy farms, extensive or organic specialized dairy farms and extensive mixed dairy farms.

Romania (Transylvania and Maramures region – mixed farms)

The project partner in Romania selected three farm production types to be part of the case study: 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.

Spain (Basque Country and Navarra – cereal farms)

The Spanish case study focused on the spatial diversity of crops as a practice which characterizes the agro-ecological transition pathway. It grouped the farm into arable farms

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without any organic production, arable farms that partly produce organic and farms that are fully organic produce.

Sweden (countrywide – ruminant farms)

The Swedish project partner assessed livestock diversity at different agro-ecological stages, focusing on both dairy and fattening. Stage 0 of the transition pathway groups conventional farms (only fattening). Stage 1 groups more diversified fattening or dairy farms, most of which were partly organic (some farm enterprises). Stage 2 groups are very diverse, fully certified organic farms.

Switzerland (Lucerne Central Lakes region – livestock farms)

Switzerland, similar to Sweden, investigated livestock diversity at different agro-ecological stages. Stage 0 comprises conventional livestock farms. The first stage of the agro-ecological transition is a grouping of organic livestock farms. The final stage of the agro-ecological transition 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).

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

The UK case study focuses on 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). The transitional farms apply practices that are on a gradation towards organic, but may not intend to convert to organic status.

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4. RESULTS OF THE DST ASSESSMENTS

The following sections summarize the interesting patterns of DST performance results between the farm groups in the case studies with regard to the core components (Focus Topics) of the dilemmas described in Section 3.1. Additional sections describe other aspects of sustainability and related patterns.

The following sections show a summary of **patterns of similarities and differences between farm groups** for the respective topic. More information on each of the case studies is available in the case study reports, which are included in the appendix.

In the following sections contain the terms “score”, “results”, “perform”, etc., which refer to multi-criteria ratings of the biodiversity assessment in Cool Farm Tool and of SMART. Both methods output scores from 0% (worst) to 100% (best) for different categories (referred to as “themes” or “subthemes” in SMART). The latter are included in *italic* font.

4.1. Focus Topics

4.1.1. Greenhouse Gas Emissions

Austria (Ökoregion Kaindorf - mixed farm)

Results show slightly lower greenhouse gas (GHG) emissions by farmers which have agro-ecological practices. These are the farmers who actively promote carbon sequestration on their fields compared to the conventional baseline. In addition, perennial systems cause low GHG emissions or a net carbon gain due to positive changes in soil carbon stock in fruit tree orchards.

Czech Republic (Vysočina region – dairy farms)

Results for the SMART subtheme *Greenhouse gases* show a better score for organic farms. The factors reducing the score of conventional farms include e.g. storage and application of slurry, lower proportion of grassland, higher consumption of nitrogen fertilisers, higher energy intensity (higher electricity consumption per hectare).

On the other hand, there are some similarities in both groups, e.g. the extensive management of permanent grassland and little interest in non-tillage farming as well as in renewable energy sources.

Finland (Nivala region – dairy farms)

For the SMART subtheme *Greenhouse Gases*, the subtheme score varies from 41% at a conventional farm to 64% at an organic farm. The group of the latter farm also performs on average better in comparison to the other two conventional farm groups.

France (Auvergne-Rhône-Alpes – winegrowers)

All farms exhibit two main sources of GHG emissions. These are energy used for plant protection and land maintenance, and energy used for harvesting and crop residue management.

Organic farms tend to consume more energy for land management and land maintenance. This result could be explained by the fact that organic winegrowers practice energy intense mechanical weeding while conventional winegrowers only use few nitrogen fertilisers.

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Germany (Nienburg in Lower Saxony – arable farms)

An average farm in the case study area emits 887 tons of CO_2eq. However, large differences can be observed across the farms. As the major share of GHG emissions originates from the activities of manure management and feed production, farms involved in livestock production emit larger quantities of CO_2eq compared to those which deal only with crop production. Focusing on the differences in the context of crop production, the impact of implemented agro-ecological practices can nevertheless be observed. Farms with practices like reduced tillage reveal considerably lower GHG emissions for comparable crop products.
Interestingly, the GHG emissions for the off-farm transport represent a minor share of the total emissions due to all farmers selling their products to neighbouring wholesale markets or cooperatives (or even directly from the field). This implies that the results do not cover all transport emissions, which emerge along the transport-route to the end-user.

Greece (Imathia region of Central Macedonia – fruit farms)

According to the case study results, farms that use agro-ecological practices have higher emissions than the conventional ones. This can be attributed to the fact that the number of fertiliser and pesticide applications is the same with (or higher than) the conventional farms. Moreover, the farms that support agro-ecological farming approaches have higher energy requirements for fieldwork, as in the case of drip irrigation, which is considered as a more energy-consuming irrigation method.

Hungary (Belső Somogy region – arable farms)

In general, all farms scored similar SMART results ranging from 43% to 58% of goal achievement with regard to greenhouse gas emissions. The variation between the results can be explained by other reasons such as the variation in soil cultivation methods ranging from the full tillage in the conventional baseline to no-till in the most advanced agro-ecological farm group. These SMART results are also confirmed by Cool Farm Tool with the highest differences in CO_2eq emissions were due to differences in soil cultivation practices.

Italy (Chianti region – winegrowers)

The agro-ecological farm groups exhibit lower GHG emissions per hectare than the conventional baseline. This is mainly due to increased carbon sequestration connected to conservation farming techniques applied in the two agro-ecological farm groups. In turn, the latter groups exhibit higher GHG emission due to energy use related to fieldwork, which could be because of the higher specialisation in winegrowing (rationalization) for the agro-ecological groups.

Latvia (countrywide – dairy farming)

The emissions from the dairy livestock operation in both the conventional and the organic farm groups, are many times higher than the emissions from the cropland. Conventional farms exhibit higher feed-related GHG emissions due to a greater amount of feedstuff being purchased instead of grown on the farm.

Emissions from soil and crop fertilization are higher for conventional farms due to the additional use of mineral fertilisers. Similarly, the use of plant protection products on some of the conventional farms results in higher GHG emissions.

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Lithuania (countrywide – dairy farming and cheese making)

With regard to animal rearing, enteric fermentation contributes the most to GHG emissions on all farms. The second highest share relates to manure management practices. Consequently, organic farm farms have shown lower emissions per kg FPCM with regard to dairy enterprises due to their improved manure management (among other factors).

Romania (Transylvania and Maramures region – mixed farms)

Results for the subtheme *Greenhouse Gases* from SMART vary for the Romanian case study. The subtheme scores vary from 56% to 73% with an average of 64.5% goal achievement. There is a slight tendency that the more extensive (organic) farms receive higher scores (corresponding to lower emissions). Conventional farms moreover have slightly lower scores, however with very little variation from the average and the dairy farms.
The use of large amounts of external feed inputs on the non-grazing conventional farms results in large GHG emissions compared to the organic and conventional grazing dairy operations. The largest GHG emissions are related to the production of off-farm produced feed inputs.

Spain (Basque Country and Navarra – cereal farms)

Greenhouse gas emission per hectare is 56% bigger in the group formed by mixed and conventional farms compared with the farmers using agro-ecological practices. For the latter, despite the spread of data in all farm groups, the explanation is the result of lower fertilisers and plant protection products use.

Sweden (countrywide – ruminant farms)

Based on SMART score, there is a slight tendency that the more extensive beef farms receive higher scores (corresponding to lower emissions). The conventional farms have slightly lower scores, however with very little variation from the average and the dairy farms.

Results from CFT for the climate impact at farm and product level show that emission intensities for beef per kg live weight vary from 11.3 kg CO_2eq/kg live weight to 40.2 kg CO_2eq/kg live weight. The Swedish average per kg slaughter weight has previously been measured to be around 20 kg CO_2eq/kg (SW) (Moberg *et al.* 2019). For milk, the three farms included in the Swedish case have emission intensities that match average values for Swedish production, around 1.2 kg CO_2eq/kg fat and protein corrected milk, PFCM (Moberg *et al.* 2019). For both, milk and beef, methane emission from enteric fermentation and emissions associated with feed production are the two main contributors of greenhouse gas emissions.

Switzerland (Lucerne Central Lakes region – livestock farms)

When comparing the GHG emissions of different crops between the defined farm groups, the averaged emissions of the conventional farms are always higher than the organic farms. Despite a high spread in the data, recently introduced no-till practices of organic farmers are likely to have contributed to the result. These practices resulted in negative GHG emissions for some organic farms. Without the effect of no-till, organic farms only exhibit lower emissions for grassland and barley, mainly explained by higher application rates of N-

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fertiliser on conventional farms while organic farmers are limited with organic fertiliser application because of legal P fertilization limits (see further below).

The emissions of dairy farming are similar for both the conventional and the organic farms. The average emission of CO_2eq per kg of PFCM is 0.86 kg (off-farm processing energy input not included).

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

The management practices characterizing the organic farms, produced direct climate benefits in both cropland and livestock enterprises. These practices include the long-term organic fertilization on one organic farm, which contributes to an increase in the stock of Carbon in arable soils.

Cross-case analysis

An interesting pattern emerges from the results of the case studies. The farming system plays a crucial role in the GHG mitigation potential of agro-ecological farm groups. In perennial systems, the high use of organic pesticides offsets other agro-ecological practices with regard to greenhouse gas emissions (France and Greece). In addition, some agro-ecological field management practices, such as mechanical weeding or drip-irrigation, contribute to higher GHG emissions (France and Greece).

This picture changes in arable systems, where soil conservation techniques contribute to GHG mitigation (Austria, Germany, Hungary, Italy and Switzerland) and pesticide use is normally higher for conventional farm groups (Latvia and Spain). One main contribution to GHG emissions on arable farms is the application rate of N-fertiliser, which is normally lower in more agro-ecological farm groups (Czech Republic, Spain and Switzerland).

With regard to animal husbandry, differences in results are more subtle. Some agro-ecological practices, such as growing instead of buying the feed and a less CO_2eq-intense manure management can contribute to lower GHG in agro-ecological farm groups (Latvia, Lithuania, and Romania).

4.1.2. Biodiversity

Austria (Ökoregion Kaindorf - mixed farm)

The biodiversity performance of all farm groups is poor to medium (Cool Farm Tool). However, while the conventional baseline has very poor ratings in almost all biodiversity categories, farms with agro-ecological practice score better. This is in line with the SMART result for farm groups *without* perennials where SMART rates the conventional farm group lower because of the frequent use pesticides. SMART however rates farm groups *with* perennials higher in the subthemes *Ecosystem*, *Species* and *Genetic Diversity*, irrespective of whether they are farms with agro-ecological practices or not.

Czech Republic (Vysočina region – dairy farms)

The organic farms scored in most CFT biodiversity indicators better than their conventional counterparts did. The only exception was the indicator *Farmed products* evaluating the diversity of crops and livestock. The reason was that conventional farms, unlike organic farms, also devoted to fattening pigs or poultry and more often kept several breeds. However, all evaluated farms cultivated a diverse spectrum of crops (about 10 different crops, of which 4-5 cereals) and used more than one variety for 1-3 crops.

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CFT confirms the higher rating of organic farming with regard to production practices. The clear benefit of organic farming is the elimination of pesticides and mineral fertilisers that are commonly used on conventional farms. Conventional farms used seed dressing, growth regulators, desiccants and preventively applied herbicides and fungicides.

The low value of the *Small habitats* indicator for both groups of farms confirms their narrow focus on the core agricultural activity. Also, the *Woodland, Wetland and Acquatic flora and fauna* indicators have low values across all farms with slightly better scores for organic farms. The main reason for the low scores is that farms try to avoid landscape elements such as hedges, ponds etc. when renting land because they risk penalties when those landscape elements are destroyed (e.g. by the land owner).

Higher rating of organic farms in the *Arable* and *Grassland flora* indicators is given mainly by higher representation of areas with naturally occurring grasses and flowering plants (field margins, field corners, verges along roads), which is related to keeping smaller fields in organic farming (2-6 ha compared with 10-18 ha in convention).
In line with the CFT results, also organic farms scored better with regard to the SMART theme *Biodiversity*. The main explanatory factors for the lower scores of conventional farms are a different structure of crop production, intensive use of pesticides and fertilisers, lower proportion of permanent grassland (20% on average on conventional farms to 40% on organic farms) and larger average size of the fields of arable land. That interconnection of areas to promote biodiversity is not common in both farm groups affected the rating of the SMART theme *Biodiversity* negatively.

Finland (Nivala region – dairy farms)

For *Biodiversity*, the SMART scores for the *Species diversity* ranged from 42% on conventional farms to 60% on an organic farm. The group of the latter farm also performs on average better than the other two conventional farm groups.

France (Auvergne-Rhône-Alpes – winegrowers)

Farm groups performed similarly with regard to *Biodiversity*, whether they are organic or not.

Germany (Nienburg in Lower Saxony – arable farms)

Within both farming groups, the major share of the land is used for intensive agricultural production. In addition to the wide and intensive application of fertilisers and pesticides, only few areas and practices target biodiversity (between 97% and 100% of the total farm land is used for agricultural production). This is reflected in the low biodiversity scores of the CFT (29% on average). While biodiversity indicators concerning "farmed products" or "arable flora" do not vary substantially across all farms, farms with some implemented agro-ecological practices perform better for several other indicators. Noticeably higher performing results concern, for instance, "farming practices" and "soil fauna", the latter shaped by farms practicing reduced tillage. The results are also backed-up by the outcomes of SMART. On average, achieving the sustainability objectives of the SMART subtheme "Biodiversity", namely "genetic diversity" (23%), "species diversity" (39%) and "ecosystem diversity" (34%) is rated as "limited" for all assessed farms.

Greece (Imathia region of Central Macedonia – fruit farms)

Conventional farms score lower with regard to *beneficial invertebrates* than weak agro-ecological and the agro-ecological farms. One reason for this is the application of plant

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protection products potentially harmful to invertebrates, while the agro-ecological practices (traps and pheromone dispensers) aim to substitute pesticide application.

Hungary (Belső Somogy region – arable farms)

SMART subtheme results generally are low for all farms, because they are highly specialised in crop production and exhibit a relatively low number of elements in crop rotation (3-4 elements). However, soil conservation techniques had an impact on the biodiversity score of the farms. The no-till farm group, and in general farms with more advanced soil management practices, scored better with regard to *soil fauna*.

Italy (Chianti region – winegrowers)

With regard to the biodiversity indicators calculated using both SMART and Cool Farm Tool, it appears that biodiversity is relatively homogeneous in all of the groups of farms. This is not surprising considering the high specialization of the area in winegrowing.

The Cool Farm Tool biodiversity indicators for livestock and crop varieties, small habitats, aquatic flora and fauna indicators are slightly higher for the farms classified at the third stage of the transition, while arable birds and flora indicators are higher for the farms classified at the second stage of the transition.

Latvia (countrywide – dairy farming)

In general, the organic farm group scored better than the conventional farm group. Some reasons include that organic farmers have slightly greater diversity of on-farm produced fodder crops (e.g. grains), cultivate intercrops and have a higher share of permanent grassland. This results in a higher biodiversity in terms of *grassland flora* and bird biodiversity. However, neither conventional nor organic farm groups implement targeted measures to promote flowering plants and habitats for birds.

Lithuania (countrywide – dairy farming and cheese making)

With regard to the Cool Farm Tool biodiversity assessment, the organic farms scored better in the promotion of different *species groups*. This is mostly because of mixed farming (dairy and arable) and organic practice.

With regard to the Cool Farm Tool scores of *farming practices*, extensive farmers and organic performed similarly. This was also the case for *farmed products* because none of the farms especially focused and aimed for crop/animal diversity between and within species.

Similar to Latvia, targeted measures to promote biodiversity were not common.

The group of extensive, mixed grazing livestock/dairy farms performed best with regard to the SMART rating. This is due to the fact that conceptually, and to some degree practically, farms in this group oriented themselves towards sustainability (at least the environmental aspect).

Romania (Transylvania and Maramures region – mixed farms)

Lowest SMART biodiversity scores are found on two conventional farms that are using fertilisers and plant protection. However, even if conventional farms are using chemicals and fertilisers, SMART results are between 40- 60%.

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Spain (Basque Country and Navarra – cereal farms)

The farmers with agro-ecological practices scored higher than conventional farmers with regard to *biodiversity*. The main reasons for the differences were the use of mineral fertilisers and plant protection products by the conventional farmers. The variety of crops, the number of elements in the crop rotation, the biodiversity promotion areas and other factors also contributed to explaining the differences.

Sweden (countrywide – ruminant farms)

With regard to the SMART subthemes *ecosystem* and *species diversity*, conventional farms score at the lower end of the spectrum. The main explanatory factors for the lower scores seem to be lack of effort for interconnection of areas to promote biodiversity, the use of pesticides and small shares of land under woodland and/or permanent grassland.

In all of the farm groups, the grassland is managed extensively. Organic farmers tend to score higher as their genetic diversity reached by diversification and different number of different livestock types of rare or endangered.

Switzerland (Lucerne Central Lakes region – livestock farms)

With regard to the SMART theme *Biodiversity*, the conventional farms scored lower than the organic farms (50% compared to 66% to 75%). One main reason is that there are more tree habitats on the farms belonging to the group of organic livestock farms (pigs and dairy) and farms with special crops (both forest and fruit trees). Two organic farm groups, (special crops and extensive mixed livestock) keep rare breed and cultivate rare crops, which also contributes to the higher SMART rating. The use of chemical synthetic herbicides on the conventional farms and their higher N- fertiliser application rate contributed to a lower score in *Biodiversity*.

The biodiversity rating of Cool Farm Tool reveals the lack of larger nature protection areas across all farms assessed.

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

The organic farm group scored highest with regard to biodiversity. Scores were lower on conventional and transition farms because of the use of chemical fertilisers and crop protection products.

Cross-case analysis

In most cases, with the exception of perennial systems in France and Austria, agro-ecological farm groups perform better than the conventional baseline. First and foremost, this is due to the differences in farming practices. The agro-ecological farm groups in the case studies apply soil conservation practices such as tillage practices (Hungary, Germany), biodiversity practices (Germany), exhibit a higher diversity of elements in the crop rotation (Italy, Latvia, Spain and Switzerland), a higher livestock diversity (Sweden and Switzerland) and smaller plot sizes (Czech Republic). Furthermore, they apply less or no pesticides (Czech Republic, Greece, Spain, Sweden, Switzerland and UK) and less N- fertiliser (Czech Republic, Spain, Switzerland and UK).

Often, the agro-ecological farm groups tend to have a higher share of tree habitats and permanent grassland (Sweden, Latvia and Switzerland).

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Agro-ecological farming practices do not necessarily need to go hand in hand with targeted measures to promote biodiversity (Latvia and Lithuania) or the creation of large habitats (Lithuania, Switzerland). In these areas, conventional and agro-ecological farms perform similar.

4.1.3. Soil Quality

Austria (Ökoregion Kaindorf - mixed farm)

The farm groups implementing measures for soil quality and humus formation did not perform better than conventional farms in the SMART subtheme *Soil Quality*. A first analysis of indicators shows that some of the conventional farms do apply the same techniques those with agro-ecological practices, e.g. reduced soil management, catch crops in crop rotation, green cover during winter period, mulching, and measures to prevent soil compaction.

Czech Republic (Vysočina region – dairy farms)

The rating in the SMART *Soil Quality* subtheme of the conventional farm group was slightly lower (51%) than the score of the organic group (65%). The latter did not risk residues from chemical synthetic pesticides in the soil and used legumes in crop rotation more often. Also, intercropping and undersowing crops was more common in this farm group.

Signs of soil compaction, physical soil degradation, were insignificant on all the assessed farms. Degraded lands on the farms did not exist. Similarly, the risk of erosion in the region is low - there are no steep slopes in the agricultural landscape and the slope is up to 7%. While soil analysis was conducted on the farms, none of the farms calculated the humus balance of their soils.

Finland (Nivala region – dairy farms)
With regard to the subthemes *Land Degradation* and *Soil Quality*, the organic and/or more diversified farms score lower either than one of the conventional farm groups or even both.

France (Auvergne-Rhône-Alpes – winegrowers)

With the exception of one farm which is slightly lower than the others, all farm groups scored relatively highly in the SMART subtheme *Soil Quality* (> 60%). Some of the reasons were that farms generally mulch the land and that slopes are mostly covered with grass.

Germany (Nienburg in Lower Saxony – arable farms)

In terms of the soil quality, the respective SMART scores indicate a "moderate" achievement of all related sustainability objectives, with no directly observable differences between the farm groups. To some extent, the low score can be explained by a wide application of fertiliser and pesticides. Furthermore, little erosion management beyond catch crops and green cover takes place, compost was not applied at any of the farms, and only few of the farms created humus balances. However, the farm managers generally perceive the soil quality as sufficient and do not observe signs of severe soil compaction. Interestingly, more substantial differences across farm groups can be observed for the CFT biodiversity indicator "soil fauna". Shaped by conducting reduced tillage on some farms, the soil fauna is scored at 61% for the more agro-ecological farm group, but 39% for the conventional group.

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Greece (Imathia region of Central Macedonia – fruit farms)

Based on the results, it seems that most of the farms grouped as partly agro-ecological or fully agro-ecological have a higher performance concerning soil quality. This finding seems to be reasonable as farms that apply Integrated Farming manage their soils properly by analysing soil nutrient requirements, increasing water retention and controlling soil erosion. The soil quality is also improved through preventing soil contamination by reducing chemical insecticides.

Hungary (Belső Somogy region – arable farms)

In general, all farm groups scored around 40% to 60% in SMART. The no-till farm group (only one farm) scored higher with 65%.

Italy (Chianti region – winegrowers)

No appreciable differences emerge among the selected group of farms. However, groups differed with regard to the soil quality- related practices they applied, e.g. the group organic perennial (wine) controlled soil erosion by growing grass between vine rows.

Latvia (countrywide – dairy farming)

The score with regard to the SMART subtheme *Soil Quality* is only slightly higher for the organic farm group than for the conventional. The main indicators that contribute to the slightly lower score of the conventional farm group are the use of mineral fertilisers and plant protection products (herbicides and fungicides). Organic farms rely entirely on cattle manure fertiliser and more often use intercropping, mixed crops to address weeds and include perennial grass with clover/ legumes in the crop succession to replenish soil fertility. However, farms in the conventional farm group undertake soil analyses more regularly to determine fertilization requirements.

Lithuania (countrywide – dairy farming and cheese making)

With regards to the SMART subtheme *Soil Quality*, lowest results are found in farms that grow arable crops and use fertiliser and pesticide inputs.

Romania (Transylvania and Maramures region – mixed farms)

For the SMART subtheme *Soil Quality*, all farms except one scored above 60% goal achievement. The scores range from 49% to 85% with the average score at 64.2%.

Spain (Basque Country and Navarra – cereal farms)

All farm groups scored positively with regard to *Soil Quality*, but there are differences between groups. The farm groups implementing agro-ecological practices score 71% while mixed conventional and solely conventional farmers scored 56% and 53% respectively. One reason is that soil management receives special attention in the agro-ecological group.

Sweden (countrywide – ruminant farms)

For the SMART subtheme of *Soil quality*, the outcome is generally quite good for the Swedish case due to very good conditions, no slope and abundance of land allowing letting land recover. No clear differences are found across farm types.

Switzerland (Lucerne Central Lakes region – livestock farms)

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All farm groups scored "good" in the SMART subtheme of *Soil Quality*. The rating score of the conventional group was slightly lower (66%) than the score of the organic groups (72**% -** 78%). What contributed to higher score in the organic group was the presence of undersown crops.

None of the farms used compost to increase the soil fertility. This affected the subtheme score for *Soil Quality* for all farm groups negatively.

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

There are no clear differences between the farm groups.

Cross-case analysis

Compared to other public goods, soil quality did not exhibit clear patterns between the conventional base line and more agro-ecological farm groups. In some case studies, no difference in SMART results could be noticed (Sweden and Austria), in others, only smaller differences (Switzerland, Germany and Hungary).

In those cases, where agro-ecological farm groups performed better, three main reasons for the differences could be observed: soil contamination by the use of pesticides (Czech Republic, Greece, Latvia and Lithuania), differences in soil management (Germany, Spain) and the use of mineral fertiliser (Latvia and Lithuania). With regard to the latter, the negative impact could be compensated by determining soil fertiliser requirements. This was common in one case study for conventional farmers (Latvia), and in another, it was common for farms in the agro-ecological group (Greece).

Soil management practices, which were identified as being important, were mulching (Austria, France), maintenance of grass cover between vine rows (France, Italy), undersown crops (Czech Republic, Switzerland) and no-till (Hungary, Germany). The last three practices were implemented to prevent soil erosion (Greece). In none of the case studies, composting seemed to play an important role.

4.1.4. Water Quality

Austria (Ökoregion Kaindorf - mixed farm)

SMART results show a clear trend that farms with agro-ecological practices perform better than the conventional ones.

Czech Republic (Vysočina region – dairy farms)

For *Water Quality*, the conventional group scored lower (58%) than the organic group did (80%). The main reason for lower *Water Quality* scores for conventional farms is primarily the use of chemical pesticides, which have a clear negative impact on water quality. Conventional farmers have mentioned the occurrence of water quality disputes and strong political pressure to reduce pesticide use. The risk of water pollution from other sources of agricultural activity is generally low for both farm groups.

Finland (Nivala region – dairy farms)

The group of organic farms performs better with regard to *Water Quality* than the other two conventional farm groups.

France (Auvergne-Rhône-Alpes – winegrowers)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773901.

All farm groups performed well with regard to *Water Quality*. Erosion prevention measures (e.g. mulching) was one reason among others for the good result.

Germany (Nienburg in Lower Saxony – arable farms)

With regards to the SMART water quality indicators, the farms in this case study perform mostly "moderate". While all farms implement buffer strips and/or abstain from fertiliser and pesticides applications on arable land next to water streams, their intensive application is nevertheless reducing the overall score and includes inputs which are considered to be very persistent in water and toxic to aquatic organisms according to the "PAN Pesticide Database". In contrast, the high degree of recycling, adequate disposal and information regarding the local water quality (which is not perceived as being problematic by most of the farmers) positively affected the overall score.

Greece (Imathia region of Central Macedonia – fruit farms)

Farms grouped as fully agro-ecological perform better in comparison with farms in the two other farm groups. The main two reasons are reduced fertilization and reduced pesticide use.

Hungary (Belső Somogy region – arable farms)

All farms got medium scores ranging from 50% to 63% with regard to the SMART subtheme *Water Quality*. Waste water is well managed and if there are water bodies adjacent to their parcels, farmers always leave a few meters wide, non-cultivated, grassy margins (normally used as a road) to hinder any contamination.

Italy (Chianti region – winegrowers)

Despite the use of mineral fertilisers and pesticides in the group of the conventional baseline, the SMART score for *Water Quality* does not exhibit relevant variation across farm groups.

Latvia (countrywide – dairy farming)

Organic farms score slightly higher in the SMART subtheme *Water Quality* than the conventional farms. The lower scores for conventional farms is due to plant protection products (herbicides, fungicides) and mineral fertilisers, which are not used by organic farmers. Point source contamination through wrong manure management represents the biggest risk for water contamination but cannot be attributed to a certain farm group.

Lithuania (countrywide – dairy farming and cheese making)

With regard to the SMART subtheme *Water Quality,* the farms investigated score between 59% and 91%. Farms with more conventional practices were rated at the lower end of score interval noted, whereas farms in two agro-ecological farm groups (extensive, mixed grazing livestock/dairy and organic specialist dairy) performed similarly. The lower score does not reflect the real water pollution problems caused by fertiliser-intensive farms in Lithuania.

Romania (Transylvania and Maramures region – mixed farms)

The specialised organic dairy farms score on the lower side of the spectrum and all conventional farms score lower than the worst- performing organic farm. The highest score is achieved at the mixed farm with organic dairy production.

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Spain (Basque Country and Navarra – cereal farms)

In terms of water quality, most of the farmers are not very concerned about this issue because the water is supposed to be of good quality in the most part of the region. There have been no problems with the quality of water in any of the farms.

Sweden (countrywide – ruminant farms)

The specialised organic dairy farms score on the lower side of the spectrum and all conventional farms score lower than the worst performing organic farm. One discernible pattern is that the water quality score seems to increase with how extensive the farm is, but raging across farming groups. It is not possible to say that the results mirror the pre-defined transition pathway.

Switzerland (Lucerne Central Lakes region – livestock farms)

All farms performed well with regard to the SMART subtheme *Water Quality.* While the high P-fertiliser application affected the subtheme scores negatively across all farms, some other indicators contributed to the positive rating of the farms. The absence of significant erosion processes was one of the reasons for the positive rating across all farm groups.

The conventional group scored slightly with regard to water quality than the organic groups because of the high rate of N-fertiliser application and the application of herbicides.

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

The assessment scores from SMART for the subtheme *Water Quality* ranged from 47% to 87% but with no clear pattern emerging between farm groups.

Cross-case analysis

The agro-ecological farm groups perform better in most of the case studies. This is due to a reduced use of pesticide (Czech Republic, Greece and Latvia) and fertilisers (Greece, Latvia, Lithuania, Romania, Sweden and Switzerland).

The buffer strips along rivers seem to make no significant difference between agro-ecological und conventional farm groups (Hungary). In addition, risks related to point sources did not seem to cause differences between the farm groups (Czech Republic and Latvia).

Good erosion management contributed generally to good results in this topic (Switzerland).

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4.1.5. Productivity and Farm Income

Austria (Ökoregion Kaindorf - mixed farm)

COMPAS results for the indicator **Total Output**[3] show no correlation with any of the stages in the agro-ecological transition nor with farm size. Livestock related enterprises have higher intermediate consumption, and the highest labour productivity. Although it is difficult to compare results from COMPAS and SMART, it interesting to note that the SMART results for the dimension **Economic Resilience** subthemes tend to be diametrically opposed to those of COMPAS results. While intensive pig farms perform best in all COMPAS-indicators, SMART results are better for most indicators for less intensive farms, including those with agro-ecological practices.

COMPAS suggest that in terms of net value added intensive conventional pig farms without agro-ecological practices performed better than all others. However, in terms of value added per agricultural area, farms with agro-ecological practices which engage in direct marketing perform better.

SMART result suggest that highly diversified farms with agro-ecological practices perform best in terms of profitability over the long term. Despite their workload, all farmers seemed to be quite satisfied with their work and their status as farmers. In comparison with other farms in Austria, initial inspection of net farm income suggest it is quite good and dependency on public subsidies rather low on the farms investigated.

Czech Republic (Vysočina region – dairy farms)

The *Net Value Added* (NVA) and the *Net Farm Income (NFI)* of all farms was positive. NVA per hectare of organic farms reached EUR 850 and conventional farms slightly higher EUR 1000. This corresponds exactly to FADN average EUR 825 and EUR 1000, respectively. The NVI reached from 750 EUR for the conventional and 778 EUR for organic farms per hectare, compared to the FADN average (360- 380 EUR per ha).

Both farm groups achieve almost comparable labour productivity at around EUR 32 000 per annual working unit (AWU; FADN average is EUR 23 560 in organic farming and EUR 25 856 in conventional farming per AWU). The comparison shows that organic farms with milk production can achieve comparable economic results as a convention and be viable in the long term. However, the assessed organic farms had 29% higher subsidies per hectare then conventional farms.

The difference between conventional and organic farms is apparent when comparing the total output per hectare, which was twice as low as for organic farms as for conventional

[3] Total of output of crops and crop products, livestock and livestock products and of other output. Sales and use of (crop and livestock) products and livestock + change in stocks of products (crop and livestock) + change in valuation of livestock - purchases of livestock + various non-exceptional products (FADN definition)

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farms (on average 22 000 CZK/ha compared to 48 000 CZK/ha for conventional farms). This can be attributed to lower yields, both for arable and dairy production.

The generally robust economic situation on all farms is mirrored in the scores of the SMART subtheme *Profitability*: On average 75% for conventional farms and 71% for organic farm groups. All farms, including family farm, have professional accounting, achieve stable profits and make long-term investments (most often land and equipment purchase and stable repair). Most of the selected farms also have income from other activities (petrol station, canteen, sawmill, joinery, coal or sand sale, own milk or meat processing and farm shop) accounting for maximum of 10% of the farms' total income. None of the farms reported liquidity problems.

Finland (Nivala region – dairy farms)

The group of conventional farms active in the biogas project score highest in subthemes like *Long-ranging Investment*, *Stability of Market* and *Stability of Production* which indicates sound competitiveness also in the future. The organic farms, in turn, score highest in subthemes like food quality, food safety and product information which refers to ability to provide consumers what they want and thus fulfil their needs. This kind of ability offers a competitive advantage to organic dairy farms. The conventional farms not active in the biogas project score on average lowest in 10 out of 15 subthemes in the economic dimension of SMART compared to the other two farm groups.

France (Auvergne-Rhône-Alpes – winegrowers)

For the wine producer in France, labour productivity is highly influenced by the length of the value chain into which the wine goes rather than the agro-ecological practices. Gross margin is highest for producer that sells to customers directly, leading to higher labour productivity. Lowest labour productivity is found in farms that harvest by hand or for the production of cheap wines. The size of the farms also plays a role, with smaller, less mechanized farms using more seasonal labour and less harvesting machinery.

Net incomes seem to be driven by farm size rather than by agro-ecological stages. Bigger organic farms outperformed smaller farms. Within the smaller farms, organic farms generally perform better than conventional farms of similar sizes. In terms of net income per hectare, the pattern seems to different by region. The highest level of value per hectare is held by the two smallest farms in Bugey, where wine can be sold at a better price compared to other regions. For farmers who chose to leave the appellation, they can have a higher production per hectare. The lowest performance is achieved by the second stage agro-ecological farm.

Germany (Nienburg in Lower Saxony – arable farms)

Comparable farming practices and conditions lead to similar yields and gross margins for crop and livestock products across the farms in the case study area. No differences can be observed between the different farm groups. However, whether or not arable farms are also involved in livestock production directly affects the farm net incomes and, thus, their labour productivities. While the average labour productivity of all assessed farms is €57,000, the highest values, between €75,000 and €123,000, are achieved on farms, which are additionally involved in pig production. In contrast, the labour productivity between the farms only being involved in crop production is between €33,000 and €62,000.

Following the SMART-theme of profitability, all farms show "good" results with usually more than 70% of the sustainability objectives being achieved. While all farms generate profits

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and thus cover their cost with their revenues, unmet objectives consist of, amongst others, a little degree of income diversification, including no on-farm processing of any kind.

Greece (Imathia region of Central Macedonia – fruit farms)

Labour productivity in the Greek case is characterized by a high variability between the individual farms and among the three stage of agro-ecological transition. For example, farms that are similar in size and net value added can have very different hours worked.

Farm income is very heterogeneous and not driven by agro-ecological practices, but instead by size.

Hungary (Belső Somogy region – arable farms)

Medium and large size farm make of the best available inputs, seeds, technologies and services available on market in order to maximise production and profit. That is why their average yields are much higher than the national averages, and which explains their higher labour productivity.

Italy (Chianti region – winegrowers)

The region is characterized by a long-standing tradition in winegrowing productions. The wine produced is of high quality and it guarantees high revenues, well above the average of farmer revenues in Italy. Many farmers process the grapes and sell wine bottles through their own private label, increasing their market power. The agricultural activity is also supplemented by farm housing that guarantees a more stable cash flow. The difference in farm productivity among the farm groups classified within the three stages of the transition reflects the differences in the degree of specialization addressed by farmers (measured in agricultural area covered by vineyards/UAA). Productivity as a percentage of the output is also decreasing, suggesting that margin decreases as volume of production increases.

Finally, it is notable that the size of the holding seems to play an important role in triggering changes in the management practices as it favours investments in new facilities to compost pruning residues and livestock waste and investments for new machineries for land use management.

Latvia (countrywide – dairy farming)

Subsidies make up a significant part of the Gross Farm Income of both organic and conventional farms which plays an important role in the labour productivity computation. In the case of organic farms, subsidies can be as much as 50% of total output whereas for conventional farms this is somewhat less at 25%. Consequently, subsidies can more than make up for the loss in farm output of organic agriculture. Nevertheless, in general, farm labour productivity is higher for conventional farms. Gross margin per dairy cow is generally higher for the conventional farms than organic farms.

Net Farm Income is highest for the largest conventional dairy farm, however no pattern can be observed amongst smaller farms.

Lithuania (countrywide – dairy farming and cheese making)

Milk productivity per dairy cow is the highest in conventional specialized dairy cow farms, followed by organic specialized dairy cow. The lowest productivity was found in the extensive mixed crop livestock system investigated. From the interviews, it was notable that farmers in extensive mixed crop livestock do not orient towards productivity volume, but

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rather towards the quality needed for processing and producing high quality dairy products. This explains the high share of hay in winter ration of animals.

Extensive mixed crop livestock farms which represent the third stage of agro-ecological transition have a lower labour productivity compared with the other farms.

All farms reported they had a profit scoring in SMART which was very close in the subtheme Profitability of between 61% and 71%. However, all farms reported that the cost of inputs are increasing steadily in recent years. Organic farmers that have fewer inputs are much less dependent. Farmers in non-organic extensive mixed crop livestock farms were all considering increasing the price of their produce in response to this. None of the farms involved in direct marketing had issues with demand of their products with score being from 70% to 78%. Whereas, organic specialized dairy production had doubts about organic milk market scoring 46% and 63% as their cooperative has to export the milk to neighbouring countries, as the prices offered domestically are unsatisfactory. Conventional specialized dairy reported dependence on one main customer with doubts of there being any other at an acceptable rate per tonne of milk.

Almost all farms were heavily dependent on direct payments, except for two farmers in the mixed-crop livestock system, whose proportion of direct payment to overall income was the lowest.

Romania (Transylvania and Maramures region – mixed farms)

The *Net value added*, the *Net farm income* and therefore the labour productivity of all farms are positive. One should however consider that the "true" AWU might differ between farms that have formal employees and those that are run as family farms.

The *Net value added* of conventional farms is double as high as the one of the small-scale organic farms. A large part of the *Net value added* for both farm groups is from CAP subsidies – contributing up to around 80% to the *Gross farm income* for organic farms and 50% *Gross farm income* for conventional farms.

The average income is around 50500 EUR/year, which is, converted to a hypothetical monthly salary, far above the average for farmworkers in Romania. Hence the farms seem economically sustainable. However, there are outliers: The lowest *Farm* net income is 5867 EUR/year. It could be explained that the owner of the farm receives the main income for other off-farm activities or the farming in generally is not profitable.

Overall, farmers do not have access to storage and processing infrastructure and are thus forced to sell their raw materials (fruit, milk, and vegetables) at very low prices to industrial processors in Romania or abroad.

Spain (Basque Country and Navarra – cereal farms)

In Spain, variation of labour productivity is explained by location and the resulting need for irrigation rather than due to the agro-ecological transition stage. Despite the big differences between farms all of the farms analysed are in profit.

Nothing can be concluded between the different stages of agro-ecological transition due to the limited sample size and the incomparability due to the variety of crops. Some farms have high farm income in stages. All of the farms show a high dependence on public subsidies, in the line of the agricultural sector. There are no remarkable differences between the different agro-ecological stages.

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One aspect that should be emphasized is the difference in the model of business of the agro-ecological group with the other groups. Conventional and mixed farms base their activity on increasing productivity and hectares to subsist. In contrast, in the agro-ecological farms analysed, dimension and productivity are not so important. In this business model providing added value to their products is the key factor. Agro-ecological farms of this case study are usually smaller, but their products are often better paid.

Sweden (countrywide – ruminant farms)

The *Net value added* and the *Labour productivity* of all farms is positive. One should however consider that the "true" Annual work unit may differ between farms that have formal employees and those that are run as family farms. It was not uncommon among the farmers in the case study that they stated that they work 12 to 14 hours per day, seven days a week, essentially throughout the year (approximately 4,700 hours/year) which would mean than they work more than twice as much as one employed full-time worker in Sweden (approximately 2,100 hours/year). There is however no identifiable pattern of results mirroring the pre-defined transition pathway, either for the dairy farms or the meat producing farms.

The *Net farm income* varies for the farms included in the Swedish case study. All except two farms are positive. This outcome is unexpected as these are two farms are run more as companies or businesses and the results from COMPAS do not reflect the reality described by the farmers during the farm visits. For one farm a possible explanation is the big acquisition it made during the reference year. For the second farm it is because COMPAS does not capture the on farm processing.

It should also be noted that several of the farm managers/owners receive their main income from off-farm activities, and to some extent currently, or permanently operate their farms without an aim of making a living wage from its enterprises. Notably in the Swedish context most farmers, including the majority in the case study, run "side-businesses" that are financially very important but that have not been considered in the analysis. These may be revenues for forestry which is often key to the finances of a farming company in Sweden, machine rental services (often snow clearing in winter) and performing contract work for other farmers. Therefore, the *Net farm income* says something about the economic sustainability of the farming operations isolated from other enterprises on the farm, which hence affects the outcome, but it highlights the viability of farming.

Switzerland (Lucerne Central Lakes region – livestock farms)

The average labour productivity in the different agro-ecological transition stages are all at least above the Swiss average for labour productivity in agriculture which amounted to CHF 53,000 in 2018 for one full-time equivalent (2,800 hours / year; Swiss Federal Statistical Office, 2019). The Swiss average converts to around CHF 42,400 for a full-time equivalent of 2,200 hours / year. The lowest labour productivity (basis 2,200 hours / year) in the case study is the group with **the extensive mixed livestock (second stage of agro-ecological transition)** with approximately CHF 50,000. This is because the respective farm manager has a job outwith agriculture. The average labour productivity is higher in the organic mixed perennials (second stage of agro-ecological transition) (approximately CHF 60,000) and other organic specialized dairy (CHF 85,000). Between the organic and the conventional farms, there is a large difference. The labour productivity of the control group without any agro-ecological practices amounts to approximately CHF 180,000, which is more than

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double of the highest average productivity of the organic farm groups. In summary, moving along the agro-ecological transition pathway would mean a decrease in labour productivity.

This large difference between conventional and organic farm groups is because both of the conventional farms assessed operate highly efficiently. One farm has specialized workflows on the farm by means of share farming, and the other farm exhibits a high degree of mechanisation. Additionally, the output of both farms is very high which compensates for other aspects such as the relatively low milk price. While both farms are not likely to represent typical conventional livestock farms in the region, the general difference between organic and conventional farms with regard to labour productivity seems plausible.

In general, the labour productivity for all farms does not exactly mirror the conditions on the farms because it neglects the fact that farmers often work long hours.

In SMART, all of the investigated farms scored well in the subtheme of *Profitability* (70% to 76%). In SMART, the fact that all farms could cover their cost with their revenues contributed to these "good" ratings. This is confirmed by the COMPAS indicator *Net farm income which* was clearly positive for all farms. The SMART scores for *Profitability* were negatively affected by the fact that engagement in activities with high added value (e.g. on-farm processing, agri-tourism etc.) was not common.

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

Labour Productivity ranges from -£7,346, the only farm with a negative value for productivity, to £58,773 (Figure 5b). In that respect, the negative value of labour productivity in a farm that was unable to remunerate its permanent staff.

The negative Net Value Added for one farm was due to the relatively low subsidies declared (£57,698) and high annual depreciation values (£64,428). A biogas plant generated additional income which was not considered in the calculation of the net value added. The farm with the highest Net Value Added was due to its relatively high annual subsidies (£96,304 from several agri-environmental direct payments).

Cross-case analysis

There are no clear patterns between productivity, farm income and stage of agro-ecological transition. However, some interesting patterns can be identified:

1. Almost all farms in the sample have positive incomes and labour productivity.
2. Subsidies are a significant part of the farm income across all countries.
3. Agro-ecological farms tend to have a lower labour productivity than their conventional counterparts do.
    a. This is not or to a lesser extent true for countries where subsidies make an important part of agro-ecological farm income (e.g. in Czech Republic and Latvia. Exception: Lithuania). Subsidies therefore play a crucial role in offsetting lower farm output from agro-ecological farms in those countries.
    b. The impact of short supply chains on productivity varies across Europe. While they increase the profitability of farms in Lithuania and France, this is not the case in Spain and Switzerland. This suggests that short supply chains are only in certain cases suitable to increase productivity and profitability of agro-ecological farms.

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4. Labour productivity is generally underestimated, as the calculation methods do not account for the long hours worked by the farm owner (e.g. Switzerland, Sweden, Romania).
5. Farm productivity and net value added is lower when the farm owner has another source of non-agricultural income (e.g. Romania, Sweden and Switzerland).
6. Bigger farms tend to have a higher income than smaller ones, suggesting that there are economies of scale; this is especially the case for livestock farms. Yet, similar sized agro-ecological farms tend to perform better than their conventional counterparts (e.g. Hungary, Greece, Spain and Switzerland).
7. Winegrowers in Italy show patterns opposite to all of the trends discussed above. Smaller and more diverse farm seem to be locked-in a vicious cycle. The lack of net margin leads to a lack of liquidity. As a result, the investment necessary to start the agro-ecological transition that has higher incomes is hampered.

4.1.6. Quality of Life

Austria (Ökoregion Kaindorf - mixed farm)

Less intensive farms, mixed farms as well as well as conventional fruit producing farms perform better than the other conventional farms namely intensive pig farms in SMART Social Wellbeing indictors.

Despite their workload, all farmers seemed to be quite satisfied with their work and their status as farmers. The impression gained was that farmers are convinced that they do something good and meaningful with their work. All of them gave the impression of being proud of what they are doing.

Czech Republic (Vysočina region – dairy farms)

For *Quality of Life,* the results are generally good for the Czech case. The scores of all farms ranged from 68% to 80%. This is mainly due to the employment conditions and benefits that are common in European countries (written contracts, access to health care etc.). What also contributed, are the nation-wide high standards of work place safety, strict regulation and enforcement of rules regarding use of safety equipment when handling hazardous materials, low occurrence of work-related accidents, large awareness of on-farm safety and general equality in pay between men and women.

All farms were highly mechanized which also contributed to the *Quality of life.* On the other hand, the factors affecting negatively the scores include mainly low wages in agriculture (78% of the average wage in the national economy), work overload of managers and family members in the case of family farms.

Finland (Nivala region – dairy farms)

In the SMART dimension *Social Well-being*, all the farm groups have their highest overall average dimension scores. This is because well-developed societal legislation and advanced social security system automatically ensures high level of social well-being.

France (Auvergne-Rhône-Alpes – winegrowers)

The quality of life for farm operators is generally rated highly in SMART. Labour protection laws apply everywhere in the same way, and working conditions are respected everywhere.

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The SMART tool ignores the nature of the relationships between farmers and other actors in terms of their perceptions.

Germany (Nienburg in Lower Saxony – arable farms)

Considering the SMART subtheme "Quality of life", all assessed farms in the case study perform "good" (78% on average, with no differences between the farm groups). Following the labour standards in Germany, including regulations for extra hours, minimum wage for and appropriate work safety standards, the on-farm indicators are largely rated positively. However, due to farm inputs like phosphate and soybean products, problematic working conditions in some of the countries of origin cannot always be excluded. Farmers usually assume that, at the stage of wholesale, the products are already sufficiently certified and, thus, do not consider environmental or social certificates.

Greece (Imathia region of Central Macedonia – fruit farms)

No patterns can be identified with respect to the subtheme of quality of life.

Hungary (Belső Somogy region – arable farms)

All of the selected farms had good results, which is linked to the economic performance and size described. This is because, farmers have a reasonably good quality of life, and because of the nature of their production type, as wintertime is normally quite a relaxed time for them. Based upon the size of the farms, these farmers are mostly managers of the farm not the ones working on the land continuously. The workers have a relatively good standard of living. This is due to a serious lack of trained labour and so farmers must compensate and respect workers so that not to lose them. Another relevant explanation is the rate of mechanisation. As almost everything is automated workers do not have to lift heavy weights or do other inconvenient work. The new, modern machines are air-conditioned and easy-to-handle.

Italy (Chianti region – winegrowers)

In general, the quality of life is very high in the region. Cooperation and inclusiveness guarantee the support of the less favoured groups of the society, providing the required services and assistance. With respect to farming, few large farms increase their investments and expand their activity at the expenses of smaller farms.

One aspect that distinguishes the farms grouped in the first stage of the transition, which also tends to be the smallest farms, from the others is their capacity for development and the capacity of investment, which would be necessary to replace older orchards and machinery, and invest in diversification activities.

Latvia (countrywide – dairy farming)

Limited differences exist in the scoring of organic and conventional farms on the subtheme of Quality of Life. Conventional farms tend to have a higher level of mechanisation in relation to milking, feeding of roughage and concentrated fodder and mucking out the barn.

Another major difference is that organic farms produce at least 50% of all consumed food on the farm, whereas conventional farms are less self-sufficient.

Lithuania (countrywide – dairy farming and cheese making)

Socio-economic differences with regard small farms vary but the relationship between different socio-economic aspects is very much non-linear. Well-being depends on how the

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farming system is set up. An ideal balance would be to have a decent amount of spare time and sufficient resources, which would bring satisfaction in life. This may result from family members engaging in farm activities, or would encourage family members to engage thus better ensuring continuation (inheritance) of farming practice. If a farm is well organised and sufficiently profitable it may employ additional workers that would free-up time and allow to improvements in the quality of life.

With regard to labour rights in specialized conventional dairy farms some forms of forced labour still exist in Lithuania. It was not discovered in the farms investigated but is known from broader SES context. It is in the form of unlimited working days or a lack of equal pay. Cases are known where the salary of employees can be cut in half with no reason. With regard to small farms with family workers there are usually no problems. However, in cases, where there are employed people there can be issues of forced labour (longer workdays without compensation). This is independent of transition pathways but can be more of a problem on larger farms.

Romania (Transylvania and Maramures region – mixed farms)

The average of the SMART scores is 59.3% and range from 58% to 72%. Workers take regular breaks, have access to toilet facilities and received fresh food and drink. However, workplace standards in terms of safety are rather low - there is no safety equipment used when handling hazardous materials. There is also a general lack of awareness of on-farm safety.
Just three farmers are convinced that they do something good and meaningful with their work and are proud of what they are doing. Others actually complained about stress and workload and mentioned that agriculture in Romania is not actually profitable and all the farmers are depending on subsidies.

Spain (Basque Country and Navarra – cereal farms)

There are no relevant differences between the different stages of agro-ecological transition. All coincide in the difficulties of finding temporal or seasonal workers (minimally qualified) which reduces the quality of the job.

About the quality of life of the family workers/owners, the majority have a high workload but they also have a considerable number of free days. Perhaps agro-ecological farmers have fewer free days on average due to their greater diversification of crops.

In terms of the feeling of the interviews, most of the farmers seem to be happy with their quality of life for the reason that they work in the activity they want.

Sweden (countrywide – ruminant farms)

For *Quality of life* the outcome is generally very good for the Swedish case. It should be noted that during the DST interview, it became clear that several of the farmers work hours that are significantly higher than ILO recommendations of 40 hours a week. For most of them, if not all, the working hours lead to them experience considerable stress in their work life. This is not entirely reflected in the scores for *Quality of life, which* is noted as an area for improvement for many of the farmers. Also somewhat surprising, considering the before-mentioned, is that the farm receiving the lowest score of 75% is one where the interviewer (albeit subjectively) experienced that the family on the farm where among the happiest and most content with their life situation. They seemed not to experience work overload and stress to the same extent as some of the other farms that receive higher

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scores. This points to the (obvious) observation that *Quality of life* is explained by a range of aspects which are extremely difficult to capture using the types of tools used.

Switzerland (Lucerne Central Lakes region – livestock farms)

With regard to the SMART subtheme *Quality of Life*, a slightly different pattern emerged from the ratings than for other topics. The conventional farms performed with a subtheme rating of 85% slightly better than the groups with organic farms (79% to 81%). The workload in the conventional group was, on average, lower than on organic farms. However, the spread in the data was quite substantial, ranging from 48h / week to 75 h / week (considering the worker with the worst condition of average workload over the year). The reduced workload in the conventional group was rather counterintuitive because of its dairy enterprise but could be explained by the presence of a milking robot and implementation of highly specialized share farming. This does not seem to be an exception. Farmers at the workshop argued that those dairy farms remaining during the course of the structural change in the dairy sector are bigger and better equipped technically.

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

The evidence is weak, but it is possible that the high rating of quality of life is a reflection of a belief in farming as a vocation and associated positive motivation.

There is no distinction apparent of a link to farming systems or types.

Cross-case analysis

Quality of life is high in all the countries; the justification for these results is can be classified into three groups.

Firstly, farmers generally take pride in the job they do, they feel "doing something good", and are happy to live their lifestyle regardless of long hours or low profitability (e.g. UK, Sweden, Austria, and Lithuania).

Secondly, for employed farm workers, the high level of labour rights was mentioned and therefore decent working hours was often reported (Finland, France, Germany, Spain, and Sweden). However, this is often not the case for farm owners.

Thirdly, higher levels of mechanisation reduce workload (Czech Republic). Yet agro-ecological farms tend to be less mechanised and therefore tend to have a slightly lower quality of life (Switzerland and Spain).

Finally, this study might have a selection bias. Generally, positive people are more willing to take part in the surveys, which might not have direct benefits for them.

4.1.7. Trade-offs and Synergies Between Focus Topics

Austria (Ökoregion Kaindorf - mixed farm)

No clear patterns of trade-offs and synergies emerged from the data.

Czech Republic (Vysočina region – dairy farms)

SMART and COMPAS models have confirmed that higher farming efficiency / intensity positively affects economic performance (profitability) at the expense of soil, water or air quality (e.g. due to pesticide residues the conventional farms have a worse *Water Quality* score and have disputes with water authority). Similarly, economies of scale and increased

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mechanisation improve farm competitiveness, reduce labour demand and labour costs but often go in hand with a lack of landscape features due to field consolidation.

Nevertheless, agro-ecological farms can economically compete with conventional farms, with the help of subsidies, lower AWU on farms, lower wages, lower depreciation indicating lower investments in organic farming, extensive management, minimizing of costs and the milk price premium.

Finland (Nivala region – dairy farms)

The organic dairy farms score comparably well, with regard to both, the dimension of *Economic Resilience* and *Environmental Integrity*.

France (Auvergne-Rhône-Alpes – winegrowers)

The transition to organic farming leads to some trade-offs. For example, increased GHG emissions are due to more energy consumption caused by increase in work carried out in the vineyards. The soil quality suffers due to increased copper inputs (provided that chemical synthetic pesticides did not contaminate the soil before). Smaller farms aim to limit the number of times workers need to pass through the fields for weeding which causes the soil to remain bare for a longer time.

Germany (Nienburg in Lower Saxony – arable farms)

Given their similarity of the assessed farms, no finite trade-offs can be determined. All farms show scores, which reflect the intensive agricultural production systems. On the one hand, this includes relatively poor results for indicators associated with the provision of public goods, and, on the other hand, this also reflects high labour standards and profitability.

Greece (Imathia region of Central Macedonia – fruit farms)

Synergies can be identified within the environmental dimension, as the agro-ecological farming practices applied may have a positive effect on the water and soil quality as well as on biodiversity enhancement. Such farming practices also ensure that the products fulfil the requirements for quality and safety standards, potentially enabling sales to be at higher prices.

One interesting trade-off was that drip irrigation saved water but it led to higher production costs as well as higher GHG emissions (increased energy consumption).

Hungary (Belső Somogy region – arable farms)

A central trade-off seems to be between biodiversity performance and profitability. Soil conservation practices have a positive effect on the energy, GHG emissions and material use with regard to the SMART scores.

Italy (Chianti region – winegrowers)

The main synergies among the topics investigated are between the Economic dimension and biodiversity. This is because the most specialized farms (third stage of the agro-ecological transition) are also those farms most sensitive to environmental issues in the selected group of farms.

Latvia (countrywide – dairy farming)

There is a synergy between the SMART themes Biodiversity and Water and Food Safety with regard to their scores. This can be explained by the fact that no mineral fertilisers, seed

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treatments, plant protection products and antibiotics are being used by organic farms in the production of crop feedstuffs.

Lithuania (countrywide – dairy farming and cheese making)

There is a trade-off between soil quality and farm productivity of arable crops.

Romania (Transylvania and Maramures region – mixed farms)

There is a general trade-off for small and medium-scale farms with regard to economically viability and biodiversity. Increasing mechanization at farm level improves farm competitiveness, reduces labour demand and labour costs, but negatively affects ecosystem and species diversity.

Spain (Basque Country and Navarra – cereal farms)

Biodiversity and GHG emission seem to exhibit synergies. Farms that perform better in regard to biodiversity tend to have lower GHG emissions.

Sweden (countrywide – ruminant farms)

Only three farms, if they grew exactly what they do today but keep no animals, would be able to feed more than 10 people per hectare both in terms of protein and energy. However, these are also the farms that rank low for soil quality. This is due to the increased crop production being likely to reduce the ley period, which negatively impacts soil quality.

Switzerland (Lucerne Central Lakes region – livestock farms)

The main trade-off in the case study seems to be the increased labour productivity of conventional farms (economic dimension) versus the performance of the agro-ecological farms with regard to provision of public goods.

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

No clear patterns of trade-offs and synergies emerged from the data.

Cross-case analysis

Some case studies reveal synergies and trade-offs within the same dimension of sustainability. This is the case for Spain where farms with higher biodiversity performance emit lower GHG emissions. The same is true for the Latvian case study where some key variables, such as mineral fertiliser and pesticide application are the reason for synergies between e.g. biodiversity and water quality.

The case study in Greece revealed synergies across dimensions between environmental aspects and economic performance in the form of higher market prices for agro-ecologically produced goods. Similarly, in the Italian case study, the more specialised winemakers also use more ecological practices.

However, transition to agro-ecological practices does not always mean synergies. In some cases, GHG emissions rise due to higher energy use, caused by increased fieldwork (France) or water saving, but energy intense irrigation (e.g. Greece). In addition, more plant protein production in the Swedish Case Study meant more intensive arable farming and this in turn led to a decrease in the performance with regard to soil quality.

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4.2. Case study-specific aspects of sustainability

Austria (Ökoregion Kaindorf - mixed farm)

The farms performed negatively with regard to the prevention of resource conflicts. There was no difference between the farms in terms of environmental engagement outside the farm. Nevertheless, agro-ecological farms are more socially engaged in their communities. Subsistence farming is relatively pronounced in the ecoregion. Diversified mixed livestock (pig, poultry, cattle) arable farms, which are part of the humus project, show very high degrees of self-supply.

Czech Republic (Vysočina region – dairy farms)

Two organic farms in the survey newly started farm processing and would consider as a success if they manage to sell at least 20% of their milk production directly. Conventional enterprises do not even consider milk processing in their production volume. All farms in the survey agreed on the need to continuously improve farming practices, but lacked advice on agri-environmental issues linked to the farm economy and also lack young workers open to new procedures.

Finland (Nivala region – dairy farms)

No additional, case study- specific sustainability aspects.

France (Auvergne-Rhône-Alpes – winegrowers)

No additional, case study- specific sustainability aspects.

Germany (Nienburg in Lower Saxony – arable farms)

Generally, the aspect of land ownership determines the sustainability of farms substantially (e.g. in terms of what measures farmers are allowed or obligated to implement). This includes (a) that a large share of land is rented by the farmers without secure long-term access rights, (b) extremely high land prices, and (c) that the implementation of agro-ecological practices is reported to be restricted by landowners.

Greece (Imathia region of Central Macedonia – fruit farms)

Based on the results, the farms in the partly and fully agro-ecological groups have accumulated higher scores with respect to subthemes of food safety and quality. All these farms belong to a producer group, which applies high quality and safety. This enables them to negotiate better prices for their products, strengthen their position in the existing markets and expand into new ones. Consequently, these farms may cope better with market changes increasing their resilience.

Hungary (Belső Somogy region – arable farms)

Soil erosion is one of the most pressing divers for the farmers in the case study to change their soil cultivation practices, mainly to stop ploughing. Droughts also affect these farms, so the adaptation of new cultivation methods also serves the conservation of water in the soil.

Italy (Chianti region – winegrowers)

There were no additional case study specific sustainability aspects.

Latvia (countrywide – dairy farming)

There were no additional case study specific sustainability aspects.

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Lithuania (countrywide – dairy farming and cheese making)

The agro-ecological groups exhibited a more intense cooperation than the conventional farms in contrast to the conventional farm group.

Romania (Transylvania and Maramures region – mixed farms)

There were no additional, case study- specific sustainability aspects.

Spain (Basque Country and Navarra – cereal farms)

There were no additional, case study specific, sustainability aspects.

Sweden (countrywide – ruminant farms)

In the analysis of the case study specific indicator of how many people can be fed, in terms of calories and protein, the Swedish case study partners made three scenarios per hectare of land used for the farm operations. The first scenario assumes that the farm does not keep animals and hence sells everything they produce directly for human consumption. The second scenario describes a farm which grows crops and rears animals as they do today and all crops that are not kept for on-farm feed is sold as animal feed. The third scenario assumes that the farm grows crops and rears animals as they do today, and that all crops which are not kept for on-farm feed are sold for human consumption.

Results clearly show the inefficiency of using crops to feed animals to produce edible energy (calories). For all farms, the scenario where they produce exactly what they grow today but do not keep animals and instead sell everything for direct human consumption result in more people that can be fed per hectare. For several of the farms, the number of people is more than double compared to when they grow exactly what grow today, keep, feed and rear animals as today but sell all excess crops produced for human consumption instead of feed. These results are expected, especially considering findings for the stakeholder champion's farm that was the foundation of the focus of the Swedish case study[4].

Results for the number of people that can be fed per hectare in terms of protein are more diverse for six out of the 11 farms. Two observations are: a) ruminants can be net generators of protein if fed largely roughage and only limited amounts of grain or other human-edible crops. This is in line with previous studies (Mottet *et al*., 2017; Swensson *et al.*, 2017); and, b) as most farms in the Swedish case study use such large shares of their arable land for perennial leys (20% to 90%), keeping animals to produce milk and/or meat is an efficient land-use strategy if only protein is considered. The reverse is true if only energy is considered.

[4] https://www.slu.se/globalassets/ew/org/centrb/fu-food/publikationer/publikationer-fr-l/den-hallbara-garden--juni2017_webb.pdf

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One interesting result is that Farm 5, which shows that 10.3 people could be provided with their daily need for protein per hectare if no animals were reared and all crops were sold for direct human consumption while 7.4 people/ha could be provided with protein when using the animals as well. This is explained partially by the use of maize as a whole crop silage on this farm that is considered as human-edible (if harvested differently), and partially because this is the only farm that grows and sells beans. The considerable potential for providing a large number of people per hectare with protein when growing leguminous crops is particularly relevant for the Swedish case study.

Switzerland (Lucerne Central Lakes region – livestock farms)

A recent study by the research institute Agroscope (Stoll *et al.*, 2019) acknowledged that the high phosphorous (P) loads to Lake Baldegg, one of the three lakes in the region, are still too high. This is consistent with the results from the farm assessments where all the farms in which all farms bar one had soils classified in category D (excess P) or even category E (high excess P). All those of farms take part in a programme in which they receive subsidies for reducing phosphorous emissions by various measures. This programme defines thresholds for P emissions for the different soil classes. The average of the farm groups is close to the lower threshold for soils with an excess of P.

Considering the uncertainty in the data set, there is no clear difference between conventional and organic farm groups. This is likely to be because conventional farmers are better able to decouple P-input from N-input whereas organic farmers try to maximise the already rather low N-input on their fields by going close to the thresholds of the P balance with the application of slurry and manure.

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

No additional, case study- specific sustainability aspects.

4.3. Further Aspects of Sustainability

This section summarizes observations in the case studies which neither directly concern the focus topics nor the additional, case study-study specific sustainability aspects. Compared to the other sections, this one only lists those case studies which have evaluated other aspects of sustainability.

4.3.1. General Aspects and Good Governance

Austria (Ökoregion Kaindorf - mixed farm)

The differences in the Austrian case study are bigger between different farm types (fruit versus livestock farms) than between farms of different status on the agroecological transition pathway. This is especially true for economic and social aspects evaluated.

Czech Republic (Vysočina region – dairy farms)

All farms perform quite low in the governance subthemes of SMART like *Civic Responsibility* (25%), *Mission Statement* (16%), *Transparency* (37%), *Responsibility* (29%) and *Holistic Management* (32%). There is potential for improvement with regard to sustainability planning, especially given the size of Czech farms: even small improvements in the right direction can have a great effect, e.g. implementation of nitrogen consumption calculation, humus balance or farm plan development.

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France (Auvergne-Rhône-Alpes – winegrowers)

All farms had relatively low ratings for the SMART themes in good governance, except for the theme Participation.

Lithuania (countrywide – dairy farming and cheese making)

All farms score below 20% with respect to the SMART subtheme *Mission Statement* subtheme and quite low on *Holistic Audits* and *Full-Cost Accounting*.

Romania (Transylvania and Maramures region – mixed farms)

None of the farms keep any financial records, thus scoring low, from 5% to 35%, on the *Accountability*.

Spain (Basque Country and Navarra – cereal farms)

The largest difference in the general performance of the farmers is between the agro-ecological group and the others. In this group, farmers transfer their philosophy and personal beliefs to their business model, especially emphasising environmental sustainability.

Differences between the mixed and conventional groups are not notable, due to the small proportion of organic production in these farms.

Sweden (countrywide – ruminant farms)

There are no clear differences between farm groups. This is however to be expected as there is a large variation between the farms in each group in terms of size, geographical location, local climatic conditions, type of land, diversification, organic or conventional, how long they have been operating etc. Similarities can be observed for some farm groups for some topics, but there is no consistency in the patterns, and no instances have been identified of where all four farm groups can be clearly differentiated from one another.

One interesting pattern is that for the SMART topics *Value creation, Civic responsibility, Mission statement* and *Responsibility*, all farms perform quite low with SMART scores below 50%. These topics, which capture how actively the farm participates in and contributes to the surrounding community, stand out from the rest of the SMART results. The average for *Value creation* is e.g. 40%, for *Civic Responsibility* it is 31%, for *Mission statement* it is 42% and for *Responsibility* it is 47%.

A related pattern for all farm groups is that most farmers stated they spend very little time on social activities beyond the farming activities. In summary, this highlights that all farm groups are similar in that they could more actively undertake efforts to contribute to the local community.

Switzerland (Lucerne Central Lakes region – livestock farms)

For the governance subthemes *Full-Cost Accounting*, *Holistic Audits* and *Mission Statement* all farms scored relatively low, which illustrates that management processes on the farms are in their majority not explicitly formal.

One clear difference between the average SMART subtheme ratings of the farm groups was that farm mangers in the group of agro-ecological farms with special crops seemed more concerned about the societal issues than other farms (subtheme *Civic Responsibility*). The group scored 59% percent where the other farm groups ranged from 25% to 37%. This

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result manifests itself in cooperation with ethical financial institutions was well as the voluntary social, environmental and political engagement outside the farm.

Cross-case analysis

Differences between farm groups were in some cases difficult to detect or were overlain by other patterns in the farm sample (Austria and Sweden). Regardless of the farm group, the farms assessed tend to have a relatively low rating in the topics of good governance (Czech Republic, Lithuania, France, Sweden and Switzerland). This is also the case for governance processes on the farm (Lithuania, Sweden and Switzerland) and for engagement in the community (Sweden and Switzerland).

4.3.2. Environmental Dimension Including Animal Welfare

Latvia (countrywide – dairy farming)

All of the dairy cows in the conventional farm group are dehorned whereas none are on organic farms. Organic farms do also not use antibiotic drying agents, whereas the conventional farms do.

However, the feed grain storage quality on all organic farms is inadequate to limit losses and contamination. In addition, none of the organic farms have materials to keep animals busy whereas one of the conventional farms does (e.g. scratching brush).

Lithuania (countrywide – dairy farming and cheese making)

Even though environmental performance varied between farm groups, all scored relatively high with regard to the SMART theme of Animal Welfare.

Romania (Transylvania and Maramures region – mixed farms)

The *Animal Welfare* theme is slightly weaker for organic farms due to limited investments in animal housing infrastructure and cattle manure storage facilities.

Switzerland (Lucerne Central Lakes region – livestock farms)

In many SMART subthemes, the farms scored in a similar range. This is e.g. true for animal welfare. Additional data collected on the field confirmed that all the farms were certified with the same animal welfare labels.

Cross-case analysis

Across the cases, no general pattern between agro-ecological and conventional farm groups emerges with regard to animal welfare.

4.3.3. Economic Dimension

Austria (Ökoregion Kaindorf - mixed farm)

One similarity between the farm groups is the high level of diversification. All fruit farms grow a high number of fruit species and varieties, and some farms which have additional income from arable crops. The fruit producing farms also engaged in on-farm processing, at least in a small scale, and process second quality class fruits to juice, dry fruit, vinegar, brandy etc.

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Czech Republic (Vysočina region – dairy farms)

With one exception, contracts for land leases of farms covered a period less than 10 years. The share of own land in farms ranged from 10 to 20% with an average number of lease contracts of around 500. In the Czech Republic, the statistics show that 90% of the land is rented. Conventional farms showed roughly double the crop yield than organic farms.

Greece (Imathia region of Central Macedonia – fruit farms)

The extreme weather conditions (strong winds, heavy rain and hail in summer) in the last three years had a considerable impact on the quantity and quality of produce. All farms seem to be vulnerable to the impact of climate change.

Lithuania (countrywide – dairy farming and cheese making)

The farm group of extensive, specialist dairy farms is the least economically sustainable. In almost every aspect of economic sustainability it is behind other farms in the groups of conventional and specialist dairy farms, as well as extensive, mixed grazing livestock/dairy farms.

Romania (Transylvania and Maramures region – mixed farms)

In the context of *Economic Resilience,* both the organic and conventional groups show a low score on the *Stability of Markets* which is related to the unstable milk market and a moderate to a good score on *Local Procurement* as most inputs to the farms are sourced locally.
There are no investments made on the farms.

Spain (Basque Country and Navarra – cereal farms)

The marketing of products within agro-ecological group seems to be problematic since it results in a high investment of time and effort by the farmers. Most of the conventional and mixed farmers are members of cooperatives of producers (there is one in almost every village) and commercialize the production together. This is associated with less risk and lower workload compared to the time investment of agro-ecological farms, which need to search for buyers, try direct sales or process foods.

Switzerland (Lucerne Central Lakes region – livestock farms)

The group of agro-ecological farms with special crops stood out with regard to the SMART subtheme of local procurement. The farm group scored 65% whereas the other ranged from 97% to 100%. One explanation for the difference is that some farm enterprises in this group are new to the region and the corresponding inputs are not available locally.

Cross-case analysis

Other economic topics of importance were vulnerability to climate change (Greece) and diversification (Austria) for all farm groups. For the agro-ecological farm groups, a high time investment was required for direct marketing (Spain) and less locally procured inputs (Switzerland) were important.

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4.3.4. Social Dimension

France (Auvergne-Rhône-Alpes – winegrowers)

With the exception of gender inequality and the training of employees in the case of small farms, all farm groups performed well with regard to the SMART themes in the social dimension.

Lithuania (countrywide – dairy farming and cheese making)

Most similarities between farms investigated could be observed between social aspects. Most likely, the underlying reasons relate to socio-cultural aspects or individual aspects, but not so much related to place within the agro-ecological transition pathway. As a rule, most of the farms scored lower in between *Equity* subthemes while scoring higher in *Human Safety and Health* as well as *Labour Rights*.

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

With regard to the SMART theme of *Fair trading* practices, the scores of the organic and the conventional farm group are distinctly different (organic: 71% to 89%; conventional: 48% to 57%), with those in transition being between 61% to 77%.

Cross-case analysis

Within the social dimension, topics relating to equality are rated relatively low (France and Lithuania) across all farm groups.

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5. DISCUSSION AND CONCLUSIONS

5.1. Synthesis from Case Study Reports

Each case study made its own synthesis (contained in this section), providing comparisons between the agro-ecological farming systems across Europe. SMART themes or subthemes are included in *italic* font.

Austria (Ökoregion Kaindorf - mixed farm)

In general, on the farms investigated in the case study, differences in results are bigger between different farm types (fruit versus livestock farms) than between farms of different status on the agro-ecological transition pathway. This is especially true for economic and social aspects evaluated.

Livestock farmers with agro-ecological practice tend to perform better on water quality, similar results are expected from farmers with perennials.

In contrast to the initial hypothesis, the SMART subtheme *Soil Quality* does not differ between farmers with agro-ecological practices related to humus formation and the conventional base line. Reasons for that are that some of the conventional farms do apply the same techniques as their “agro-ecological”-colleagues, (e.g. reduced soil management, catch crops, mulching etc.).

Czech Republic (Vysočina region – dairy farms)

In most cases, the results mirrored the agro-ecological transition pathway and the difference between conventional baseline and the organic farm group was noticeable.

SMART and CFT models confirm the higher rating of organic farming in most indicators within the *Environmental Integrity* (Biodiversity, Soil Quality, Water Quality and Air Quality), which was expected.

Similarly, in the field of *Good Governance*, the score of the organic group was slightly higher than the score of the conventional group, although it was still a comparably low score.

A surprise was the evaluation of organic farms in the area of *Economic Resilience* (SMART), where the results were balanced with a group of conventional farms (organic farms achieved slightly better results in 10 out of 14 subthemes). Likewise, COMPAS showed that organic farms can perform similarly to conventional farms for key economic indicators, such as labour productivity.

Within the last fourth area of sustainability, *Social Wellbeing* (SMART), the organic farm group performed better for nearly half of the 16 subthemes compared to the conventional group, but there is much room for improvement.

Thanks to a better understanding of the situation, it is evident that other factors seem to prevent the expansion of organic farming, not just the concerns of farms about the decline in profitability and economic competitiveness. There are a number of other important factors e.g. the stability of agricultural policy and the amount of subsidies, the national political climate towards organic farming, capacity on the farm, the issue of new sales, the lack of advice focused on the environmental area, and the lack of qualified agronomists.

In conclusion, the group of organic farms performed better than conventional according to the results of the used models and appears to be a more sustainable way of farming for the

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future. However, it faces a number of challenges for further improvement and development, and further research is needed to help and facilitate the transition to greener agriculture.

Finland (Nivala region – dairy farms)

When comparing in broad terms the SMART results between the three farm groups a clear pattern can be found: Organic dairy farms have the highest average score in terms of economic resilience, environmental integrity and good governance. Conventional dairy farms active in the bio-plant project become ranked first in social well-being and second in all other major dimensions of sustainability. Conventional dairy farms not connected to the biogas project have the lowest average score in all the four major SMART dimensions of sustainability.

France (Auvergne-Rhône-Alpes – winegrowers)

Against all expectations, the sustainability profiles of the farms at different agro-ecological transition stage, are not very different. The exception is the DEMETER farm, which seems to be distinct compared to other farms for each of the different levels. It seems that farms that process their wine have greater economic resilience than farms that do not do the processing in-house. This is not a general rule, since the results from COMPAS are proportionally more satisfactory for farms that sell bunches of grapes to intermediaries and poorer for some farms for which bottle selling prices are restricted.

Germany (Nienburg in Lower Saxony – arable farms)

The assessment confirms the presence of highly market-oriented farming systems with few agro-ecological practices and, as a consequence, low levels of biodiversity and water quality. All assessed farms reflect a fairly high degree of social well-being and economic resilience, whereas the environmental integrity results and, more specifically, the biodiversity indicators are below average. Despite assessing farms with only minor differences in terms of their agro-ecological transition pathway, some indicators mirror the observed practices:

- While one case study farm emits, on average, 887 tons of CO_2eq, large differences can be observed between farms with and without a livestock production. In addition, farms with carbon-capturing measures (like reduced tillage) emit roughly half of the CO2 equivalents for comparable crop products.
- The state of biodiversity is generally poor in both the entire case study region and in the context of the assessed farms. While the different farm groups score similar for most of the biodiversity indicators, FG2-Farms with few field-scale and weak agro-ecological practices perform noticeably better for the indicators “farming practices” and “soil fauna”.
- The wide application of fertiliser and pesticides contributes to an average ranking in terms of the water quality across all farms in both farm groups.
- In terms of the productivity and the farm income, farms generally perform well. Differences can be observed due to different business rather than (agro-ecological) management approaches. Furthermore, the assessment reveals a relatively high quality of life, with high scores for the on-farm and, occasionally, lower ratings for off-farm activities.

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Greece (Imathia region of Central Macedonia – fruit farms)

In general, the farms investigated have many differences in terms of land area and economic size. Nevertheless, it seems that farms that in the agro-ecological transition perform better in the environmental dimension (water and soil quality, diversity of species) which in turn may impact beneficially on economic dimension (food safety and quality, net farm income). Noting that farmers who are engaged in agro-ecological farming practices are principally members of agricultural cooperatives/PGs, it can be argued that these farmers are better informed and advised on policy and environmental issues, new technologies and innovations, thus more open to adopt farming practices related to sustainable agriculture.

Hungary (Belső Somogy region – arable farms)

Farms applying more soil conservation practices, scored better for most topics. The adaptation and transition of these practices is a complex issue. There are many other factors influencing the decision of farmers and consequently the results of the assessments undertaken.

Italy (Chianti region – winegrowers)

The case study dilemma is already addressed by some of the selected farms. Contrary to what might be expected, the most specialized farms are also those farms which are most sensitive to environmental issues in the selected group of farms (those classified at the third stage of the transition). Less specialized farms are also less well equipped to implement advanced sustainable management techniques.

The main difference between the selected group of farms is related to the economic dimension. This is also considered the force that drives the investments required to implement sustainable management techniques. Sustainable management techniques impact mainly on soil biodiversity and the biodiversity of aquatic fauna.

Latvia (countrywide – dairy farming)

The farm assessment results reveal substantial similarities between the farm groups across all sustainability dimensions. Many Good Governance dimension themes and subthemes are weak for both organic and conventional groups particularly with respect to Corporate Ethics, Accountability and Holistic Management themes. Issues addressed by the Good Governance dimension are not a priority to the typical family farm in Latvia. These issues can be considered to be more relevant to larger EU commercial farming operations.

The Environmental Integrity dimension scores moderately well for both farm groups due to the overall extensive nature of farming practices and the presence of large natural habitats and wetlands that are an integral part of rural agricultural landscape in Latvia. The abundance of natural habitats contributes to biodiversity, water quality and somewhat to soil quality on agricultural land.

Overall Environmental Integrity themes score slightly higher for organic farms mainly due to the avoidance of mineral fertilisers and plant protection products. However, the Animal Welfare theme is slightly weaker for organic farms due to limited investments in animal housing infrastructure and cattle manure storage facilities. Within the conventional farm group, the large non-grazing operation ranks lower on Environmental Integrity due to more intensive fodder production practices, greater mineral fertiliser and plant protection product inputs. Furthermore, the use of large and diverse amounts of external feed inputs on the non-grazing conventional farm results in large GHG emissions compared to the

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organic and conventional grazing dairy operations. The largest GHG emissions are related to the production of off-farm produced feed inputs.

The Social Well-Being dimension scores moderately and variably within both farm groups. Many of the social issues assessed do not rank as a high priority for the small family farms in Latvia. The organic farm group scores higher than the conventional farm group in relation to the themes of Equity and Human Safety and Health themes, but lower on Labour Rights and Decent Livelihood themes as the assessed organic farms are small family operations oriented to self-sufficiency.

Conventional farms score slightly higher on Economic Resilience, but both the organic and conventional groups show a low score on the Stability of Markets which is related to the unstable milk market. Although, labour productivity is slightly higher overall in the conventional farm group, the highest labour productivity in all of the farms surveyed is an organic farm, even exceeding that of the large non-grazing conventional farm. A large part of the net value added for both farm groups is from CAP subsidies, contributing up to 50% of gross farm income for organic farms and 25% gross farm income for conventional farms.

Addressing the case study dilemmas (see Section 3.1), it is largely contingent on ensuring that most or all of the organic milk can be sold as organic milk. If the market for organic dairy products does not continue to grow, to take up the surplus organic milk production, there could be a risk that the existing level of support from Rural Development Programmes (RDP) / subsidies for organic dairy farming will not be continued at present levels and will not expanded. As RDP support payments to organic dairy farms are critical for the economic viability of these farms, policy changes that reduce support payments to organic dairy farmers could prompt existing organic dairy farmers to revert to conventional dairy production and could dissuade existing conventional farmers from making the transition to organic farming.

A key issue to be addressed is the need to increase and upgrade mechanisation on dairy farms with respect to milking and mucking-out operations and preparation and distribution of feedstuff. This would reduce the amount of physical labour and working hours for dairy farmers resulting in a healthier work-life balance and thus would serve to encourage the next generation of young farmers to pursue dairy farming.

Likewise, upgrades in animal housing infrastructure are needed to provide a healthier and less stressful environment for dairy cattle during the winter months when grazing is not possible and cattle must be kept indoors. Similarly, an upgrade in the infrastructure for storing manure, and manure spreading machinery, is required to increase the environmental performance of dairy operations. Upgrades in farm field machinery would also increase the efficiency of on-farm feedstuff production including encouraging environmentally friendlier soil tilling and crop cultivation and diversification approaches.

Lithuania (countrywide – dairy farming and cheese making)

The pre-defined transition pathway towards agroecology is reflected well by the environmental aspects of farms as investigated with SMART and Cool Farm Tool. However, non-organic mixed farming often not only over performed other types of conventional farms but also the specialized organic dairy farm. With regards to economic integrity extensive dairy system scored lowest, and in a broader SES context it is known that these are economically most vulnerable, while the future of organic farms are with regard direct

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payments but mainly due to economic and political reasons. Thus, it can be said that economic sustainability does not follow the transition pathway directly.

Romania (Transylvania and Maramures region – mixed farms)

The farm assessment results reveal substantial similarities between the farm groups across all sustainability dimensions. Many SMART themes and subthemes in the dimension *Good Governance* are weak for all farm groups particularly with respect to *Corporate Ethics*, *Accountability* and *Holistic Management* themes. Issues addressed by the *Good Governance* dimension are not a priority to the typical family farm in Romania.

The *Environmental Integrity* dimension scores high for all farm groups due to extensive farming practices and the presence of large natural habitats and trees that are an integral part of the rural agricultural landscape in Romania. The abundance of natural habitats contributes to biodiversity, water quality and somewhat to soil quality on agricultural land.

In particular, *Environmental Integrity* themes score slightly higher for organic farms rather than conventional ones mainly due to the avoidance of mineral fertilisers and plant protection products.

Within the conventional farm group, the large non-grazing operation ranks lower on *Environmental Integrity* due to more intensive fodder production practices - greater mineral fertiliser and plant protection product inputs. The production of off-arm produced feed is highly relevant for GHG emissions on the investigated farms.

The *Social Well-Being* dimension scores moderately and variably within all farm groups. Many assessed social issues do not rank high in priority for the small-scale farms in Romania. The organic farm group scores higher than the conventional farm group in relation to the themes of *Equity* and *Human Safety* and *Health* themes, but lower on *Labour Rights* and *Decent Livelihood* themes as the assessed organic farms are small family operations oriented to self-sufficiency.

The low results for *Holistic Management* and *Accountability* show that farmers in Romania do not have an integrated approach when it comes to farming.

In conclusion, the so-called "transition farms", which do not strive for an organic or ecological certification but are genuinely interested in the diversification of their farming activity, are an interesting target for further developing agro-environmental measures.

Organic farmers still cannot grasp the concept of agroecology and how this should be implemented.

Conventional dairy farms could be slowly replaced by beef farms, as the latter receive higher subsidies/ animal head, and beef demand is higher. Moreover, the price for the collected milk is low - 1.5-2 lei/litre at most. Additionally, the farmers do not process the milk themselves.

Spain (Basque Country and Navarra – cereal farms)

With regard to environmental integrity, the agro-ecological practice on farms results in lower GHG emissions, more biodiversity at farm level and better soil quality. In economic resilience, the variability between farms is elevated, but no trend is evident between the groups. It is noteworthy that all the farms have positive income, and the importance of the subsidies for their profitability, as in the whole sector.

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The principal difference in the performance of the three groups analysed can be summarized as follows: Agro-ecological producers traditionally assume a multifunctional profile. In addition to agronomic work, they also do marketing and commercialization to market their products directly.

Sweden (countrywide – ruminant farms)

The results do not mirror the pre-defined transition pathway, i.e. those farms within the Swedish case study that are organic and more diversified (system re-design farming group) do not generally perform better for the key topics listed above compared to conventional and/or less diversified farms. However, for some of the environmental indicators, all organic farms perform better than the conventional farms.

Switzerland (Lucerne Central Lakes region – livestock farms)

The results did not mirror the agro-ecological transition pathway in all cases. This was especially so for farm income / profitability as well as for the topic quality of life. For other topics, the difference between conventional baseline and the organic farm groups and were not as high as expected. One possible explanation, confirmed at the workshop with the farmers, is that the sample of farms was composed of relatively innovative and diversified farms compared to the regional typical farm.

Some of the important patterns that emerged from the data:

The high N-fertiliser input and the use of herbicides in the group conventional dairy farms has led to a negative impact on the performance of this farm group with regard to Biodiversity and Water Quality.

With regard to biodiversity, soil quality and water quality, no clear differences could be observed between the organic groups. The organic production practices of those three groups led to a higher performance with regard to Biodiversity. Two of the groups make use of rare races and breeds and therefore increase the agro-biodiversity.

The change to no-till practices for organic farms in the region has positive impacts with regard to greenhouse gas emissions as well as soil and water quality.

With regard to farm income, all farms assessed had a positive net income and either constant or growing revenues and yields. The conventional farms exhibited a substantially higher productivity.

Although the sample was composed of rather innovative farms, engagement in activities with potentially high added value, such as on- farm processing or agri-tourism, was not common.

With regard to the core dilemma of the case study region (high density of animals), innovations in the group show that the transition towards a more agro-ecological system is possible. Innovations also happen on farms which are part of the baseline of conventional practices (such as milking robot and share farming). That led to an increased quality of life and economic performances but do not directly help in overcoming the core dilemma of the case study region. There is the need to investigate further the innovations that could be helpful for the future transition of agriculture.

United Kingdom (Grampian and Tayside in north-east Scotland – mixed farms)

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All of the farms deliver to regulatory outputs and associated processes, such as financial reporting, agricultural census, and applications for farm payments. However, the business contexts, governance and size of the farms influence their needs and organisational infrastructure to create formalised strategies, which form part of the assessments of *Social Well-being* and *Good Governance* (using the SMART). The nature of some indicators means that it is unlikely that they will change significantly through time, therefore making it more challenging to track their transition towards agro-ecological farm systems.

Farms which use, or are in transition towards, organic farming practices are adding livestock for the on-farm production of manure. To do so, arable farms expand their systems accordingly. That means that farms that are solely general cropping with organic status are few in number.

Processes associated with a transition position between conventional and organic status such as farms with on-farm renewable energy production have adhered to regulatory requirements of public consultations and engagement with neighbours. However, the high scores of engagement also reflect the farmer's use of such new facilities as a focus for facilitating visits from community groups and schools. So, the content of the transition, which leads to a high score for *Stakeholder Dialogue* (100%), is reinforced by a process which leads to high scores for *Conflict Resolution* (95%). Therefore, over time that *Internal Investments* (76%) will have multiple benefits across *Energy Use* (66%).

All of the farmers in the case study convey a belief of a high quality of life associated with their farm and farming activities. This is irrespective of type of farming system and practice. There is suggestive evidence of the highest levels of perceived quality of life being associated with those who are second or third generation farmers.

Overall, the analysis of the farms in the UK case study shows a high level of delivery with respect to the overarching dilemma. Public goods are being delivered across the farms of each type of farming practice. In both farming systems, environmental (e.g. *Land*, *Atmosphere*, *Water*), animal health and welfare, outputs of food quality and food safety are contributing to economic sustainability through local procurement and stability of both production and supply (i.e. demand). Additionally, the process of operating the farms is compatible with social well-being (e.g. workplace safety and health) and *Fair Access to Means of Production*, and *Fair Trade Practices*.

5.2. Conclusions

Results show that farms are highly diverse across Europe and that agro-ecological farms can perform well. General patterns can be identified, but some exceptions have been noted in this study.

The high level of quality of life and satisfaction amongst all farms is striking, regardless of the agro-ecological transition stage. Although satisfied farmers could be partly over-represented in the this study, the finding shows that agriculture provides viable livelihoods, i.e. modes of living that fulfils people's needs and expectations, and therefore is worthwhile to be maintained and supported.

The environmental performance of farms generally increases the further along they are on the agro-ecological transition pathway. Practices introduced in the agro-ecological transition have an especially positive impact on greenhouse gas emission (soil conservation),

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biodiversity (substitution of inputs and farmlands that are more diverse) and water quality (no mineral fertilisers and chemical synthetic pesticide used). Hence, in most cases, agro-ecological farms provide more public goods and ecosystem services. Mixed farms generally perform better than specialized farms, in some cases even better than specialized organic farms (i.e. in Lithuania), implying that a combination of crop and with relatively extensive livestock can be more sustainable with regard to the provision of public goods than a specialized farm (e.g. in Sweden, Austria, Switzerland).

Some agro-ecological practices are central to the provision of public goods as they positively influence several environmental aspects, and therefore are cross-cutting: reduced chemical synthetic pesticides and mineral fertiliser use has a positive influence on biodiversity, soil health, reduced greenhouse gas emissions in arable systems or water quality. Therefore, although being at the intermediate state of input-substitution on the transition pathway, both chemical synthetic pesticides and mineral fertiliser use are important levers in the AEFS.

The economic performance of agro-ecological farming is very heterogeneous. Although all of them were profitable, agro-ecological farms tend to be less productive with regard to labour productivity and generate less income. This result can generally be explained by the smaller size and the lower level of mechanisation of agro-ecological farms. Where the level of mechanisation is higher (Czech Republic), agro-ecological farms perform better economically. In general, however, there is a trade-off between supporting the provision of public goods and the economic viability of the farms.

Yet, patterns can be identified from the study that show synergies between the public goods and economic performance, addressing the dilemma between economic and environmental performance at its core. One example is the higher subsidies that compensate for the economic loss (e.g. Latvia). Another example is the short supply chain, through which the whole direct margin flows to farmer directly (e.g. in Spain, Lithuania, France). Yet this option is constrained by the relatively small market compared to the mainstream value chains, and in some countries it has been in decline (e.g. Spain). In addition, in the Italian case study, higher rationalization and economic success lead to more ecological practices on the vineyards. Similarly, the adoption of innovations applied by conventional farms in the Swiss case study (share farming and higher mechanisation) could increase synergies for Swiss agro-ecological farms.

In line with that, further analysis of these data should explore the linkages between mechanisation, farm size, in relation to agro-ecological transition and economic performance. This could provide an understanding of the extent to which policies could support mechanisation or growth in the size of agro-ecological farms in order to increase productivity of agro-ecological farms without reducing the provision of public goods and ecosystem services. Policies could then address lock-in situations (e.g. Italy) and support where it makes the sense for investments to be made to implement agro-ecological transitions.

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8. APPENDIX: CASE STUDY REPORTS

The appendix contains the reports from the UNISECO case studies for Task 3.2 provided by each case study partner.

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1. AUSTRIA (ÖKOREGION KAINDORF - MIXED FARM)

By Ruth Bartel-Kratochvil (BOKU), Alexander Hollaus (BOKU), Rainer Weisshaidinger (BOKU)

1.1. Description of Case Study Dilemma

The overall objective of the bottom-up initiative *Ökoregion Kaindorf* is to establish an ecological circular-flow economy in the region, targeting different sectors to combat climate change and develop mitigation strategies. Specific objectives are:

- pursue ecological circular-flow economy,
- reduce the societal CO2 balance of the entire region,
- sequestrate carbon by various methods to increase soil fertility and reduce soil loss,
- transfer of knowledge and spread of information to farmers and society on circular-flow economy related to agriculture but also other sectors.

In terms of agriculture the key challenges and key dilemma are as follows:

Key Challenges: The key challenges in the *Ökoregion Kaindorf* are the decrease in soil fertility as well as climate altering emissions caused by intensive agricultural practices.

Key Dilemma: How to tackle impacts due to climate change (e.g. increasing water stress), increase carbon sequestration in soils, prevent soil degradation and reduce soil fertility loss from arable land whilst maintaining or improving the farm's social and economic sustainability and contributing to climate change mitigation.

The Association "*Ökoregion Kaindorf*" with roughly 250 conventional and organic farmers is focusing on increasing soil fertility and carbon sequestration. More efficient and environmentally friendly use of nutrients originating from manure, compost and charcoal. The program includes knowledge transfer to farmers ("Humusakademie"), CO2 compensation certificates, compost application and a biochar initiative, reduced soil tillage and compulsory green cover of arable land, mixed cropping, etc. Furthermore, agro-forestry was introduced as a separate approach in 2012. Findings on soil fertility and carbon sequestration are exchanged in a group of regulars ("Humus-Stammtisch").

Various tools are used to improve agro-ecology:

- Provision of information and training in the broader context of soil fertility to farmers,
- Cultivation techniques: reduced tillage, bio-char and compost application, green cover and mixed cropping, agro-forestry,
- Promotion of national and international networking, including research,
- Collection and provision of essential research knowledge to practical operators,
- Certificates for carbon sequestration are issued to farmers,
- On-farm research and experimental projects.

The methods applied have numerous positive effects on mitigating climate change, adapting to climate change, reducing loss of soil and soil quality and higher diversity of cultures and landscape features. On average 10 tonnes CO_2 per hectare per year are sequestrated over a

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total of 2,500 hectares. Water-storage capacities have significantly increased. Companies (e.g. retailers) are purchasing certificates. Meanwhile an international audience is participating in events of the Association.

1.2. Description of Investigated Farm Groups

In Austria, there are about 160,000 farms in total, 1,897 of them are involved in the FADN (BMNT 2018[5]). According to IACS database (INVEKOS 2013[6]), the 3 municipalities of the "*Ökoregion Kaindorf*" comprise 316 farms. When transferring the Austria-wide proportion of FADN farms to the "*Ökoregion Kaindorf*", that is only about 3 farms. Thus, due to the smallness of the case study region, a relation of the farms investigated to FADN data makes no sense. For the final report, we will evaluate IACS data for 2018, which are only recently available.

Figure 1. Investigated farm groups

Farm group	Description Farm group (FG)	Humus farmer	Additional AEFS (org, div)	Farms surveyed in FG	Farm Codes* (anonymised)
Farm group 1	FG1: Conventional, fruit production & partly arable farming	No	no	2	FG1A FG1B
Farm group 2	FG2: Conventional, fruit production & arable farming	Yes	no	2	FG2A FG2B
Farm group 3	FG3: Organic, fruit production & arable farming	Yes	organic	1	FG3A
Farm group 4	FG4: Conventional, pig production combined with arable farming	No	no	1	FG4A
Farm group 5	FG5: Conventional, pig production combined	Yes	no	2	FG5A FG5B

[5] BMNT (2018): Grüner Bericht 2018. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. Bundesministerium für Nachhaltigkeit und Tourismus, Wien.

[6] INVEKOS (Integriertes Verwaltungs- und Kontrollsystem; IACS, Integrated Administration and Control System) (2013) Database. Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, Vienna.

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	with arable farming				
Farm group 6	FG6: Diversified Conventional, poultry / cattle fattening combined with arable farming	Yes	diversification	2	FG6A FG6B

**On farms, which codes are highlighted red, farm assessments are not finished.*

Due to time limitations on farm side (fruit harvest until the end of October), parts of 3 interviews cannot be finished until beginning of November 2019. These 3 farms represent farm group 2 and 3. Therefore, no trends can be analysed for these farm groups nor for the transition pathway between FG 1-3.

Limitations:

- The ecoregion is characterized by a high diversity of farm activities, the farm groups selected mirror only a small part of the diverse regional reality.
- Data survey relates - in particular for COMPAS only to a single year. (For some issues, SMART covers a period of 5-10 years, CFT chooses longer periods to calculate carbon stock changes.) Especially for fruit producing farms, the past growing seasons were characterized by large fluctuations in yield and price. The year 2018 was a particularly successful one. In particular, the calculated results for COMPAS indicators are therefore to be treated with caution.
- We had some difficulties to sample farms for especially FG 4 (conventional livestock producing baseline). Farmers willing to contribute to UNISECO research are probably representing the top-end of farms in these groups in terms of sustainability.
- The “humus farmer”-concept refers to single field plots rather than the whole farm. E.g. the degree of “humus farmers” according their engagement in carbon sequestration and soil fertility is quite diverse: some “humus farmer” apply AEFS only on selected field plots while others apply AEFS on a relatively large number of plots. Thus, there is almost no farmer applying the “humus farmer”-concept on his whole farm.
- The “humus farmers” receive certificates and money after they have been able to carbon sequestration on the project surfaces for 5, 10, 15… years. This means, that carbon sequestration measures are mainly carried out on private land which long-term cultivation is secured and not on leased land. Farmers, who have few own land, tend to participate in the project with a smaller share of land.
- The Association “*Ökoregion Kaindorf*” actually is introducing the “humus farmer”-concept for fruit orchards, what is one of the main farming activity in the region. This means that until now only arable farms or fruit farms with arable land could participate in the project.

1.3. Focus Topics

DIRECT AND INDIRECT GREENHOUSE GAS EMISSION

Results show a trend of slightly lower GHG emissions by "humus famers" compared to the conventional baseline. Perennial systems (FG 1; FG 2-3 not finalized) cause low GHG

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emissions or a net carbon gain due to positive soil carbon stock changes in fruit tree orchards. The highest contributions (on a low level) of GHG emissions in these farm groups stem from the categories energy use as well as soil and crop fertilization and on farm FG 1A fertiliser production.

Concerning the farms with livestock production (FG 4-6), pig production systems show higher GHG emissions compared to beef and broiler production systems: FG 4A – pig: total GHG emissions of 444 t CO2e, 84% from livestock; FG 5A - pig: 85 t CO2e, 63%; FG 5B – pig: 578t CO2e, 47%; FG 6A – broiler: 312 t CO2e, 3%; FG 6B – beef: 240 t CO2e, 11%. "Humus farmer" FG 5B has higher GHG emissions due to deficits in manure and crop residue management. FG 6B is preparing compost based on urban organic waste in a large scale. On this farm, fertiliser production contributes by far the biggest share to GHG emissions. In intensive pig farming systems (FG 4A and FG 5B) the following categories explain major GHG emissions: manure management, feed production for livestock, soil and crop fertilization, crop residue management and fertiliser production. FG 5A represents a more extensive pig production system, resulting in lower GHG emissions in all categories compared to the previous ones. For FG 6A and FG 6B fertiliser production explains GHG emissions to a high degree.

All farms investigated, including the conventional baseline, show positive soil carbon stock changes. Meanwhile not only "humus farmers" are applying measure to increase soil carbon such as reduced tillage and soil management, mulching and mulch seeding, integration of catch crops into crop rotations etc.

BIODIVERSITY

According to CFT, biodiversity performance of all farms is poor to medium and a trend relation between AEFS transition and ratings in CFT-biodiversity categories is obvious for FG 4 to FG 6 (FG 4A: 21%, FG 5A: 31%, FG 5B: 30%, FG 6B: 31%, and FG 6A: 39%). The conventional baseline (FG 1 and FG 4) is reflected by very poor ratings in almost all biodiversity categories. Similarly, this is shown by inferior SMART biodiversity results for FG 4, whereas SMART draws a totally different picture concerning farms with perennials (FG 1). Ecosystem, Species and Genetic Diversity are rated higher for FG 1 compared to other FGs within SMART. This is a result of different indicator sets and impact weightings especially if they are applied to perennial systems like in fruit production.

In SMART weak performance is detected in intensive pig production and arable systems (FG 4A and FG 5A). Examples for weak performance are: Almost none of the investigated farms do have rare or endangered crop and many have short rotations (2-3 crops). Frequent applications of pesticides (which are not regulated in the ecoregions programme) and a relatively high number of pesticides, which are e.g. toxic to bees were detected. Furthermore, one these farms only few grassland areas are managed extensively.

SOIL QUALITY (SOIL AS A MEANS OF PRODUCTION)

In contrast to our expectations, SMART soil quality do not differ between "humus farmers" and conventional farmers. Results are easier to explain on an individual farm rather than on farm group level: FG 1A 64%, FG 1B 77%, FG 4A 50%, FG 5A 59%, FG 5B 64%, FG 6B 50%, and FG6A 66%. A first analysis of indicators show that some of the conventional farms do apply the same techniques as their "humus farmer"-colleagues, e.g. reduced soil management, catch crops in crop rotation, green cover during winter period, mulching, and measures to prevent soil compaction. Moreover, as mentioned above the "humus farmer"-concept

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refers to single field plots rather than the whole farm and some "humus farmer" apply AEFS only on selected field plots which limits the concept's effects. The conventional baseline in FG 1 (perennial system) performs better than other FGs, but a comparison to FG 2 and FG 3 reflecting the AEFS transition in perennial systems is not possible at the moment as survey is not completed in those FGs.

WATER QUALITY

The conventional baseline in FG 1 (perennial systems) performs best in terms of water quality, but a comparison to FG 2 and FG 3 reflecting the AEFS transition is not possible at the moment as survey is not completed in those FGs. The AEFS transitions between FG 4 (51%), FG 5 (63%) and FG 6 (69%) show a clear trend to higher water quality results with AEFS transformation. We expect that after finishing analysis of FG 1-3 similar trends can be determined also for fruit production systems. The intensity of crop rotations, fertiliser application rates, measures for preventing soil erosion as well as application of pesticides are relevant indicators.

PRODUCTIVITY

COMPAS, qualitative data from SMART. COMPAS: The indicators determining the level of productivity and farm income. Relate to impacts of specific production systems, factors of production, policy subsidies, or market prices; How can differences in gross margins of comparable products be explained?

COMPAS results for the indicator **Total Output**[7] show no correlation to the farm group (e.g. status on agroecological transition pathway), either the farm size. Though, animal producing farms (FG 4-6, except FG 4A) tend to achieve higher Total Outputs than fruit producing ones (FG 1). The fruit producing FG 1B, which is the smallest of all farms surveyed according its UAA, gain higher Total Output than the animal producing FG 5A and obtain by far the highest Total Output per hectare UAA of all farms. One reason behind this fact could be that the operation has been partner of the Austrian FADN for decades and the farmer is quite familiar with bookkeeping and managing along economic key figures.

At the same time **Total intermediate consumption**, summarizing all costs of production[8] is on animal producing farms (except FG 6B) higher than on fruit producing. This fact becomes particularly clear when Total intermediate consumption is related to Total Output. Except

[7] Total of output of crops and crop products, livestock and livestock products and of other output. Sales and use of (crop and livestock) products and livestock + change in stocks of products (crop and livestock) + change in valuation of livestock - purchases of livestock + various non-exceptional products (FADN definition)

[8] Total specific costs (seeds and plants, fertiliser, crop protection, other crop-specific costs, feedstuff, other livestock-specific costs) and overheads (machinery & building current cost, energy, contract work, other direct inputs) arising from production in the accounting year (FADN definition)

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FG 6B, which relies for animal feed mainly on on-farm resources, the other animal producing farms (FG 4-5, FG 6A) are buying concentrates from outside the farm to a large extent.

The both high intensity pig farms (FG 4A, FG FB; “intensity” expressed in terms of UUA, animal places, daily weight gain, diversity of crop rotation) are able to realise the highest **Labour Productivity**[9] among the farms surveyed. Due to the high working intensity of small-plot vegetable production, AWUs on FG 6B is relatively high and Labour Productivity therefore relatively low compared to absolute Net Value Added. On the other farms (FG 1A, 1B, 5A, 6A) the results for Labour Productivity are in one line with the results for Net Value Added.

Results for COMPAS and **SMART** are hardly to compare as COMPAS calculates figures on the basis of one years data, whereas SMART works much more qualitatively, for some indicators on a longer period of time and based on a sometimes vast number of indicators impacting one subtheme. E.g. 71 (also ecological) indicators have impacts on SMART-results concerning the subtheme profitability. Despite these limitations, it is interesting to note that the SMART results for the dimension **Economic Resilience** general speaking tend to be diametrically opposed to COMPAS results: While intensive pig farms (FG 4A, FG 5B) perform best in all COMPAS indicators, SMART results are better for most indicators for less intensive farms (e.g. FG 6B). Perhaps, this can be taken as an indication that the economic performance of the more intensive companies is good in a narrower sense, but should be considered critical before the thematically broader and longer-term background of a SMART sustainability assessment.

The results for some selected SMART-subthemes are the following:

- With regard to **Stability of Production**, all farms investigated show average results. Contrary to our expectations, fruit farms facing highly fluctuating yields in recent years, cut here no worse results than the other farms.
- FG 1A and 6B are diversified concerning their sales channels, are engaged in direct marketing and can fall back on long lasting custumer relationships. The latter also applies to FG 5A, who’s dependency on his main customer is relatively low. Therefore, these farms gain the highest scores in the subtheme **Stability of Market**.
- Due to high Austrian Standards – valid also for conventional – fruit production, farms belonging to FG 1 reach the highest scores for the SMART-subtheme **food quality.**
- Similarly, farms of FG 1 together with FG 6B are engaged in direct marketing, contributing to good results for the SMART-subtheme **product information** (strongly related with indicators like “Length of customer relationships”, “Transparency of

[9] Farm net value added per AWU (FADN definition)

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production" and of course "Direct sales"). Moreover, these farms fall back on more environmentally and socially responsible farm inputs than livestock farms do.

FARM INCOME

COMPAS, qualitative data from SMART

Due to their farm size and level of farming intensity, the pig producing farms FG 4A and FG 5B gain the highest **Net Value Added**[10] as well as **Net Farm Income**[11] in total terms of all farms surveyed. In contrast, the third pig producing farm (FG 5A) which produces considerably more extensive, cuts significantly worse for these two indicators. Moreover, FG 1B gain – due to its smaller size – lower absolute values for Net Value Added and Net Farm Income than other farms. Because of its unfavourable cost-output-ratio FG 6A obtain relatively low values for these two indicators compared to the Total Output.

When relating these indicators to **UAA**, smaller farms engaged in fruit production (FG 1) and direct marketing activities resp. (FG 1A, 1B, 6B) emerge to be more successful than bigger, non-direct marketing ones. FG 1B once more turns out to be the most successful farm. Interestingly, concerning Net Value Added and Net Farm Income per hectare resp., the both high intensity pig farms (FG 4A, FG 5B) lie in the middle range of the results for the farms investigated.

Farm size and high farming intensity is (still) decisive for farm economic success, measured in absolute values. Whereas in our case smaller farms are able to perform better concerning the indicators Total Output, Net Value Added as well as Net Farm Income when these are related to hectare UAA.

The results for some selected **SMART**-subthemes are the following:

- Concerning SMART results, farms belonging to FG 6 show the best results concerning the subtheme **profitability**, probably due to their high level of diversification.
- Farms which quoted the absence of any cases of illiquidity and without any bank liabilities, perform best in SMART-subtheme **liquidity** (FG 5A, 4A, 6B).
- All farms surveyed (except FG 6A) perform quite badly concerning **Local Procurement**. This is primarily due to the fact that the production location of central

[10] Gross farm income (total output and the subsidies, minus the total intermediate consumption) minus the depreciation

[11] Net value added minus the total external factors (wages, rent and interest paid) --> "Remuneration to fixed factors of production of the farm (work, land, capital) and remuneration to the entrepreneurs risks (loss/profit) of the accounting year" (FADN definition)

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farm inputs is spatially far away (e.g. feed, planting material in FG 1B) or its origin is unknown to the farmer (e.g. pesticides, seeds).

- As **Value Creation** comprises similar indicators as Local Procurement, supplemented by indicators concerning qualitative aspects around the topic of employees, results for the subtheme Value Creation are only slightly different (except FG 6A) to those of Local Procurement.

QUALITY OF LIFE

SMART: Indicators contributing to the subtheme score. To do this, check the value extract of SMART (see section 4.2), filter for a certain subtheme and "ScoreIndicator" in the Type column and sort the indicator column.

Similarly to the sustainability dimension Economic Resilience, less intensive farms (e.g. FG 6B) as well as fruit producing farms (FG 1) perform better than intensive pig farms (FG 4A, FG 5B) in most SMART subthemes comprised in the dimension Social Wellbeing.

The results for some selected **SMART**-subthemes are the following:

- Ratings for the subtheme **Quality of Life** is relatively high for all farms, irrespective their farm type or AEFS-status. This means that both spheres represented by the indicators - quality of work for family workers as well as for employees - can be classified as good.
- In general, all farm groups are characterized by only few or no **days of absence** due to occupational injuries and work-related illnesses, but the situation in FG 1 isn´t as good ad in FG 4-6.
- The Number of working hours per week is relatively low in all FG s.
- Pig and poultry farmers (whether AEFS or conventional) buy feed from oversea destinations, which may have social problematic background. Thus, these farms gain bad ratings for all subthemes associated with Fair Trading Practices and partly also Labour Rights.
- In contrast to most of the other subthemes summarised under the Social Wellbeing dimension, fruit producing farms obtain the lowest scores of all farms investigated concerning the subtheme **Support of Vulnerable People**. The reason for this rating may be that while farms employ a large number of seasonal workers, they do not take any special measures for proactive support of disadvantaged groups or anti-discrimination.

OTHER, CASE - STUDY SPECIFIC SUSTAINABILITY ASPECTS (SUCH AS RESILIENCE)

SMART), including physical work load / degree of mechanisation and information related to working time (overtime etc.).

- Concerning the prevention of resource conflicts, the two intensive pig farms (FG 4A, FG 6A) perform negatively.
- Concerning environmental involvement outside the farm we can state no correlation to the farm's AEFS-status. Nevertheless, AEFS-farms show more social involvement in community issues.

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- Subsistence farming is relatively high in the ecoregion. Farms of FG 6 show very high degrees of self-supply.

1.4. Farm Comparison

GENERAL DIFFERENCES BETWEEN FARM GROUPS

See section 5 for instructions on how to fill in the result template.

Is the pre-defined transition pathway mirrored in the results of the 3 DST? Are there unexpected results? Why? When having analysed the focus topics in more depths, are there any other interesting patterns related to other topics?

GENERAL SIMILARITIES BETWEEN FARM GROUPS

See section 5 for instructions on how to fill in the result template.

Due to the small number of farms investigated and their high diversity according to production type and size, it is difficult to draw general conclusions. One similarity between the farm groups is the high level of diversification on the single farms; all of them run several business branches: All fruit farms grow a high number of fruit species and varieties, on some farms additionally supplemented by arable crops. All fruit producing farms are engaged in on farm-processing at least on a small scale and process second quality class fruits to juice, dry fruit, vinegar, brandy etc. Livestock farms produce the feeding basis and also some concentrates on their own farms; pig farms keep breeding sows and produce piglets for their own pig fattening branch. Other livestock keeping farms run other business branches beside arable farming and livestock keeping (e.g. vegetable growing, biogas plant).

Another similarity between farmers investigated we observed during the interviews: Despite their workload, all farmers seemed to be quite satisfied with their work and their status as farmers. We got the impression that farmers are convinced that they do something good and meaningful with their work. All of them gave the impression of being proud of what they are doing.

In comparison to other farms in Austria, on a first sight net farm income seem to be quite good and dependency on public subsidies rather low on the farms investigated. Maybe, this provides an explanation for the observed high satisfaction among the farmers surveyed.

1.5. Trade ‐ offs / Synergies Between Focus Topics

Are there any trade-offs and synergies between focus topics, e.g. is there a pattern of performing better in one topic and worse in another? Or seems the performance in different topics linked?

While results for different topics within the same tool seem to be conclusive, trade-offs mainly relate to partly contradictory valuation results between the DSTs:

Generally speaking, SMART results for the dimension **Economic Resilience** tend to be diametrically opposed to COMPAS results: While intensive pig farms (FG 4A, FG 5B) perform best in all COMPAS-indicators, SMART results are better for most indicators for less intensive farms (e.g. FG 6B).

According to **biodiversity performance DSTs show different results**: Both the Cool Farm Tool and SMART ratings for the conventional baseline of the livestock farms (FG 4) are very

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poor in almost all biodiversity categories. Within CFT, the same is true for fruit producing farms so that in Cool Farm Tool a trend relation between AEFS transition and ratings in Cool Farm Tool biodiversity categories could be identified. On the contrary, SMART draws a totally different – more positive - picture concerning farms with perennials (FG 1).

1.6. Synthesis of Task 3.2 Results in the Case Study

The synthesis should include a summary of the most important findings. It also should reflect on: 1) Is the case study dilemma already addressed by some farms? How? 2) How do those farms perform in terms of the focus topics and in comparison with the conventional farms?

In general, on the farms investigated in our case study **differences** in results are bigger between different farm types (fruit versus livestock farms) than between farms of different status on the agroecological transition pathway. This is especially true for economic and social aspects evaluated.

While intensive pig farms (FG 4A, FG 5B) perform best in all COMPAS-indicators in terms of absolute values, smaller farms, engaged in fruit production (FG 1) and direct marketing activities respectively (FG 1A, 1B, 6B) emerge to be more successful than bigger, non-direct marketing ones when relating Total Output, Net Value Added as well as Net Farm Income to **UAA**.

Generally speaking SMART results for the dimension **Economic Resilience** tend to be diametrically opposed to COMPAS results: While intensive pig farms (FG 4A, FG 5B) perform best in all COMPAS-indicators, SMART results are better for most indicators for less intensive farms (e.g. FG 6B). Perhaps, this can be taken as an indication that the economic performance of the more intensive companies is good in a narrower sense, but should be considered critical before the thematically broader and longer-term background of a SMART sustainability assessment.

Similarly to the Economic Resilience, less intensive farms (e.g. FG 6B) as well as fruit producing farms (FG 1) perform better than intensive pig farms (FG 4A, FG 5B) in most SMART subthemes comprised in the dimension **Social Wellbeing**.

Concerning environment, results show a trend of **slightly lower GHG emissions** by "humus famers" compared to the conventional baseline.

According to **biodiversity performance DSTs show different results**: Both the Cool Farm Tool and SMART ratings for the conventional baseline of the livestock farms (FG 4) are very poor in almost all biodiversity categories. Within Cool Farm Tool, the same is true for fruit producing farms so that in Cool Farm Tool a trend relation between AEFS transition and ratings in Cool Farm Tool biodiversity categories could be identified. On the contrary, SMART draws a totally different – more positive - picture concerning farms with perennials (FG 1).

The AEFS transitions between within the livestock farms investigated show a **clear trend to higher water quality results with AEFS transformation**. After finishing analysis we expect similar trends for fruit production systems.

In contrast to our expectations, SMART **soil quality do not differ between "humus farmers" and conventional farmers**. Reasons behind that are that some of the conventional farms do apply the same techniques as their "humus farmer"-colleagues, (e.g. reduced soil management, catch crops, mulching etc.). Moreover, the "humus farmer" concept refers to

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single field plots rather than the whole farm and some “humus farmer” apply AEFS only on selected field plots which limits the concept’s effects.

Soil quality results can be seen as a good indicator of the overall concept: The case study dilemma is already addressed by some farms, but as the „hums farmer”-concept shows some limits (field plots instead of whole farm approach, applicable only for arable land up to now, preferred implementation on own land and not on leased land) its effects measurable by DSTs are restricted. However, this should not hide the fact that the „humus farmer”-concept is implemented outside the region by 250 farms and is already going to be imitated internationally.

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2. CZECH REPUBLIC (VYSOČINA REGION – DAIRY FARMS)

By Andrea Hrabalová (Bioinstitut)

2.1. Case Study Dilemma

The case study dilemma for the Czech case is how to maintain good practices on arable land of dairy farms applying organic farming as an agro-ecological farming system (AEFS) in Vysočina region with a positive impact on water quality and improved soil fertility whilst ensuring their economic viability.

(The question behind is also what prevents the expansion of organic dairy farming and why the number of dairy cows in organic farming (OF) has stagnated around 7000 heads (less than 2% of all dairy cows) since 2012, although milk is one of the major commodities purchased as organic in CZ.)

The Vysočina region (NUTS3) was selected as the main area of milk production in the Czech Republic (production in 2018 of over 571 million liters represents almost one fifth of the nationwide production). Similarly, the region is also the largest producer of organic milk (production of 9 million liters represents almost 30 % of total organic production). In addition, the only sales cooperative for organic milk "Czech Organic Milk" was established in this region in 2012.

2.2. Investigated farm groups

The Czech case study focused on the comparison of two farm groups to assess the agro-ecological transition pathway by three selected decision support tools (DSTs: CFT, SMART and COMPAS).

Based on the methodology and the selected dilemma, dairy farms with a significant share of milk sales (code FADN 450) in the Vysočina region were selected. To compare the agro-ecological transition the organic farms and traditional conventional farms as baseline were selected.

The selection and addressing of farms took place in several steps:

- Organic farms were selected on the basis of own database and the Organic Operator Register. The effort was to involve the organic farms from the cooperative Czech Organic Milk, which was successful.
- For the selection of conventional farms, typical representatives were first selected from the data of the Czech Statistical Office. Statistics have shown that large-scale farming prevails, 450 farms with 74 000 dairy cows are in Vysočina region. Farms with an area up to 200 ha hold only 5% of agricultural land and 6% of the total dairy cows in the region; farms from 200 to 700 ha take care of 9% of agricultural land and similar proportion of dairy cows. Most of the land and dairy cows are kept in holdings over 1000 ha (nearly 76% of the land and 71% of dairy cows). Therefore, the investigation targeted large conventional dairy farms as typical representatives in the region.
- The contacts of suitable farms were then collected (recommendations of accredited advisors, contacts from the Agricultural Union, contacts from the own database on

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organic farms that returned to the convention, contacts to demonstration farms, etc.)

- Bioinstitut then contacted and sent out project information to approximately 30 conventional farms with a request to participate in the project. However, the interest was minimal and the contact had to take place in three rounds. Organic farms were managed without problems thanks to the long-term activity of Bioinstitut in the organic sector.

Finally, we managed to cooperate with 4 conventional and 4 organic businesses. Due to the number of models and the size of farms, the number of 8 farms was approved as final for the Czech case study. Organic farms range from 200 to 1090 ha (with arable land share of 50-65%) and with dairy cows from 40 to 330 head. Conventional farms have a total area of 2215 to 2860 ha (with arable land share of 80%) and dairy cows ranging from 750 to 980 head. From the point of view of legal subjectivity, almost all forms are represented - from family farm, through cooperative, Ltd. and Joint-stock company.

All farms were asked to send background information (see Annex 1) which was used to prepare the assessments using the three DSTs. The farm visits were conducted from mid-June to the end of September, the time spent on one farm is estimated to be at least 7 days incl. 2 days on the farm.

2.3. In-depth topic analysis

DIRECT AND INDIRECT GREENHOUSE GAS EMISSIONS

Results for *Greenhouse gases* and *Air quality* from SMART show a better score for organic farms. The average score for OF is 61 (range from 49 to 72), for conventional farms is 45 (range from 39 to 52). The factors reducing the score at the convention include e.g. production, storage and application of slurry, lower proportion of grassland, higher consumption of nitrogen fertilisers, higher energy intensity (higher electricity consumption per hectare).

On the other hand, there are some similarities in both groups, for example, the minimum change in land use (almost no grassing, plowing or afforestation or deforestation), extensive management on permanent grassland, little interest in non-tillage farming, as well as in renewable energy sources. As positive effects on *Air quality* both groups follow the rules e.g. not to burn of plant residues in the field or to prevent of environmental pollution from point sources of nutrients on the farm, based on legislation or subsidy conditions (e.g. GAEC 6: Maintaining the level of organic soil components, including a ban on stubble burning).

BIODIVERSITY

Evaluation of *Biodiversity* through CFT was in favor of organic farms in most indicators (see Figure 1).
The only exception was the indicator *Farmed products* evaluating the diversity of crops and livestock.
Given the large size of Czech farms, with arable land in the range of 100 to 650 ha in OF and around 2 000 ha in convention, the assessment of diversity is difficult. All evaluated farms cultivated a diverse spectrum of crops (about 10 different crops, of which 4-5 cereals) and used more than one variety for 1-3 crops. Conventional farms, unlike organic farms, also

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devoted to fattening pigs, one fattening poultry, more often kept several breeds. For this reason, the indicator *Farmed products* and *Livestock, crop and variety* came out higher for convention.

CFT confirms the higher rating of organic farming with regard to *Production practices*. The clear benefit of organic farming is the elimination of pesticides and mineral fertilisers that are commonly used on conventional farms. Due to the intensive farming and cultivation of highly bred varieties of crops, conventional farms use a wide range of plant protection products, including seed dressing, growth regulators, desiccants, preventive use of herbicides and fungicides. So far, no conventional farm has tested any biological or organic certified product in the investigation. Conventional farms prefer rather precise agriculture with the aim of saving spraying and fertiliser (innovation, GPS, technologies to reduce pesticide drift such as low drift nozzles, application of inhibitors, use of monitoring, etc.). In innovation, conventional farms are ahead of organic farms. They rely mainly on nature, do not use any crop protection products / any fertilisers, either certified for OF. Consultants consider this attitude to be a weakness of further OF development, especially for produce on arable land - too extensive approach is reflected in the economic sustainability of organic farms below.

The biodiversity rating of CFT reveals the lack of *larger nature protection areas* across all farms assessed. Vysočina is a traditional agricultural region: 60% of its area is covered by agricultural land, of which 77% is arable land. None of the farms was located in a protected area or in Natura 2000 areas.

The low value of the *Small habitats* indicator for both groups of farms (13 and 10) confirms their narrow targeting to agricultural activity. Taking care of the landscape elements (boundaries, terrace, grassy valley, woody group, alley, solitary trees, ditch, wetland or pond) is risky for farms, so they try not to include them in lease agreements when renting agricultural land. This is due to an unclear interpretation of the mandatory maintenance requirements (GAEC 7: Preservation of landscape features) and a high risk penalties if destroyed. Farms have no way of avoiding interventions caused by another person or directly by the landowner (cutting down trees, trimming branches, damaging bushes…). In addition, these areas were appreciated by the financial authority and are levied on them as if it were a production area. For this reason, the *Woodland, Wetland and Acquatic flora and fauna* indicators have low values across all farms with slightly better scores for organic farms.

Higher rating of organic farms in *Arable and Grassland flora* indicator is given mainly by higher representation of areas with naturally occurring grasses and flowering plants (field margins, field corners, verges along roads), which is related to keeping smaller fields in OF (2-6 ha compared with 10-18 ha in convention). *The large size of arable land fields is a problem in CZ in general. Therefore, with effect from 1 January 2020, the condition of limiting the cultivation of monocultures to a maximum of 30 ha contiguous areas will be implemented by the standard of good agricultural and environmental condition GAEC 7d.*

Better value for conventional farms, closer to OF, in the *Grassland birds* indicator (21 and 27) is probably due to the mandatory condition to leave an uncut grassland strip annually (min. 3% and max. 10% of field area) on plots greater than 12 ha if they are included in one of the titles of AE Measures of Grassland Care. This condition was respected by all evaluated conventional farms.

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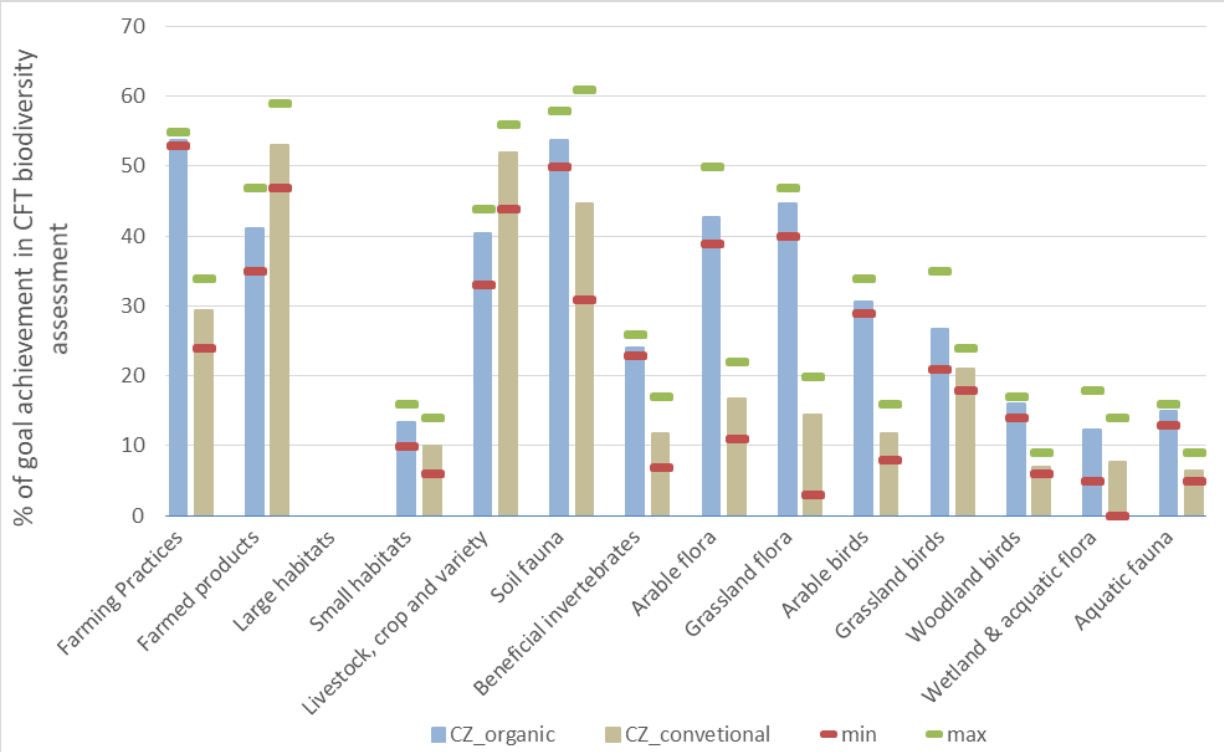

Figure 1: Goal achivement rating (0-100%) for the biodiversity module of CFT for different impact categories.

Also with regard to the SMART theme *Biodiversity*, the conventional farms scored worse than the organic farms (in average 33 compared to 61). Similarly for all three subthemes: *Ecosystem diversity* (25-32 to 52-56), *Species diversity* (32-37 to 63-67) and *Genetic Diversity* (35-38 to 59-66).

The main explanatory factors for the lower scores are a different structure of crop production, intensive use of pesticides and fertilisers (use of chemical-synthetic pesticides and higher N- fertiliser inputs), lower proportion of permanent grassland (20% in convention to 40% in organic farming) and larger average size of the fields of arable land.

Identified differences in plant production

Although all farms had varied crop rotation, the difference is crop selection - conventional farms donated 40 to 50% of arable land for cereal cultivation (winter wheat and spring barley dominated), almost 40% of arable land for winter rape, silage maize and potatoes, only 10% was fodder. Organic farms, on the other hand, grow fodder crops on almost 40% of arable land and about half took up cereals. The structure of cultivated cereals is also different in OF, it is more balanced - although winter wheat also dominates, other cereals also have a significant share: triticale, oats, winter barley, rye. Organic farms used also more intercrops (about 10% of arable land), usually mustard, autumn legume-grain mixture and Landsberg mixture.

The consistency across farms was in the composition of fodder forage. A legume-grain mixture (oats and peas) with a clover undersown is used, which is left on the plot until the second year. Diploid older clover varieties are often chosen with lower yield but better quality for silage.

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Similarly, there was no difference in the extent of arable land cover over the winter between convention and organic farms. The coverage of arable land outside the growing season was in the range of 45-55%. However, there was a difference in the crop used - in convention soil coverage is ensured mainly by winter cereals and winter rape, in OF by winter cereals and clover undersown (undersown in OF occupied 15-20% of arable land; in the convention only about 5 %).

In order to ensure comparability, farms of similar production orientation were selected for the investigation, i.e. both organic and conventional farms use classical manure from their own livestock production to fertilize arable land. The difference is that organic farms are trying to make it with their own manure - annually fertilizing 20 to 30% of arable land at a rate of about 25 tonnes / ha. None of the organic farms in the survey uses other supplementary fertilisers. Conventional farms, on the other hand, consistently mentioned that production could not be expected without the supply of mineral fertilisers. All convetional farms in the survey fertilize the entire area of arable land annually (the dose is between 100 and 200 kg N/ha). Conventional farms also use P-fertilisers, at least K-fertilisers. Due to the need for straw / litter, plowing of plant residues is not very typical in CZ. *In the Czech Republic, the obligation for farmers to calculate the nitrogen balance in order to comply with an upper limit has not been applied yet. The change will now come with a new programming period. Exceptions are Vulnerable Areas by Nitrates Directive where the legislation sets upper limits for the amount of nitrogen per crop and farmers are obliged to keep records. In OF, the regulation sets an upper limit of 170 kg N/ha, which is hardly exceeded by organic farms. In neither case did the farm calculate the humus balance, this is not yet a common practice in CZ.*

The management of permanent grassland is very similar among farms and is valid for the whole CZ. The grasslands are managed extensively (1-2 cuts) and not fertilized (maximum a mixture of technical water from the milking parlor, silage juices and slurry with a content of up to 0.5% N is used).

All farms follow **the same rules for riparian strips**, where they do not use sprays or fertilisers. In CZ, there is a mandatory condition GAEC 1 Compliance with protective strips along watercourses, which mandates to maintain a protective strip of non-fertilized soil with a width of at least 3 m from the bank line or with a width of at least 25 m in the case of a slope of the land above 7 degrees.

As mentioned above, Czech farms are focused primarily on agricultural activity - the occurrence of forest, agroforestry systems, water bodies and other landscape features is minimal. Neither organic farms nor conventional farms are engaged in targeted support for biodiversity and take **no measures for interconnection of areas to promote biodiversity -** impacted the rating of the SMART theme *Biodiversity* negatively to promote biodiversity.

On the contrary an abstention from the use of GMO feed and crops across all farms assessed impacted the rating of the SMART theme *Biodiversity* positively. *(There is a market motive for not using GMO feeds - the "GMO free" milk surcharge, which has made conventional farms switch from soya to rapeseed cakes. A similar motive also applies to renouncing glyphosate.)*

Changes in favor of biodiversity, e.g. land use change - afforestation / grassing, tree planting, boundary or wetland building are limited by fragmented land ownership in CZ. These changes can only be made with the consent of the owner, who usually disagrees,

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because is afraid of the decline in land value. According to the farms, the situation is "conserved" without the possibility of significant changes. No farm in the survey, except one with ten-year leases, has certainty of land in the longer term. The share of own land in farms ranged from 10 to 20% with an average number of lease contracts of around 500. In the Czech Republic, the statistics show that 90% of the land is rented.

SOIL QUALITY (SOIL AS A MEAN OF PRODUCTION)

The rating score in the SMART *Soil Quality* subtheme of the conventional group was again slightly lower (51%) than the score of the organic group (65%).

One aspect that may explain the good outcome of the organic group is the overall absence of pesticide usage and uncontaminated soil by their residues. What also contributed to higher score in the organic group is almost twice higher use of legumes in crop rotation, more frequent intercrops and undersown crops – these practices can be generalized for OF as general.

Signs of soil compaction, physical soil degradation, was insignificant on all the assessed farms (only field headland and manure storage areas were mentioned where mechanisation travels are more frequent). Similarly, the risk of erosion in the region is low - there are no steep slopes in the agricultural landscape and the slope is up to 7%. Higher tendencies were identified only in a limited number of fields where erosion protection was sufficient for all farms. *(In CZ, conditions of GAEC 5 - Arable land management in so-called strongly and slightly erosion-endangered areas are in force. Growing of erosion crops (maize, potatoes, beet, sunflower, etc.) on strongly erosion-endangered areas is prohibited and their cultivation on slightly erosion-endangered area is limited by use of soil-conservation technologies. Restrictions apply also to cereals and oilseed rape on strongly erosion-endangered areas where cultivation is also possible only with the use of soil-conservation technologies.)*

Another aspect that also comes out as a beneficial factor for all farms is the absence of degraded lands on the farms. During the interviews, no farmers stated to have any real difficulties with soil degradation. Both groups of farms strive to improve the quality of soil consistently mainly by supplying organic matter (manure / slurry), crop rotation, liming or proper cultivation (ploughing to different depths or undermining). The inclusion of farms in soil analysis at national level is evaluated positively. On the contrary, the negative impact of the *Soil Quality* subtheme had that none of the farms calculated the humus balance of their soils. (*In CZ, the Agrochemical Testing of Agricultural Soils (AZZP) is carried out since 1961 according to the Fertilisers Act, the soil reaction (pH), the content of carbonates and accessible nutrients are evaluated in regular six-year cycles and optimum doses of phosphorus, potassium, magnesium and liming can be determined. Participation in AZZP is voluntary and the farm must apply for inclusion.)*

WATER QUALITY

Both farm groups scored "good" in the SMART *Water* theme, the conventional farms reached in average 65 and the organic farms 75 - scores that fall within ranges labelled as green by SMART. For *Water Withdrawal* subtheme there was no difference between organic and conventional farms (70 and 71), while for *Water quality* the outcome of the conventional group was again lower (58) than the score of the organic group (80).

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The main reason for lower *Water quality* scores for conventional farms is primarily the use of chemical pesticides, which have a clear negative impact on water quality. Conventional farmers have mentioned the occurrence of water quality disputes. Two of them operate partly in the protected area of water resources and feel strong political pressure to reduce pesticide use. The number of allowed plant protection products is reduced for them every year (as part of the regular review of active substances) and the pressure of water authorities to reduce pesticide residues is also increasing. (*Both farms voluntarily entered into a three-year pilot project in 2019, under which they undertook to reduce by 20% the doses of pesticides used and eliminate the selected high-risk pesticides altogether. The entry into organic farming is unimaginable for them yet*).

The risk of water pollution from other sources of agricultural activity is then low. In CZ, there are strict rules that must be observed by all farms. Each farm must have a so-called Emergency Plan describing measures against leakage of harmful substances into the environment, which is based on the requirements for the protection of groundwater and surface water quality and must be approved by the water authority. The plan includes, for example, the location of field manure storage with regard to water protection conditions and the Nitrate Directive. *(In CZ, there is an obligation to place a field manure storage at least 50 m from the watercourse, in places where there is no erosion-threatened soil or waterlogged soil or there is no amelioration. Solid organic fertilisers may be stored on agricultural land before their use, for a maximum of 24 months; in vulnerable areas of nitrogen for a maximum of 12 months and in the same place for up to 4 years.)*

From the point of view of *Water Withdrawal* - irrigation is not used very much in CZ and the evaluated farms, with the exception of the crisis year 2018, do not experience the effects of drought on the yields of cultivated crops. The farms do not deal with any water catching measures (e.g. reservoirs to retain rainwater from roofs, etc.) and have consistently stated that there are no disputes concerning the amount of water. However, all farms are aware of their dependence on water for dairy farming and are trying to manage water efficiently. By comparing water consumption per hectare, organic farms seem to be more economical than conventional.

The use of high-pressure cleaning equipment is standard. It is common to store technological water separately and reuse it for cleaning the milking parlor. Technological waters are then applied together with slurry to fields, most often to grassland. Organic farms do not use chlorine cleaners during sanitation. Only part of the technological water is discharged into the sewer, always in accordance with the Waste Water Act. *(In dairy farming, water consumption is an important input. The average daily water consumption is around 100-120 liters per dairy cow. Technological water consumption for cleaning of the plant is reported to be about 15-20 liters per dairy cow per day, i.e. a total of 45 m3 per dairy cow per year).*

However, the interviews showed that farms do not have a precise overview of water consumption because they take part of the water, especially for animals, from their own wells. There is no information about water availability and quality. *(The Water Act imposes an obligation to measure the quantity and quality of water for wells with a groundwater abstraction of more than 6,000 m3 per year. In case of lower consumption, there is no obligation to keep records and pay a fee of CZK 3 per m3 according to the law.)*

PRODUCTIVITY

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The survey was dominated by farms with formal employees (organic farms 20-35 AWU, conventional farms 70-90 AWU). The average number of workers per 100 ha of agricultural land is 3.1 AWU (range 2.9 to 4.3), which is close to the FADN average for dairy farms (3.5 AWU/100 ha UAA for organic farms and 3.85 AWU/100 ha UAA for conventional farms).

The difference between conventional and organic farms is apparent when comparing the total agricultural production per hectare, which was twice lower for organic farms (on average 22 000 CZK/ha compared to 48 000 CZK/ha in convention). The value of production converted to AWU was also lower in OF (0.8 to 1.5 million CZK in convention). The lower value of production in OF is, besides the higher proportion of non-market crops on arable land, associated with lower yields (average of winter wheat was 3.9 tons to 6.9 tons per hectare in convention, i.e. 60% of the conventional yield). Similarly, the dairy cows have a lower yield in OF (6300 litres to 9800 litres per year in convention, i.e. 64% share).

Here it is necessary to mention the difference in the breed - in OF dominates Czech Spotted dual purpose cattle, while the convention is dominated by dairy Holstein cattle. The decrease in production is compensated by the price premium for organic production, the farms in the survey achieved on average 25% surcharge for milk (10.80 CZK to 8.57 CZK per litre) and almost 60% surcharge for cereals (6000 CZK to 3800 CZK per ton of winter wheat). The values correspond to the national averages.

The structure of production also shows a greater economic dependence of organic farms on milk production (on average 70% of sales), while in conventional farms milk production represents 55% and arable land has a significant share (35% of sales versus 10% in organic farming).

The indicator of economic performance *Net Value Added* (total agricultural production after adding operating subsidies and deducting direct costs of production and depreciation) shows whether the company is able to pay wages, rent and interest and to cover its production factors. **The *Net Value Added* of all farms was positive**. NVA per hectare of organic farms reached EUR 850 and conventional farms slightly higher EUR 1000 (respond exactly to FADN average EUR 825 and EUR 1000). Given the comparable number of AWU in both farm groups (3.1 AWU/100 ha), both farms achieve almost comparable profitability of production at around EUR 32,000 per AWU (FADN average is EUR 23,560 in OF and EUR 25,856 in CF per AWU). **The comparison shows that organic farms with milk production can achieve comparable economic results as a convention and be viable in the long term.** However, **it should be kept in mind that the NVA value is for organic farms** more than for other groups of farmers **dependent on the level of subsidies**. FADN reported up to one third higher subsidies per hectare in OF compared to the convention, for farms under investigation the subsidies per hectare were 29% higher in OF. At the same time, the amount of depreciation is mostly lower in OF and accounts for about 80% of the value of depreciation of conventional farms (survey and FADN).

FARM INCOME

***Net Farm Income* was positive for all evaluated farms**. The farms were able to cover all external production costs, in particular wages and rent of rented land, and to generate profits. The amount of the indicator per farm ranged from less than 200 thousand EUR to 2.5 million EUR. Per hectare, the average NFI value for both farm groups was almost comparable, reaching 750 EUR for the convention and 778 EUR for organic farms (a slightly higher value in OF is due to the inclusion of a family farm where the NFI also includes

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remuneration for family work). Compared to the FADN average (360-380 EUR per ha), the values are twice as high. It is difficult to estimate the reasons and errors in the conversion of data to the model cannot be excluded.

Similarly, close values were reported by both groups of farms when converting FNI per AWU, after excluding the family farm, the average in OF reached approximately 20,300 EUR and average in the convention of 23,700 EUR per AWU. Again, these values are more than double compared to FADN for dairy farms (10,783 EUR in organic farming and 9,342 EUR per AWU for convention).

The indicator was influenced mainly by the cost of wages, the lease of land and investment subsidies. E.g. the amount of investment grants was significantly different between farms, from 0 to 24 million EUR. On the other hand, the differences in the price of land lease were minimal, amounting to about 2500 CZK per ha (100 EUR/ha). Exception was only farm CZ7, which pays rent 3200 CZK, but the only one also stated in the questionnaire that it has no fear of lack of land and trying to have min. 10-year lease. The comparison with FADN shows higher rental prices in the selected region (1800 EUR/ha), which was confirmed by farms with regard to higher bonita and fertility of the soil in Vysočina.

Wages are an important cost item in agriculture, accounting for almost a third of total costs on farms and, according to farms, they have been growing rapidly, especially in recent years. The trend of lower wages on organic farms was evident, average in OF amounted to 324,000 CZK per AWU (12,960 EUR) compared to 470,000 CZK per AWU in convention (18,800 EUR). Lower wages in OF are also confirmed by FADN and reach 80% of wages in the convention (11,700 EUR to 14,800 EUR per AWU). Wages for the assessed farms were higher than the FADN average. Moreover, for two conventional farms (CZ5 and CZ7), labour costs do not include the costs of agency workers covered in services.

Monthly labour costs for the evaluated farms ranged from 1030 to 1600 EUR, which, after paying compulsory insurance (about 25%), represents an average gross wage around 1000 EUR/month. (For comparison, the minimum wage in CZ in 2018 was approximately 500 EUR/month and the average wage was 1275 EUR/month).

The economic situation of farms can be assessed as “good” also by the SMART *Profitability* subtheme, all farms received scores that fall within the ranges labelled as green (75 conventional and 71 organic farm groups). All farms, including family farm, have professional accounting, achieve stable profits and make long-term investments (most often land and equipment purchase and stable repair). Most of the selected farms also have income from other activities (petrol station, canteen, sawmill, joiner, coal or sand sale, own milk or meat processing and farm shop), but these activities do not account for more than 10% of the farm's total income. (Farms mentioned that these activities are not very profitable, they sometimes subsidize them). None of the farms reported liquidity problems.

QUALITY OF LIFE

For *Quality of life* the outcome is generally good for the Czech case. All farms received scores that fall within ranges labelled as green by SMART. The average score is 75 ranged from 68 to 80.

This is mainly due to the employment conditions and benefits that are common in European countries. The basis is an employment contract, which includes working hours, overtime compensation, holidays, access to health care, etc. In all evaluated farms, workers were

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provided meals (most often in the form of a canteen in the company, eventually ordering meals or at least access to equipped kitchens). Of course there is access to toilet facilities, take regular breaks and freedom of assembly.

Additionally, the high scores for *Quality of life* are also explained by nation-wide high standards of work place safety, strict regulation and enforcement of rules regarding use of safety equipment when handling hazardous materials, low occurrence of work-related accidents, large awareness of on-farm safety and general equality in pay between men and women. *(In CZ, there is an obligation for employers to provide employees with periodic training on regulations to ensure the safety and health at work and fire protection regulations. The obligation is to keep and report accidents at work and to have a safety plan drawn up.)*

The high mechanisation facilitating human labour available in all farms also contributes to improving the *Quality of life.*

On the other hand, the factors reducing *Social wellbeing* include mainly lower wages in agriculture (a drop to 78% of the average wage in the national economy), work overload of managers and family members in the case of family farms. Only one farm has created new jobs in connection with the introduction of dairy farm processing. For other farms, the number of jobs has been declining in the long term; it is more about retirement than layoffs. Most farms reported labour shortages. Family farms solve this by purchasing mechanisation (milking robots) or performing work by a service. Large farms are forced to use agencies (i.e. employ foreign workers). This is also related to the increase in the number of conflicts at the workplace, which the manager is forced to solve, as stated by half of the farms interviewed. The fluctuation of staff on farms remains low.

Both groups of farms in the *Capacity development* subtheme achieved a lower score (only 48 on average). This result is due to the low involvement of workers in trainings and external education, especially in organic farms. Advisory services were rated positively, but the lack of sustainability topics (environmental farming with a link to the economy) was reported by all farms in the survey.

INCENTIVES TO IMPROVE FARM SUSTAINABILITY (CASE STUDY SPECIFIC ASPECT)

Specific indicators have been proposed in the Czech case study focused mainly on the farm motivation to transfer farming towards more environmentally friendly forms.

Farm responses confirmed worsening public opinion on agriculture. Thanks to the media, agriculture is seen as the biggest enemy responsible for climate change, drought in the countryside, disappearance of wild plants and animals, etc. Furthermore, the misunderstandings between the village and the farms are deepening as a result of changing rural populations without a link to agriculture. "Agriculture has begun to stink the people in rural area," farms say. The social status of farmers is deteriorating, employees do not identify themselves with the farm and there is no motivation of the young generation to enter this field of work. Organic farms have complained that they do not feel neither sufficient public appreciation for their considerate farming nor public demand for organic food. They have no advantage when renting land, the owners are only interested in the amount of rent. There are cases where landowners are afraid to rent land to an organic farm because they are afraid of weeding the land due to not using herbicides in OF.

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The barrier to entry into OF is also a large dependence on subsidies, which threatens their long-term sustainability. Subsidies account for up to half of the revenue compared to 20% in the convention. In the case study, subsidies for organic farms accounted for 40% and for conventional farms up to 20% of income. The higher dependence of organic farms on subsidies is caused mainly by extensive farming, especially on arable land, not reaching the price premiums due to lower demand for organic products (lack of processors), consumption of a significant part of plant production as feed within the company = close farm cycle with minimum external inputs.

Improving sales and using alternative sales channels (yard sales, CSA, agrotourism…) is not easy in the conditions of Czech large agricultural holdings. Two organic farms in the survey newly started farm processing and would consider as a success if they manage to dispose of at least 20% of milk production by direct sale of dairy products. But they will still depend on the sale of milk through the cooperative Czech Organic Milk. Conventional enterprises do not even consider milk processing in their production volume.

All farms in the survey agreed on the need to continuously improve farming practices, but lacked advice on agri-environmental issues linked to the farm economy and also lack young workers open to new procedures.

2.4. General differences between farm groups

As was noted previously, there are a number of similarities within a selected group of conventional farms that distinguish it from the organic group. The main ones include:

- **Different structure of land use** (lower share of permanent grassland, only a quarter of the forage production and half cultivation of legumes compared to OF, lower use of intercrops and under-sowing, significant cultivation of maize for silage and winter rape…)
- **Higher intensity in crop production** (double yields compared to OF, purchase of N and P fertilisers, use of a wide range of pesticides,… as well as increased use of innovations and precision agriculture to save costs of inputs, twice the size of fields)
- **Higher intensity in livestock production** (Holstein dairy breed compared to combined Czech Spotted cattle in OF and by one third higher production of milk, balanced unified feed ration throughout the year (corn silage and supplementary feed purchased) compared to green feeding or grazing, clover and own cereals used in OF, larger herds and lower number of lactations 2-3 compared to 5 sometimes up to 8 in OF…)
- **Higher agricultural production** (per hectare and AWU reached double the production value, dependence on milk sales is lower than in OF, income from crop production is important, lower production prices due to global market surpluses…)
- **Lower dependency on subsidies** (subsidies account for 20% of income compared to almost half of organic farming)…

2.5. General similarities between farm groups

On the other hand, there are common characteristics for all farms in the case study, as well as the Vysočina region or the Czech Republic as a whole. Here are the main ones:

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- **Professionalization and high mechanisation** (milk production is at a high level in CZ - loose housing, clean and space stables, heated drinkers, scrubs, collars controlling ruminants, robots in the parlor…)
- **Uncertainty of agricultural land** (farms manage 80 - 90% of leased land, which leads to the risk of increasing rents, land loss, failure to comply with five-year commitments when entering subsidy measures, but it is also a limitation when land use change is needed…)
- **Low interest in targeted conservation of nature and landscape** (narrow focus on agricultural activities, low interest in AEO, avoidance of landscape features or otherwise valuable areas (efforts to exclude them from lease contracts), low share of forest, water areas or agroforestry systems, extensive management of permanent grassland with minimal renewal)
- **Compliance with stricter CAP standards and conservation rules** (all farms comply with mandatory regulations and rules for granting subsidies (GAEC in CC, AECMs, OF, national constraints…), for example the condition to leave an uncut grassland strip on plots greater than 12 ha, provide protection strips along water courses or minimal soil coverage outside the growing season, adapt the management on arable land in strongly and slightly erosion-endangered areas, comply with fertilization limits in vulnerable areas of nitrogen, etc.
- **Comparable economic results** (Net Value Added per AWU (profitability) is comparable for both groups of farms with milk production (about 32,000 EUR), also FADN states that dairy farms traditionally belong among the most successful production orientations in OF and can equalize convention. The Net Farm Income indicator was also close for both groups (750 EUR/ha in convention to 778 EUR/ha in OF) as well per AWU (23,700 EUR in convention to 20,300 EUR in OF). All farms achieve stable profits and have no liquidity problem.
- **Fair working conditions** (clear working conditions, gender equality, no occurrence of child labour or forced labour, possibility of breaks, regular meals, freedom of association and collective bargaining, fair access to production, stable suppliers and buyer relations, etc. it applies to farms both in the case study and in the Czech Republic and can be assumed to be valid across the EU. In CZ, social wellbeing in agriculture is reduced by low wages, which reach less than 80% of the average wage in the national economy and most agricultural workers do not reach the average salary, even so the fluctuation of staff on farms remains low.
- **Lack of long-term sustainability planning** (lack of evidence of positive and negative farm impacts on society and low involvement in local activities; all farms perform quite badly with SMART subthemesubthemes like Civic Responsibility (25), Mission Statement (16), Transparency (37), Responsibility (29) and Holistic Management (32) covered Sustainability Management Plan and Full-Cost Accounting. There is potential for improvement and especially with regard to the size of Czech farms even small

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improvements in the right direction can have a great effect, e.g. implementation of nitrogen consumption calculation, humus balance or farm plan development.

2.6. Trade-offs / synergies between above topics

Probably the biggest compromise that farms in the case study, but also in the Czech Republic and the EU in general solve, is the same as the dilemma of the UNISECO project - how to ensure economic viability and at the same time can afford to apply more agri-environmental farming system. Applying a more environmentally-friendly management method usually means a decrease in revenues or an increase in costs. At least it always requires a change from established practices - that means more energy and capacity from the farm management.

SMART and COMPAS models have confirmed that higher farming efficiency / intensity positively affects economic performance (profitability) at the expense of soil, water or air quality (e.g. due to pesticide residues the conventional farms have a worse Water Quality score and have disputes with water authority). Similarly, economies of scale and increased mechanisation improve farm competitiveness, reduce labour demand and labour costs, but negatively affect Ecosystem and Species Diversity indicators (lack of landscape features due to field consolidation) and make difficult to implement targeted landscape conservation measures (e.g. a company with 2000 ha is not able to hold specific management in a valuable location of 2.5 ha since it has no little mechanisation , crossings on the field are expensive, lack of know-how, agronomist capacity…).

Often several factors act simultaneously and contradictory, e.g. the COMPAS model confirmed on NFI and NVA indicators that dairy farms can be economically comparable to the convention, but it should be added that this is at the expense of: higher dependence on subsidies, lower AWU on farms, lower wages, lower depreciation indicating lower investments in organic farming, maintaining high extensiveness and minimizing costs, and high dependence on the milk price premium. At the same time, organic farms are better able to cope with stricter CAP rules and regulations, and their quality of life is higher (they are not so much under public pressure and have escaped from dependence on external inputs and traders through adherence to a closed cycle).

SYNTHESIS OF TASK 3.2 RESULTS IN THE CASE STUDY

With respect to the case study topic, it was expected: *confirmation of better arable farming practice in dairy farms compared to conventional farms and a better understanding of their economic situation in order to set recommendations for their better economic viability. In addition, efforts have been made to understand more barriers to the greater spread of organic farming in the dairy sector…*

In most cases, the results mirrored the agro-ecological transition pathway and the difference between conventional baseline and the organic farm group was noticeable.

SMART and CFT models confirm the higher rating of organic farming in most indicators within the ENVIRONMENTAL INTEGRITY (Biodiversity, Soil Quality, Water Quality and Air Quality), which was expected.

Similarly, in the field of GOOD GOVERNANCE, the score of the organic group was slightly higher than the score of the conventional group, although it was a low score against other indicators.

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A surprise was the evaluation of organic farms in the area of ECONOMIC RESILIENCE (SMART), where the results were balanced with a group of conventional farms (OF achieved slightly better results in 10 out of 14 subthemes). A similar conclusion emerged from the COMPAS model, which showed on selected indicators that dairy farms can achieve comparable economic results as convention and be viable in the long term.

Within the last fourth area of sustainability, SOCIAL WELLBEING (SMART), the organic group performs better for nearly half of the 16 subthemes compared to the conventional group, but there is much room for improvement.

Thanks to a better understanding of the situation, it is evident that other factors seem to prevent the expansion of organic farming, not just the concerns of farms about the decline in profitability and economic competitiveness. There are a number of other important factors e.g. the stability of agricultural policy and the amount of subsidies, the national political climate towards organic farming, know-how and capacity in farm, the issue of new sales, the lack of advice focused on the environmental area, the lack of qualified agronomists and other…

In conclusion, the group of organic farms performed better than conventional according to the results of the used models and appears to be a more sustainable way of farming for the future. However, it faces a number of challenges for further improvement and development, and further research is needed to help and facilitate the transition to greener agriculture.

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3. FINLAND (NIVALA REGION – DAIRY FARMS)

By Janne Helin (LUKE), Jyrki Aakkula (LUKE), and Kristina Svels (LUKE)

3.1. Case Study Dilemma

How to reduce harmful climate, water and soil impacts of dairy farming in Nivala region without sacrificing economic viability of the local dairy sector, by means of envisioning and implementing a multipurpose bio-product plant along the principles of circular bioeconomy, with the aim of producing bioenergy (mainly biogas) and organic fertilizers from manure. What are incentives of the major actors to support the transition process towards more carbon neutral milk production in Nivala region? What are barriers that may prevent the bio-product plant to become realized despite of almost unanimous local consensus backing the idea?

3.2. Investigated farm groups

The Finnish case study investigates farms producing milk. Conventional dairy farmers were recruited in cooperation with Valio (biggest dairy cooperative in Finland and a key actor in local MAP) which aims to deliver carbon neutral milk by 2035 and is cooperating with energy company Gasum to build biogas plants in Finland, starting with the one planned in Nivala. Organic dairy farmers were identified with the help of major Finnish agricultural advisory organisation Pro Agria. Three of the dairy farmers investigated belong to a set of farmers that have been involved in planning the bio-product plant in Nivala from the beginning (2016). For comparison, three organic organic dairy farmers and three conventional dairy farmers without specific interests in the bio-product plant project were included. The farm visits were conducted between April 30th and August 8th.

As indicated above, nine farms are included in the case study, divided between two FADN farming groups, namely:

- **FG1: Conventional dairy farms, but active in the proposed biogas project (FADN 450)**
  This group consists of three conventional (dairying combined with field crops) farms that have supported the plans of Valio dairy cooperative to build a new biogas plant in Nivala and are seen as potential (committed) suppliers of feedstock to the plant.

- **FG2: Conventional dairy farms not connected to the biogas project (FADN 450)**
  This group consist three conventional (dairying combined with field crops) farms that are not active supporters of the new biogas plant.

- **FG3: Organic and/or more diversified dairy farms (FADN 832)**
  This group consists of three organic dairy farms that are not actively part of the biogas project and have adopted certified organic milk production as the agro-ecological production concept.

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At the start of the data collection period agreed in the project management plan/grant agreement, the tools to collect farm data were not ready to be used and the data quality is poor because of the many mistakes in the collection template.

SMART RESULTS, OVERALL CONCLUSIONS

When we compare in broad terms the SMART results between the three farm groups we can find a clear pattern. FG3 (Organic dairy farms) has the highest average score in terms of economic resilience, environmental integrity and good governance. FG1 (Conventional dairy farms active in the bio-plant project) becomes ranked first in social well-being and second in all other major dimensions of sustainability. FG2 (Conventional dairy farms not connected to the biogas project) has the lowest average score in all the four major SMART dimensions of sustainability (see Table 1).

Table 1. Average scores of the farm groups (FG1, FG2, FG3) in relation to the four major dimensions of sustainability (highest score in green and lowest score in red).

Sustainability dimension	**FG1**	**FG2**	**FG3**
Economic resilience	54,6	51,1	60,1
Environmental integrity	61,3	60,0	67,6
Good governance	49,9	40,4	53,2
Social well-being	73,6	68,1	70,8

Because the number of farms analysed is small and because there is lots of variation inside the groups, it is not possible to draw statistically valid conclusions. However, the overall SMART results reflect the fact that organic farms, in general, pay more attention to sustainability than conventional farms. This is, of course, due to the principles and basic ideas of organic farming, especially when environmental integrity is concerned.

What comes to FG1 compared to FG2, it is likely that conventional dairy farmers in FG1 are more keen on developing their production practices than conventional dairy farmers on the average. Their interest to the bio-plant project is a signal of that. They may not express similar innate appreciation of sustainability as organic dairy farmers but they have a clear understanding of how consumer expectations about sustainable production will develop in the near future.

If we consider the economic resilience dimension, FG2 has, as already indicated, the lowest average score of the groups and has the lowest value in 10 out of 15 subthemes and no highest subtheme value at all. Consequently, FG1 has the highest score in 3 subthemes and FG3 in 10 subthemes. This supports the conclusion that conventional dairy farmers not involved in the bio-plant project (FG2) may be the first ones facing economic problems if the dairy market encounters challenges. The question is not only about profitability but about more comprehensive ability to adapt to unexpected changes in the economic operating environment. This ability seems to be stronger in FG1 and FG3. FG1 scores highest in subthemes like long-ranging investment, stability of market and stability of production which indicates sound competitiveness also in the future. FG3, in turn, scores highest in

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subthemes like food quality, food safety and product information which refers to ability to provide consumers what they want and thus fulfil their needs. This kind of ability offers a competitive advantage to organic dairy farms.

Not surprisingly, FG3 does well when environmental integrity is concerned. It has the highest score in 12 out of 14 subthemes. This supports the common understanding that organic farming is environmentally friendlier than conventional farming. However, somewhat strange is that in the subthemes land degradation and soil quality FG3 becomes ranked behind either FG1 or FG2 or even both. On the average, environmental integrity performance is close to each other in FG1 and FG2, although FG2 has the lowest scores in 8 subthemes, reflecting again the impression that the conventional dairy farms that are involved in the bio-plant project are frontrunners among all conventional dairy farms also in the environmental sense.

In good governance all the farm groups have their lowest overall average dimension scores. This is probably due to the fact that the general Finnish administrative and governance structure is so well-developed that farms do not need to address particularly many of the issues emphasised in this sustainability dimension. In social well-being, in turn, all the farm groups have their highest overall average dimension scores. The explanation is to some extent similar as above: well-developed societal legislation and advanced social security system automatically ensures high level of social well-being partly independent of farms' actions.

As a conclusion we can say that way SMART measures sustainability is not necessarily in all respects suitable and well-fitted for the Finnish farming conditions. However, the sustainability assessment clearly reinforced presuppositions: organic dairy farms (FG3) showed themselves as the most sustainable and conventional dairy farms involved in the bio-plant project (FG1) appeared to be more sustainable than "regular" conventional dairy farms (FG2), implicating that interest towards new sustainable solutions is reflected also in the current state of farm operations and practices.

3.3. In-depth topic analysis

DIRECT AND INDIRECT GREENHOUSE GAS EMISSIONS

Even though biogas investments can be justified with various economic or social arguments, one of the key premises is that use of fossil fuels can be replaced with renewable energy sources. Furthermore, in the case of Nivala, the proprietor of the initial investment grant for a new plant concept, Valio, has been marketing the project as a significant step towards carbon neutral milk production. Therefore, greenhouse gasses from the farms that would be impacted by the investment should be verified before and after the plant investment.

The Finnish UNISECO case study has examined the premises required for an external evaluation of the impact from the perspective of farms. From the beginning, it was clear that implementing decision support tools that have not been tailored to Finnish environmental and production conditions will pose some challenges. No peer reviewed

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publications were discovered in the literature review for prior Cool Farm Tool application in Finnish conditions. In particular, high organic matter content peat soils are common in the case study region and exceed the values that the default tool configuration allows. Thus, effort was made to create custom soil types in the tool to describe farming on peat lands. However, not all modelling issues could be solved before the reporting dead line.

Due to issues with the dairy and crop modules of Cool Farm Tool, we have not been able to obtain reliable results for the direct and indirect greenhouse gas emissions on farm-level or per kg milk.

The initial carbon foot print results that were obtained from the CFT range between 0.34 and 3.25 CO_2 ekv. per kilogramme of energy corrected milk. Rather than a true range of the carbon foot print, this range likely reflects mistakes and omissions made in the application of CFT in Finland. Correcting for feeding and fertilisation inputs narrowed the range from 0.94 to 1.35 CO_2 ekv. per kilogramme of energy corrected milk for farms that could be checked before submission. Possible mistakes concerning double counting or omission of energy used in farm fodder consumption should be still evaluated.

Results for *Greenhouse gases* and *Air quality* from SMART vary for the Finnish case study. For the first-mentioned, the subtheme score varies from 41 at a conventional farm to 64 at an organic farm (compared to 42 to 65 in Swedish case study). In SMART the green house gas indicator is composed of 205 answers related to different farm management aspects. However, these results do not form an actual carbon foot print of the product and for example increasing the farm non-renewable electricity consumption did not decrease the indicator value. SMART indicators for GHG emphasise shares environmentally practises and the overall land foot that is often larger in organic farming is not as such decreasing the GHG score. For *Air quality* the scores vary from 52 to 81.

BIODIVERSITY

Organic farming is expected to contribute more towards biodiversity than biogas initiatives. For the Finnish case study, biodiversity forms an objective that the investigated agro-ecological solution is not likely to improve. The organic farms provide a reference point on what could be achieved if another type of agro-ecological practise would be targeted in Nivala.

We were unable to collect the data for Cool Farm Tool biodiversity assessment as farm visits were already started when the joint data collection sheet for this part became available and it was not possile to incorporate another part of the data collection procudure agreed with the farmer.

For *Biodiversity* from SMART, the score for the *Species diversity* ranged from 42 on conventional farms to 60 on an organic farm.

PRODUCTIVITY

Productivity and agricultural income are traditionally the dominant issues in sustainability of agriculture discourse in Finland. For acceptance of the agro-ecological solution, the impact on farm economy is likely to be more important than the ultimate environmental impact.

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COMPAS data is incomplete for all 9 farms and are hence not included in the analysis.

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4. FRANCE (AUVERGNE-RHÔNE-ALPES – WINEGROWERS)

By Emmanuel Guisepelli, Philippe Fleury and Audrey Vincent (ISARA)

4.1. Description of Case Study Dilemma

This case study is a network-based case study involving several French farm machinery cooperatives (CUMAs) aiming at working together (figure 1). An innovative aspect of the case study is the aim to interconnect different territorial groups. This network is starting. Depending on the area and on individual choices, farmers sell their grapes to cooperatives while other do on-farm wine processing and direct sale. The farming practices are currently rather conventional. Locally some farmers are already implementing agro-ecological practices but the majority of farmers intend to start implementing agro-ecological practices such as using green manure to reduce external fertiliser use and using combined cropping to reduce pesticides use (wine shrubs and other crops).

KEY DILEMMA: How to reduce dependency on external fertilisers and to reduce pesticides use (especially glyphosate) through agro-ecological practices increasing soil ecological services (soil biology) while maintaining the economic profitability of farms?

This social network is complex with numerous actors. In this complex network the main controversial matter that we observe concerns the consequences of agro-ecological and environmental practices on agricultural productivity. We face not only conflicts of interest between agricultural and supply chains actors and other actors.

The decision-making processes are sectorial with some gaps between decisions related to marketing strategies on one side, public support towards agroecology on the other side and finally on the side of local dynamics.

In the regional federation of CUMAs, some of them actively participate in the establishment of the regional agro-ecological network while others are less involved in it but are nevertheless in the process of an agro-ecological transition. It is the case for the winegrowers interviewed in the Bugey region (Ain department). Some of these winegrowers are engaged in a strong agroecology (i.e. Biodynamic DEMETER certification) and we considered that it was important to handle this diversity for the diagnosis at farm level in WP3.

4.2. Description of Investigated Farm Groups

All the investigated farms are located in Auvergne-Rhône-Alpes Region (FADN 192/193). The farms are all in viticulture. This large region has very different production areas. Five wine-growing regions were surveyed:

-farmers members of CUMA in Bugey (3 surveys), in the department of Ain (north-east of the region). It is a very small wine-growing region where a sparkling rosé wine is produced, Cerdon, which has a protected designation of origin. With the exception of two municipalities where 80% of the useful agricultural area is occupied by vineyards, the area occupied by vines does not exceed 1% of the UAA for the surrounding municipalities

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-farmers from CUMA in Beaujolais (2 surveys north and centre of the region): Beaujolais in the north of the region has been almost exclusively a wine-growing area for several centuries. Three types of red, white and rosé wines are produced under the protected designation of origin, as well as crémant, which are mainly exported. The zone surveyed is the Beaujolais village area, wine of medium range, and currently experiencing a major crisis both at the level of individual farmers and at the level of cooperative cellars. About 500 to 600 ha of vines are abandoned each year in the area.

CUMA des Coiron et CUMA de Fraïsse in Ardèche (3 surveys - SW of Auvergne Rhône-Alpes Region): unlike the two previous territories where winegrowers process all or part of their production, winegrowers here sell their grapes to cooperatives. Ardèche is a diversified department. Excepted for the Saint-Joseph appellation area (not surveyed) which generates good incomes, the wine-growing area in this department is below the regional average in terms of valuation per hectolitre of wine. The diversification of grape varieties is much higher on average here than elsewhere because although the wines are under protected geographical indications, they are not bound by very strict regulations. The diversification of grape varieties also allows winegrowers to increase their sources of income, some grape varieties such as viognier for example, being much better remunerated than others.

CUMA des coteaux, Puy de-Dôme Department, west of the region (1 survey). As in Ardèche, farmers in this area especially those who are members of the CUMA des Coteaux, do not process their grapes but sell them to a cooperative which sells again the grapes to a second intermediary who vinifies and promotes the finished product.

CUMA des Eboulis Savoy, east of the region (1 survey). In this small wine-growing region south of Chambéry, several protected designations of origin are combined or even superimposed on each other over 400 to 600 hectares of vineyards (the Savoie wine appellation extends over both the Savoie and Haute-Savoie departments). The surveyed farmer is focused on the transformation of the product into an individual cellar and direct sales.

Of the ten farms investigated, 3 are organic (or in the process of conversion) and 7 are conventional but engaged more or less towards agroecology Their UAA varies from 1.8 to 18 ha.

Of the organic farms:

-One has a biodynamic DEMETER certification (Biodiversity based farming system, Therond *et al*., 2017)

-Two are in the process of converting to organic farming, (Biological input-based farming system, ibid.).

Of the conventional farms:

-Three of them use agro-ecology and inputs reduction (pesticides/fertilisers) as the crucial strategic focus of their farm's operating mode (Biological input-based farming system, Therond *et al*., 2017). To this end, these three farms promote both individual practices at the farm level and collective local pooling practices to increase local compost production and reduce inputs and greenhouse gas emissions (chore system between farmers to reduce the movement of machines on adjacent plots, composting platform for agricultural and non-agricultural green wastes, exchanges of services...)

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-The other four conventional farms are more oriented towards a simple adaptation of their individual practices ("Chemical input-based farming system"/ "Biological input-based farming system", ibid.)

All but one of the farms are located in designation of origin areas (Controlled Designation of Origin, or Protected Geographical Indication). However, not all of them produce wine under these labels. Three of them produce specific wines based on the identification of grape varieties (e.g. Merlot, Chardonnay, etc.), either by choice or by constraint.

This last point is very important to understand the drivers and barriers to agro-ecological transition in some farms, because the latter, depending on whether they are linked to binding or non-binding product specifications or on the possibilities of economic valorisation of the transition, will not have the same room for manoeuvre.

4.3. Focus Topics

DIRECT AND INDIRECT GREENHOUSE GAS EMISSIONS

Overall, farms share in common the fact that they have two main sources of GHG emissions: energy used for plant protection and land maintenance on the one hand and energy used for harvesting and crop residue management on the other hand.

Winegrowers visit their vineyards between 5 and 9 times a year. Because fungicide control is carried out at certain vegetative stages in the growth of plants and bunches. The use of this energy is generally related to the size of the operation. Smaller farms obviously use less fuel.

In some cases, winemaking techniques increase this consumption, particularly in Beaujolais where the press juice is heated to 65°C for maceration.

Organic farms tend to consume more energy for land management and land maintenance. For example, the energy consumption of one of these organic farms; e.g. an organic farm of 6 ha has the same emission rate as a conventional farm over 18 ha. This result could be explain by the fact that organic winegrowers practice mechanical weeding and conventional winegrowers use few nitrogen fertilisers, which are both energy consuming practices.

One point should be stressed: some organic and non-organic farms have a positive sign score for the evolution of the carbon stock in the soil. This is explained by the clearing practices of areas colonized by forest vegetation after abandoning agriculture. The default calculation methods used in the CFTs do not take into account the fact that these are still former agricultural lands that are rehabilitated for production and that this clearing is never carried out on a primary forest.

Another aspect must also be taken into account in the transport of goods or operations. Some organic farms are isolated. Being outside cooperatives or common marketing systems, they sell their wine to distant urban customers. Because they are positioned in niche markets, they cannot find a local channel.

BIODIVERSITY

With regard to biodiversity, it is striking to see how similar farms are, whether they are organic or not. Only fully biodiverse farms stand out somewhat from the point of view of interspecific and ecosystem diversity with better results.

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In the SMART analysis, they are all included in the moderate (yellow) sustainable development zone. This is due to the limited number of varieties of vines that cannot be high in vineyards especially in appellation areas (the most important diversity amounts about 15 grapes varieties).

Indeed, the definition of product quality and its identification are linked to specific wine-making processes based on grapes that are defined as being site-specific for historical, cultural and shared technical know-how reasons. This is the reason why wines in PDO cannot have a high diversity of vines. On the other hand, those who do not produce wine under the appellation have more room for manoeuvre to diversify the grape varieties.

However, the Cool Farm Tool evaluations qualify these initial results and reveal that conventional farms can have practices that are very favourable to biodiversity. This is due both to practices at field level (presence of grasslands, mulching, etc.) and to the diversity of the landscape around the cultivated areas. The lighting of these two elements shows that, for an equivalent area, some farms in the process of conversion to organic farming have less favourable results than some conventional farms engaged in a strong agro-ecology.

However, it is necessary to nuance this point by pointing out calling that SMART and Cool Farm Tool produce photographs and do not show the ongoing movement of operations in transition.

Another aspect to mention in the assessment is the threshold effects related to the size of the farms. Those with the highest biodiversity "score" are farms (conventional or organic) that generally have the largest cultivated areas. For their own reasons (family, heritage, history, contracts, etc.), they are generally characterised by a diversity of land use patterns and can afford more extensive practices on uncultivated areas than smaller farms (less than 6 hectares).

In these small farms, the degree of latitude for biodiversity are more restricted by the risks of yield losses, which are felt much more strongly if the product is not well valued.

It is here that the landscape elements around the farms should be more widely taken into account in the calculations, because in Bugey (department of Ain) and in Ardèche the forest and heathland occupy 25 to 30% or even more (locally 60 to 80%) of the total surfaces of these regions. And for very small farms, the importance of the surrounding area is a key element for the biodiversity present on the cultivated areas.

SOIL QUALITY (SOIL AS A MEANS OF PRODUCTION)

With the exception of one farm that is slightly below the others, the quality of the soil as a mean of production is generally good (green zone in SMART). This is due to a strong maintenance with mulching which allows to amend the land by reducing fertilisers. Most of the vines, which are on a slope, are grassed either totally or partially but always for at least 20% of the surface area. Most of the cleared areas concerned the areas formerly occupied by men and gained by wasteland as a result of the rural exodus. Rotational spade systems that turn the soil superficially in the opposite direction to the slope direction prevent erosion where there is no grass cover. More locally, there is a rehabilitation of the old crop terraces to break the force of the water while providing natural irrigation.

In addition, the on-site reincorporation (with or without shredding) of crop residues also helps to maintain the soil and to prevent erosion. However, this practice is not possible everywhere. Burns are authorized by the French administration. Even if it is less practiced

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than in the past, burning is therefore sometimes preferred to reincorporation either for practical reasons or for reasons of health risks with downy mildew (fungus).

The presence of fauna and flora on the soil is also highlighted by the Cool Farm Tool assessment, which does not, however, sufficiently highlight a crucial point to be taken into account: the natural grass cover not sown between the rows of vines that have a real role in the ecosystem of the useful agricultural surface. A farmer in Ardèche, for example, testifies the damage caused by wild boar in the vines because they come to collect earthworms. Two others testify in Beaujolais to be always followed by hawks at harvest time, the passage of their machines producing the fear of thousands of insects on which they feed and thus can more easily catch.

WATER QUALITY

The good scores for water quality on winegrowing farms in SMART are largely due to the weight given to weeding and mulching practices in the variables used to calculate the indicators. These practices are carried out globally on sites where the risk of erosion is highest (slope greater than 15%). It is true that the practice of grassing, whether sown or natural, produces a buffer effect that is not negligible. All the farms we surveyed have medium to steep slopes excepted for two of them, which have flat plots. A larger survey of farms in lowland areas may have yielded different results.

The good results for water are also linked to the fact that winegrowers in French protected designation of origin areas do not have the right to irrigate: as a general rule, winegrowers in these areas, even if they do not produce wines under the appellation, avoid irrigating, either because they do not need it or because they reserve the right to return to the appellation in the event of a crisis, for example.

The quantity of water is also worth mentioning. It seems that the calculation values indexed in the SMART and Cool Farm Tool tools give a poor rating to irrigation processes from the outset. The existence of drilling also seems to be a negative point.

In a number of cases, for geological or climatic reasons (Beaujolais, Ardèche) winegrowers have limited access to water and pumping is one of the only viable solutions to maintain production activity. The assessments attributed to these practices seem a little exaggerated. Indeed in irrigated fields the volume of water used does not exceed 10mm of water per m².

While it is true that pumping here is carried out on fossil groundwater in two out of three cases where this situation has been encountered, it may be appropriate to insert a weighting of these results in SMART and Cool Farm Tool in view of the number of boreholes in the area surrounding the farm.

PRODUCTIVITY

The added value of labour to the product depends on the price of the hl in relation to the type of vine variety but also on the quantities cultivated and sold by vine variety from one year to the next (especially outside the AOC production areas). These prices is itself linked to maximum authorised production volumes (quotas) on the one hand and on the way the product is valued (short, long circuit).

Thus the conventional Savoyard farm has a higher productivity (380009€) because the totality of the production is sold directly in the form of bottles whose price varies from one terroir to another according to the quality of the products. Moreover, in this case, all the

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terroirs are well valued. The diversity of the vintages makes it possible to broaden the range of product offers whose wholesale price for intermediaries is offset by the greater quantities sold. It also has a high degree of mechanisation (less human labour required per hectare). It is followed by organic farms in Bugey and Beaujolais (150€ & 100k€), which sell their grapes and/or bottles better at the final price.

These farms are followed by well-mechanized mid-size conventional farms (between 50 and 100K€) where processing is carried out by a cooperative.

The farms with the lowest labour productivity are those that harvest by hand (Bugey, Ardèche) and/or the price per hectolitre of wine is less highly valued (Beaujolais, Ardèche). Here conventional and organic farms are concerned. The size of the farms also plays a role, with smaller, less mechanized farms using more seasonal labour and less harvesting machinery.

FARM INCOME

Unlike labour productivity, where the differences between farms are very marked, net incomes seem on the contrary to be more homogeneous, except for the Savoyard farm, which is much higher than the others in absolute values. Net incomes are the lowest - between 40 and 60K€ per year - for small farms in Bugey (2 farms) and farms in Ardèche under a protected geographical indication (2 farms). They are outperformed by medium-sized farms with net incomes ranging from €60 to €80k, including an organic farm in Bugey and two PGI farms in Ardèche and Puy de Dôme (the latter two not processing on site). The income above concerns an organic farm in Beaujolais and one in conventional and non-PGI in Ardèche area. This result seems to argue that, with the exception of the largest conventional farms, organic farms generally fare better in their respective segments than conventional farms.

However, we must not forget the size of the farms concerned. When we reduce the net income per hectare for each farmer the contrast is particularly striking:

-With a net income per hectare between €4,000 and €6,360, The Ardèche and Beaujolais areas appear to be the regions with the lowest level of valuation per hectare.

-With a slightly higher range between €7,800 and €10,000, the Puy-de-Dôme and Savoy AOCs wines and the organic farm of Bugey are in a middle rank. Here the effect of the protected designation of origin and the niche market for biodynamics clearly shows a positive effect...

- The highest level of value per hectare is held by the two smallest farms in Bugey with an income of between €22,000 and €24,500 (respective UAA: 2.39ha 1.8 ha). This difference in income is explained by the price of Bugey bottles, which is better valued than for other regions on average; it is also explained for one of them by the quotas which can amount to 72hl/ha (or even 78 hl/ha by derogation). For the other farmer in this sector who has chosen to leave the appellation, no quota limits his production and can make per ha between 145 and 165 hl/ha. These performances allowed by conventional methods cannot be achieved in DEMETER whose productivity is around 40 to 45hl/ha, in our surveys)

QUALITY OF LIFE

The quality of life for farmers operators is generally well rated in SMART. Access to abundant, relatively healthy and varied food has long been a given in our countries. In

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addition, the labour protection laws that apply everywhere in the same way, the working conditions are respected everywhere. Nevertheless, the notion of quality of life as measured in SMART is not sufficient to account for how farmers experience their profession and their place in society.

Because the tool does not take sufficient account of the extreme variability of production from one year to the next, which gives it a feeling of precariousness and insecurity. The SMART tool also ignores the nature of the relationships between farmers and other actors in terms of perceptions.

It should be noted that in France, farmers are generally in a very widespread unease. The successive crises that have affected the profession (price falls, health matters), climatic hazards and production variability, often make their situation very insecure. This deterioration in their living and working conditions is aggravated by the common impression felt by farmers of a certain contempt emanating from a completely urban society that no longer understands their practices.

All this contributes to increasing farmers' feeling of misunderstanding and isolation. In France, a farmer commits suicide every other day. A rate 20% to 30% higher than the rest of the population[12]. The breeders are most affected. Nevertheless, the common sense of belonging to a peasant community makes them react negatively to the accusations they feel they are victims of.

On the other aspects of social well-being, farmers are rather well disposed, except for the question of gender inequalities and the training of employees who do not make sense for small farms: winegrowers are often alone on their farms and are not required to train the seasonal workers they receive a few days a year. Similarly, these discriminations and the issue of gender equity do not arise in the same way as for a large company. Farmers in search of labour take over either local or foreigners and the question of their status concerns first and foremost the employer groups or employment associations to which winegrowers turn during the harvest season.

CASE STUDY SPECIFIC ASPECT POINT TO TAKE INTO ACCOUNT IN ASSESSMENT IN VINEYARD

For this part we prefer to talk less about the content of the results than about the measurement instruments of the decision support tool, because they introduce biases in the analysis of the results themselves with regard to the vine. Indeed, despite a large spectrum of dimension assessed, DSTs ignore the inherent complexity of vine cultivation.

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12 HTTPS://WWW.FRANCEBLEU.FR/INFOS/SOCIETE/LE-SUICIDE-DES-AGRICULTEURS-EN-CHIFFRES-1517491824

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We will take as an example the units of measurement per tonne used in the tools to estimate the quantities produced. All DST use ton or ton/ha units to assess yields. But these are not appropriate units of measurement to process vine production, for which three measurement systems coexist:

-the most common is the number of hectolitres per hectare and the total number of hectolitres per farm.

-The second, equally widespread among winegrowers who process and sell their production on the spot, is the number of bottles per year (the most widespread capacity: 0.75l; but there are also units of measurement depending on the containers such as Bag in Box -BIB - of 5l, 10l, etc.).

-Finally, in some cases, quite rare in the Auvergne Rhône-Alpes region, the tonne is used as a unit of measurement by winegrowers who sell their cooperative grains or to traders. But even in this case, a multiplier coefficient is applied per hectolitre to obtain the number of kilograms of grapes per type of vine variety, this coefficient can range from 1.3 to 1.45, depending on the terroirs and the estimated average yield of the different vine families.

-Another absolutely crucial point to take into account is the price per hectolitre of wine, the difference between which can vary from 1 to 8 not only between two different grape varieties, e.g. Syrah and "muscat petit grain", but also within the same grape variety when used for two different types of vinification: e.g. “muscat petit grain” vine for liqueurs (very high added value, €550/hl) and that used for white wines with a lower remuneration €80/hl).

It follows from these considerations that the values calculated per tonne can vary considerably from one farm to another and even from one year to another for one farm. The values that can vary greatly depending on the type and quantity of grape variety produced and marketed for each year.

This complexity is intrinsic to wine production, and not taking it into account biases the understanding of farmers' strategies and results in this production sector.

This has also social, economic and environmental consequences because the grapes, depending on their variety and the soil on which they are grown, do not require the same treatment and fertilization depending on the final transformation planned for them.

-Another type of complexity must be taken into account: the complexity of practices within the farm. A conventional farm may very well use organic farming techniques on part of its plots without being declared as such by the farmer. These plots can be ecologically measured without glyphosate and without being in organic farming either. The diversity of the terroirs being the rule, the plant protection plans are adapted to each soil and each type of grape variety on these soils.

4.4. Farm Comparisons

GENERAL DIFFERENCES BETWEEN FARM GROUPS

One might think that there are significant differences between farmers' groups. Against all expectations, the sustainability profiles, as we will see in the next paragraph, are not so different from each other except for the DEMETER farmer operation, which seems to stand out more than the others on the different levels. It seems that farms that process their wine

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have more economic resilience than farms that do not process knowing that it is generally fragile (farms located mainly in the yellow zone on SMART.

But this is not a general rule since COMPAS gives results that are proportionally more satisfactory for farms that sell their bunches to intermediaries and less interesting for some farms whose bottle selling prices are restricted.

One thing is certain: the two smallest farms, conventional (with dose reduction), are the most efficient in terms of value added per hectare.

GENERAL SIMILARITIES BETWEEN FARM GROUPS

According to SMART, the farms all seem to have the same sustainability profile with a "star" structure where good and bad marks alternate within each major heading. Between farms the main points of strength are at roughly the same places in the overview: good rating concerning social welfare (except for the equity part we already explained why), a rather poor to very poor assessment for governance except for the participation part, a rather average to low assessment concerning economic resilience and environmental integrity.

For governance aspect, this situation is similar to the Swedish case study, for example.

In the French case, the average environmental integrity is inherent in the vine, which is in any case more "poor" than other crops (see topic 4 Biodiversity)

About Governance the general poor scores on corporate ethics reveals according to us another conception of sustainability amongst French farmer from what is suggested in SMART. In fact, SMART give a great importance on an ethic supported by charters and written documents. This vision, except when a farm engages in an official quality or processing approach, is not part of French culture, which is very much based on the co-learning of good practices, and on verbal exchanges by mutual agreement.

Moreover, if this approach can be understood for analysing large companies, it is even outside the thinking of the small farms we surveyed, which are based on family models. It is for the same reason that these farms are most often not in the perspective of sustainability reporting.

Still under the heading of good governance, the low score on civic responsibilities seems not fair.

On the one hand it is a photograph at a given time and does not take into account future or past responsibilities.

Four farmers out of 10 have had civic responsibilities in the past by holding responsibilities as presidents in different social or political bodies. Not to mention those who volunteer in activities where time does not count (e. g. this farmer from Beaujolais who is also a volunteer firefighter and must be available day and night)

-Two are young people who are thinking about taking responsibility.

Similarly, the variables used to size the local economy are mainly based on local or external input supply, permanent job creation, and also training aspects.

However, for the small farms in question, job creation can only be seasonal most of the time.

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In SMART, there is the whole dimension of induced employment that is not taken into account: the pooling of harvests in cooperatives induces sufficient volumes to create jobs among intermediate actors (processing cooperatives, traders, local trade…), and the costs incurred for the maintenance of the farm also supports a large local workforce of small craftsmen.

The local integration of farmers thus involves not only the fulfilment of civic responsibility in the formal sense but also a very dense network of daily relations of sharing, exchange of goods, equipment and services. It involves an economy induced not by the activity of a single operator but by the activity of several of them.

4.5. Trade - offs / Synergies Between Focus Topics

There is a close link between energy consumption and the work carried out in the vineyards, (for the treatment of the plant and the harvest). There is a trade-off between GHG emission and inside environmental integrity.

In the conversion of organic farms, the replacement of chemical weeding by mechanical weeding has several consequences:

-the multiplication of passages in the vineyards with an increase in GHG emissions. Up to three more volumes per hectare (based on examples from our surveys)

- The use of copper in much greater quantities with the consequences that this could have on soil quality with the presence of heavy metals

-For smaller farms, the transition to organic farming requires that, in order to limit the number of times they pass through the fields while limiting competition from weeds, the soil is likely to remain bare more often.

All of the farmers have to deal with such trade-offs, while dealing with economic valorisation of their product

SMART's technical-scientific indicators must leave room for farmers' cultural knowledge and know-how. The criteria for good governance mask a whole range of knowledge that could be gained from the work of farmers:

-For example, the concrete actions they carry out with their partners in the context of full-scale experiments on plots,

-the collective exchange of equipment and the chore between farmers in the same sector,

-processes for co-learning crop characteristics and plant management methods…

To better see the compromise between the themes, they must be enriched by other variables concerning, for example, the concrete modality of local integration of the agricultural holding as explained above.

4.6. Synthesis of Task 3.2 Results in the Case Study

1) General observation:

On average we observe a quite good rating for winegrowers for the different sustainability criteria. Overall, farms have a rather good sustainability assessment on the different

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dimensions, whether in terms of greenhouse gas emissions or even on the parts related to environmental integrity. This could be linked to changes in farmers' practices for several decades.

However, the economic component obtains the lowest performance. First, we observe an interannual variabilities of the tonnages harvested. Secondly the market for some sectors is not at the best. The wines of Ardèche outside the Saint Joseph appellation area are difficult to sell at a good price, while the wines of Beaujolais are going through a major crisis. The few winegrowers who succeed in economic terms are those who have started to modify their market strategy on one hand or have engaged actions to reduce or even to eliminate inputs on the other hand. Organic wines are on average better valued than conventional wines, excepted for two farms of Bugey, which have high-performance niche markets. It is not sure this model of organic wine is able to work with very small UAA (<3ha).

2) Comparison

What strikes first is the relative parallelism of the curves from one farm to another in SMART. The appearance of the curves in SMART, complemented by information from COMPAS on economic aspects and information on atmospheric and biodiversity aspects from Cool Farm Tool, show that we are dealing with cultural profiles in both agronomic and social terms for French winegrowers. *Agronomic* because the way vines are grown obeys environmental imperatives and profitability objectives, and *social* because the ways of cultivating are linked to old and inherited know-how and always in renewal with the support of technical advices and personal or mutual learnings. The socio-economic and spatial structures of vines and wines are based on similar criteria of production and know-how, whether or not the grapes are processed at farm level

This general movement contributes to explain why sustainability assessments with DST show no contradictory pathway between conventional and organic farms. Farms have broadly the same profile but with varying degrees of intensity.

3) Which farms types are sustainable?

The only farm that meets all the sustainability criteria is the DEMETER farm. Does this mean that the ultimate research model in the SMART evaluation is the DEMETER model?

If this is the case, given its lower yields compared to conventional or organic practices, how can very small farms integrate this movement? Does sustainability require a minimum threshold of crop area or will the smallest ones be entitled to it?

4.7. References

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5. GERMANY (NIENBURG IN LOWER SAXONY – ARABLE FARMS)

By Johannes Carolus and Gerald Schwarz (TI)

5.1. Case Study Dilemma

The case study area in Nienburg, Lower Saxony, is an intensive agricultural area with particular sustainability issues regarding biodiversity loss and water pollution threats. The area comprises 83,100 hectares and approximately 1,500 farms. It is adjacent to intensive livestock regions with severe issues in manure management and impacts on land (rental) prices (cf. Polaschegg, 2018). The German case study provides an example for the analysis of what is required to initiate a transition process to agro-ecological farming in cases of highly market-oriented farming with low level of agro- ecological innovation. Farmers participate in relevant agri-environmental measures supported under the RDP, but with a low uptake of dark green agri-environmental measures. Therefore, the experience with strong agro-ecological practices such as intercropping, agroforestry and integrated biodiversity is very limited. However, some experience exists with flowering strips and protection strips for wild herbs, extensive field margins, tillage practices, cover crops, nutrient management and organic farming. The level of cooperation is relatively low, but multi-actor platforms for biodiversity-friendly farming exist, on which this case study builds. In the complex social network of actors that influence the key dilemma, the main controversies concern the consequences of agro-ecological practices on the economic viability of farms and conflicts through different perceptions and opinions about the property rights of agricultural land use and its implication for public good provision.

5.2. Investigated farm groups

Given the circumstances in the case study area, the selected farm groups picture an agro-ecological transition pathway at its early stage. The baseline consists of conventional crop farms with nearly no implementation of agri-environmental measures or agro-ecological practices (FG1), whereas the second farm group, FG2, represents crop farms with some weak agro-ecological practices implemented. In addition, some farms in both farm groups are involved in pig or chicken production, yet despite their economic significance, the focus of the case study remains on arable farming systems.

It is, however, worth to highlight that the farms in both farm groups differ marginally. The German case study focuses on the initiation of agro-ecological transitions in conventional systems. Due to a low uptake on agri-environmental measures and comparable practices, the requirements for being grouped into FG2 are not ambitious. More precisely, the farms in FG2 implemented some measures like flower strips and/or low or conservation tillage practices, whereas the farms in FG1 did not implement such practices.

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5.3. In-depth topic analysis

DIRECT AND INDIRECT GREENHOUSE GAS EMISSIONS

An average farm in the case study area emits 887 tons of CO equivalents. However, large differences can be observed across the farms (with emissions between -42 and 2,900 tons of CO2 equivalents). Unsurprisingly, the major share of GHG emissions originates from manure management and feed production (Figure 1). Thus, with a range between 409 and 2,900 tons of CO2 equivalents, the farms which are also involved in livestock production emit the largest quantity of CO2. In contrast, farms involved in crop production emit between -42 and 247 tons of CO2.

Interestingly, the emissions due to off-farm transport are relatively negligible. However, the low value is due to all farmers buying and selling the majority of their farm inputs and products at the local cooperatives (or even at-field in the case of silage maize). Thus, the assessment considers only a fraction of the actual off-farm transport which is likely to occur for most of the products.

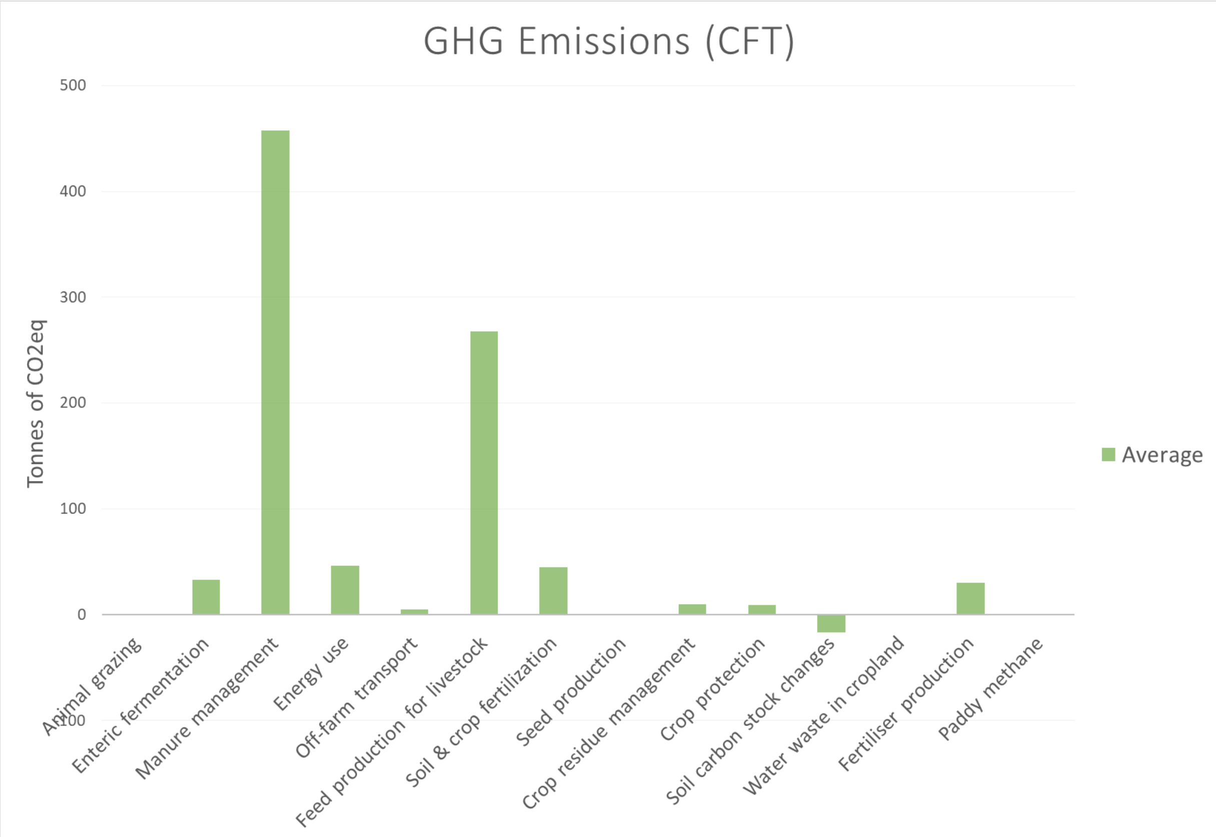

Figure 1: The average GHG Emissions (CFT) of all case study farms, split into different activities.

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Despite being largely determined by the farms' production, an impact on GHG emissions of the few implemented agro-ecological practices can nevertheless be observed. Considering the crops which are cultivated by most of the case study farms, namely barley and silage maize, Table 1 highlights that GHG emissions in FG1 are considerably higher compared to those in FG2. Despite otherwise similar practices (e.g. regarding fertiliser and pesticides applications), the impact of agro-ecological practices can directly be observed in the CFT results. More precisely, when looking at the CFT indicator "soil carbon stock changes", reduced and no tillage practices in two FG2 farms results in -5.3 and -96.6 tonnes CO2 equivalents, respectively, and thus in capturing GHG with practices that are relatively simple to implement.

Table 1: The average GHG emissions of producing maize and barley for FG1 and FG2

Crops	Unit	FG1	FG2
Silage maize	Emissions per tonne (in kg CO2 equivalents)	18.2	0.3
	Emissions per hectare (in kg CO2 equivalents)	921.5	-190.1
Barley	Emissions per tonne (in kg CO2 equivalents)	227.5	18.7
	Emissions per hectare (in kg CO2 equivalents)	1337.5	162.0

These observations can be confirmed by the SMART indicator on "Greenhouse gases". The land-use is generally constant within the last 20 years, i.e. no natural land has been converted into agricultural area. In contrast, farms mostly have – if at all – only smaller grassland or forest areas and apply relatively large amounts of N fertiliser. While applying reduced or no-tillage contributes positively to the scores of two farms applying such practices, other performance-shaping indicators are associated with whether or not the farmers are involved in pig production. On average, the scores are 52% for farms with pig production and 62% for farms without pig production (60% for FG2 and 53% for FG1).

BIODIVERSITY

The relevance of one sustainability issue of the case study dilemma, the poor state of the biodiversity, is best evidenced by the results of the farm assessments. On average, achieving the indicators of the SMART subtheme "Biodiversity", namely "genetic diversity" (23%), "species diversity" (39%) and "ecosystem diversity" (34%) is scored as "limited" for all assessed farms. In addition to the wide and intensive application of fertilisers and pesticides, only few areas and practices target biodiversity. And more often than not, grasslands are cultivated intensively. Surprisingly, the scores for FG2 are even below those of FG1 (Figure 2). While this highlights the marginal differences between the farms in both farm groups, some more substantial differences in terms of the soil fauna can be observed (cf. section on soil quality).

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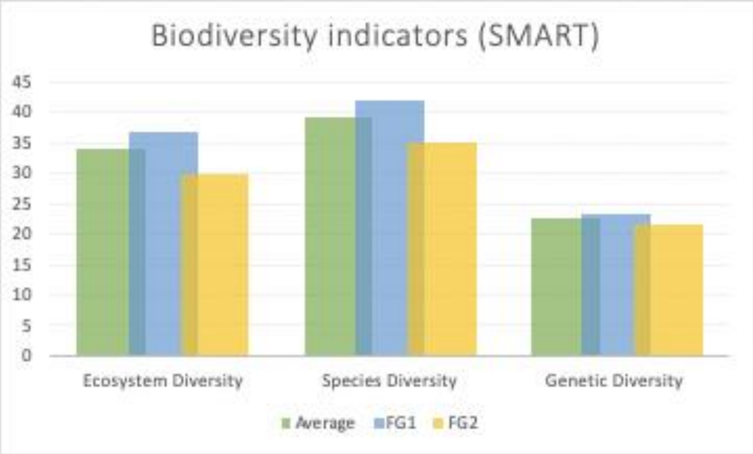

Figure 2: Biodiversity indicators (SMART)

With an average score of 29%, the CFT indicators further underline the insufficient state of biodiversity in the case study area. Both farm groups combined, the highest average biodiversity performance can be observed for “farmed products” (50%), the lowest for “large habitats” (6%).

The CFT biodiversity indicators which are associated with the crop production (rather than with the impact of the present biodiversity enhancing measures) differ only marginally between FG1 and FG2. More precisely, indicators like “farmed products” or “arable flora” do not vary substantially across farm groups. In addition, and determined by the intensive agricultural production landscape, large habitats are for both groups somewhat absent. However, FG2 performs better for several other indicators (such as livestock, crop and variety). Noticeably higher performing indicators are thereby “farming practices” and “soil fauna”. Scored as 61% for FG2 but 39% for FG1, the “soil fauna” indicator is shaped by the majority of FG2-Farms practicing reduced or no tillage (Figure 3).

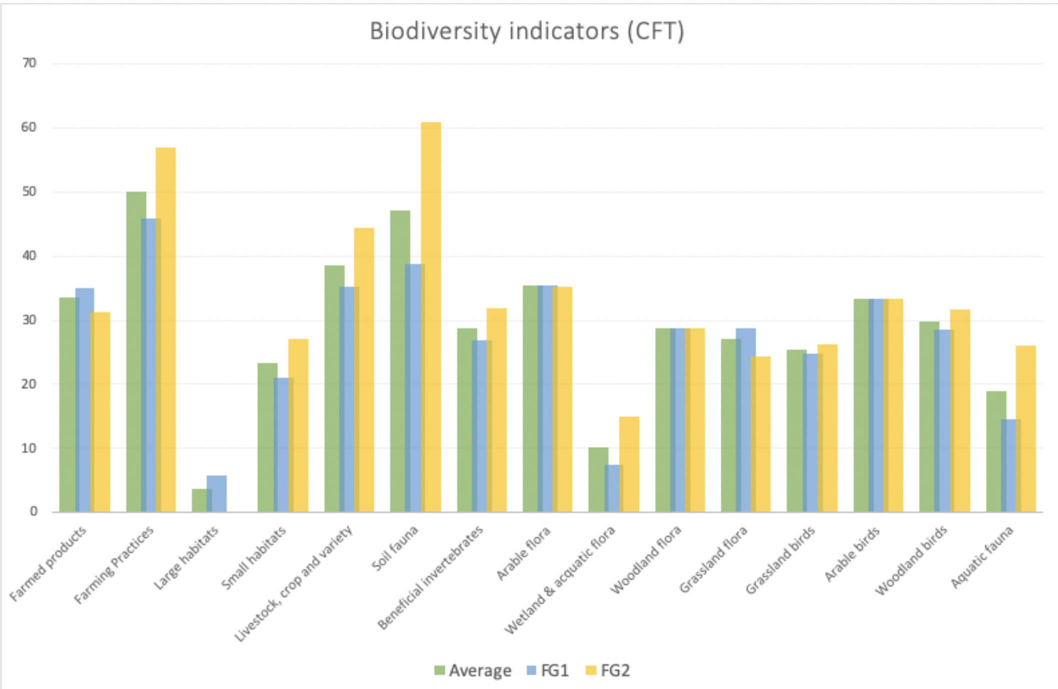

Figure 3: Biodiversity indicators (CFT)

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SOIL QUALITY (SOIL AS A MEAN OF PRODUCTION)

When referring to the SMART sub-theme of "soil quality", the average score of all farms is 55% and thus rated as "moderate" (with a range between 49% and 61% across the farms). Both farm groups perform similar (55% for FG1 and 56% for FG2). To some extent, the relatively low score can be explained by a wide application of fertiliser and pesticides. For instance, pesticides- intensive rape was cultivated on the majority of the farms. Furthermore, and considered as largely adequate by farmers due to all slopes being below 15%, little erosion management beyond incorporating grain residues and some catch crops takes place. Moreover, compost was not applied at any of the farms, and only few of them created humus balances. In contrast, signs of soil compaction were not apparent on all covered farms.

Interestingly, more substantial differences across farm groups can be observed for the CFT biodiversity indicator "soil fauna". Shaped by conducting reduced or no tillage of some farms, the soil fauna is scored as 61% for FG2 but 39% for FG1 (cf. Figure 3).

WATER QUALITY

While both farm groups perform similar in the SMART subtheme of "water quality" (61% for FG1 and 59% for FG2), larger differences can be observed across farms (with a range between 54% and 74%). The "moderate" performance across the majority of the farms can largely be explained by the wide application of fertiliser and pesticides with a negative impact on water quality according to the "PAN Pesticides Database". Overall, the water quality score highlights the case study dilemma of insufficient water quality in the case study region, but also how possible water quality enhancing actions may affect current farming practices. In contrast, the high degree of recycling, adequate disposal and information regarding the local water quality (which is not perceived as being problematic by most of the farmers) positively affected the overall score.

PRODUCTIVITY

Defined as the net value added per annual work unit (with 2,200 yearly working hours), the average labour productivity of all assessed farms is €57,000. However, the performance across farms varies substantially (Figure 4). Notably, the labour productivity of farms in FG1 is €72,000 and €38,000 in FG2. However, different farm characteristics (such as their size and number of farm enterprises, reflected in the large differences of the output and consumption values in Figure 4) allow for no conclusions other than that farms generally perform fairly well. This is further stressed by the scores of the SMART indicator of farms' "profitability". With 74% for FG2 and 72% for FG1, the scores are similar across farm groups and considered as performing "good".

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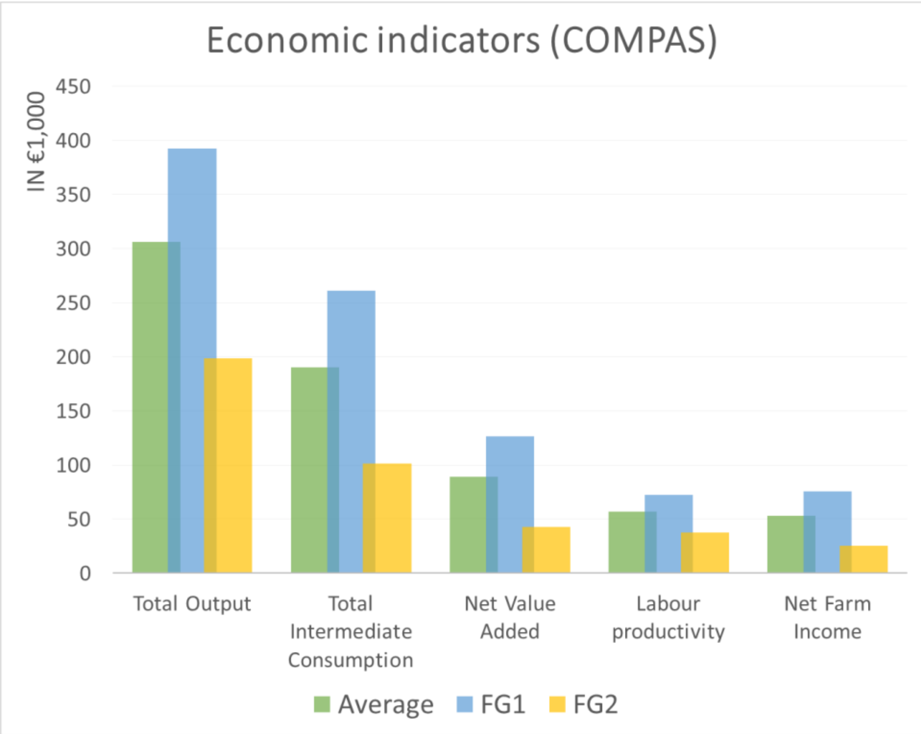

Figure 4: Economic performance indicators (COMPAS)

The highest labour productivity, between €75,000 and €123,000, is achieved on farms which are additionally involved in pig production. Typically, the pig production then represents a major share of the total revenues a farm is gaining. In contrast, the labour productivity between the farms only being involved in crop production is between €33,000 and €62,000.

FARM INCOME

As previously introduced, the scores of the SMART subtheme "profitability" are similar across farms and farm groups and considered as performing "good" (74% for FG2 and 72% for FG1). All farms are highly professionalised businesses. This includes the use of professional bookkeeping, stable or even rising yields and profits, and no issues with loans or banks. The fact that none of the farms sell via collective sales channels or are involved in on-farm processing contributes negatively to the scoring in the subtheme. Additionally, all farms were affected by the water shortage in 2018, particularly those without irrigation systems and/or further farm enterprises.

The COMPAS indicator "net farm income" supports the positive economic performance and shows positive values for all farms. However, with a range of €9,000 and €244,000, substantial differences can be observed across farms. This range, and the difference between FG1 (€25,000) and FG2 (€75,000), is, however, associated with considering farms with and without livestock production. Farms with pig production reveal substantially higher net farm incomes (€110,000) compared to those merely being involved in crop production (€12,000). The crop producing farms in FG2 perform better (€18,000) or similar (€9,000) than the one in FG1 (€10,000). The crop and pig producing farm in FG2 pictures a net farm income which is in the range of the one of farms in FG1 (€38,000 – €244,000).

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QUALITY OF LIFE

Considering the SMART subtheme "Quality of life", the assessed farms in the case study perform "good" (78% on average, with no differences between FG1 and FG2). Following the labour standards in Germany, including regulations for extra hours, (at least) minimum wage for all employees and appropriate work protection, the on-farm indicators are largely rated high on all farms. That mostly no means exist to prevent discrimination against vulnerable groups, and that the workload is often high, can be explained due to farms being mostly operated by one or two family members without further employees other than contract work.

However, the SMART indicator "quality of life" is defined as not only entailing the on-farm conditions, but also to what extent farm practices may affect livelihoods throughout the entire supply chain. Due to farm inputs like phosphate and soybean products, problematic working conditions in some of the countries of origin cannot always be excluded. The farmers always buy such inputs at the local agricultural wholesale/collective. They usually assume that, at the stage of wholesale, the products are already sufficiently certified and, thus, do not consider environmental or social certificates.

5.4. The case study dilemma and how to overcome it: first impressions gathered on farm visits

The German case study provides an example for the analysis of what is required to initiate a transition process to agro-ecological farming in cases of highly market-oriented farming with low level of agro-ecological innovation. Only few farms implement some field-scale and weak agro-ecological practices (Wezel et al., 2013, Prazan and Aalders, 2019), namely tillage practices and flower and buffer strips. In the complex social network of actors that influence the key dilemma of poor biodiversity and water quality in the case area, the main controversies concern the consequences of agro-ecological practices on the economic viability of farms and conflicts through different perceptions and opinions about the property rights of agricultural land use and its implication for public good provision. Concerns regarding the economic viability of farms thereby include the high bureaucratic burden and low compensation payments for increased efforts, in both field and the office.

Generally, farmers appear to increasingly recognize (also through the media and public) and adopt similar practices. Several farmers had no agri-environmental measures implemented during the assessment year (typically 17/18), however they were starting to implement practices in 2019 or planning to do so in the subsequent years.

In contrast, whether or not implementing some biodiversity and water quality enhancing measures or practices, all farms are shaped by a highly market-oriented production with high application rates of fertilisers and pesticides. The biodiversity and water quality indicators reflect low scores throughout the case study. However, the positive impact of some basic measures, such as the carbon-capturing of no- or reduced-till agriculture, reveals the potential of improving the uptake of basic measures which appear to not compromise the farms' abilities to compete on the "conventional" markets. But the results also indicate that more substantial improvements, e.g. in relation to biodiversity and water quality,

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require more systemic changes that result in a redesign of the farming systems. Generally, the impression is that farmers are willing to enhance the farms' provision of public goods, including biodiversity and water quality, provided that there is an adequate remuneration for the services and good provided. The latter, however, is - in its current state – hampered by (too) low payments and (too) high bureaucratic efforts.

GENERAL DIFFERENCES BETWEEN FARM GROUPS

Due to considering farms at very similar, namely initial, stages of an agro-ecological transition pathway with only few implemented agro-ecological practices, significant differences for most of the assessed indicators cannot be observed between the defined farm groups, FG1 and FG2. Most described and assessed topics are, however, strongly affected by whether or not a farm is additionally involved in livestock production.

Focusing on the crop production, differences across farm groups can nevertheless be observed as a consequence of implementing agro-ecological practices. Most notably, the farms in FG2 score higher ratings for some of the biodiversity indicators. For instance, shaped by reduced or no till agriculture of some farms, the CFT soil fauna is scored as 61% for FG2 but 39% for FG1.

GENERAL SIMILARITIES BETWEEN FARM GROUPS

Due to comparing farms with fairly similar farming approaches, the farm groups perform alike in the majority of the considered themes, with FG2 only having a considerable lead in terms of their soil biodiversity rating. The major difference in many of the indicators is rather determined by whether or not the farm is involved in livestock production.

TRADE-OFFS / SYNERGIES BETWEEN ABOVE TOPICS

Given their similarity, no finite trade-offs can be determined based on the assessed farms. All farms show scores which reflect the intensive agricultural production systems. On the one hand, this includes relatively poor results for indicators associated with the provision of public goods, and, on the other hand, reflects high labour standards and profitability. While farms in FG2 reflect higher biodiversity scores, the impact on the economic performance cannot be measured. Trade-offs will be assessed in more detail in the next steps of the case study analysis exploring and simulating changes in future farm management.

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5.5. Synthesis of Task 3.2 results in the case study

In conclusion, the assessment confirms the presence of highly market-oriented farming systems with few agro-ecological practices and, as a consequence, low levels of biodiversity and water quality. Nevertheless, and despite assessing farms with only minor differences in terms of their agro-ecological transition pathway, indicators mirror the observed practices:

- While one case study farm emits, on average, 887 tons of CO equivalents, large differences can be observed between farms with and without a livestock production. In addition, farms with carbon-capturing measures (like reduced till agriculture) emit roughly half of the CO2 equivalents for comparable crop products.
- The state of biodiversity is generally poor in both the entire case study region and in the context of the assessed farms. While the different farm groups score similar for most of the biodiversity indicators, FG2-Farms with few field-scale and weak agro-ecological practices perform noticeably better for the indicators "farming practices" and "soil fauna".
- The wide application of fertiliser and pesticides contributes to an average ranking in terms of the water quality across all farms in both farm groups.
- In terms of the productivity and the farm income, farms generally perform well. Differences can be observed due to different businesses rather than (agro-ecological) management approaches. Furthermore, the assessment reveals a relatively high quality of life, with high scores for the on-farm and, occasionally, lower ratings for off-farm activities.

5.6. Literature

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6. GREECE (IMATHIA REGION OF CENTRAL MACEDONIA – FRUIT FARMS)

By Alexandra Smyrniotopoulou and George Vlahos (AUA)[13]

6.1. Description of Case Study Dilemma

The Greek case study focuses on fruit orchards, mainly on peach trees both for fresh fruit production and canning in the Regional Unit (NUTS 3) of Imathia, Region of Central Macedonia, Northern Greece. The key dilemma is to sustain the long-term economic viability of farms and to improve the competitiveness of products and their market access whilst protecting the natural resources.

6.2. Description of Investigated Farm Groups

Three different farm groups have been identified in the case study area.

The 1st farm group includes the conventional farms in which no agro-ecological practice is implemented. These farms focus on the intensification of the production process using synthetic chemical pesticides and in general no care is taken for mitigating the environmental impact of agricultural activities.

On the contrary, two agro-ecological practices are applied in the case study area: the Integrated Crop Management methods and insect sexual confusion methods for pest control.

Integrated farming can be seen as an environmentally friendly farming method that controls the use of fertiliser, pesticides and irrigation. In Greece the implementation of Integrated Farming is certified against the two national standards of Agro2. These standards ensure rational management of the whole production process, record keeping, products' traceability system, safety procedures for farmers, etc.

The application of insect sexual confusion methods for pest control is an agri-environmental measure under the Greek Rural Development Programme (RDP) 2014-2020. The measure aims to gradually abolish the application of chemical insecticides through the application of traps for monitoring the population of pest insects in order to control by disrupting insect mating with the use of micro sprayers (dispensers) which release synthetic pheromones. Thus the number of harmful insects is reduced contributing to increasing biodiversity, water quality and in general environmental protection in the tree orchards.

[13] The authors collaborated with Yiannis Iordanidis, who conducted the DST interviews. We would like to thank our colleague for his valuable help.

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The 2nd farm group includes farms that apply either Integrated Crop Management methods or insect sexual confusion methods for pest control, while farms within the 3rd group apply both afore-mentioned agro-ecological farming practices.

At the end, a total of eight farms took part in the assessment with the three DSTs. Two of the farms (Farms 1 & 2) are characterised as conventional and belong to the 1st farm group. The 2nd farm group consists of three farms (Farms 3 & 5 apply mating disruption method, while Farm 4 implements Integrated Farming), and also three farms (Farms 6,7 & 8) belong to the 3rd farm group representing the eco-efficiency and input substitution stages on the agro-ecological transition pathway.

All farms can be considered family run holdings specialised in peach trees cultivation, with the only exception of Farm 2 that grows pear trees. Their farm size varies from 2 to 18 hectares, while the average size of permanent crop area per holding in the Regional Unit of Imathia is around 3.5 hectares.

6.3. Focus Topics

DIRECT AND INDIRECT GREENHOUSE GAS EMISSION

Based on the results, it seems that farms that apply the agro-ecological practices have higher emissions than the conventional ones. This can be attributed to the fact that the number of fertiliser and pesticide applications is the same with (or higher than) the conventional farms. Nevertheless, the type of products is eco-friendly as well as the application is based on nutrient management plan. Moreover, the farms that support agro-ecological farming approaches have higher energy requirements for field work, as in the case of drip irrigation, which is considered as a more energy-consuming irrigation method (e.g. the case for Farms 5 and 8).

BIODIVERSITY

In reference to beneficial invertebrates, the results show that the conventional farms have lower scores compared to the farms grouped in the 2nd and 3rd types. This evidence seems to be reasonable as the farm management activities may directly influence biodiversity. In reference to farming practices, all crop protection products applied in the Integrated Farming are targeted against the species deemed as harmful and cause losses in tree crops, while the agri-environmental measure applies traps and pheromone dispensers aiming at banning chemical insecticides completely. Consequently, the transition towards agro-ecology includes farming practices that may encourage the conservation of beneficial insects as well as increase species diversity. Concerning the farmed products, the highest score of Farms 7 and 8 is not surprising, since they grow diverse varieties of peach trees in their orchards.

SOIL QUALITY (SOIL AS A MEAN OF PRODUCTION)

Based on the results, it seems that most of the farms grouped in 2nd and 3rd types have higher performance concerning the soil quality. This finding seems to be reasonable as farms which apply Integrated Farming use proper soil management conducting soil analysis in order to reduce nutrient leaching, increase water retention and control soil erosion. The soil quality is also improved through the application of the agri-environmental measure which aims to replace entirely the chemical insecticides with dispensers that release synthetic pheromone resulting in soil protection from contamination as well.

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WATER QUALITY

Based on the results, for the subtheme related to water quality it seems that farms grouped in the 3rd type perform better in comparison with farms under the other two types. On the one hand, Integrated Farming controls the irrigation, fertilisation and pesticides use, on the other hand the agri-environmental measure aims at gradually substituting insecticides with pheromone dispensers and traps, thus both agro-ecological farming practices contribute to reducing water pollution and improving its quality.

PRODUCTIVITY

Concerning the labour productivity indicator, there is large variability between the individual farms and among the three farm groups. For instance, Farms 4 & 5 have the same agricultural area and almost the same net value added, however they are differentiated by the total hours worked on the farm. The necessity of increased number of employed workers in large farms may impact negatively on the level of labour productivity (e.g. Farm 8). On the contrary, high levels of labour productivity can be linked to investments in equipment and machinery, use of advanced technologies and skilled employees. But it seems that this is not the case for Farm 2 which has a significantly low net value added since the pear variety selected has failed to bear fruits (lack of fruit set) resulting in yield losses whilst production costs have remained quite high.

FARM INCOME

Given that farms differ considerably in terms of their physical size (i.e. hectares of land area) and farm management, there are differences in their farm income even within the same farm group. Considering that farm income mainly depends on farm productivity and production costs, the results about farm income of the agro-ecological farms seem to be valid. These farms use better management and proper crop protection methods taking into account the real needs of tree crops and advisory services provided by consultants, resulting thus in saving production costs and increasing farm productivity and profitability.

QUALITY OF LIFE

Concerning the subtheme of quality of life, the performance of the different farms ranges more or less at the same level as there are not differences in labour conditions and agricultural mechanisation among the farm groups and in the case study area in general. Nevertheless, it could be argued that the implementation of the agri-environmental measure of insect sexual confusion methods for pest control requires farmers to devote more hours to their farms in order to detect and monitor the harmful insect population and prevent the infestation.

OTHER, CASE-STUDY SPECIFIC SUSTAINABILITY ASPECTS (SUCH AS RESILIENCE)

Based on the results, the farms grouped in the 2nd and 3rd types have accumulated higher scores with respect to subthemes of food safety and quality. It should be mentioned that all farmers who comply with the Integrated Farming Standards as well as implement the insect sexual confusion methods for pest control belong to an agricultural cooperative/Producer Group (PG), as they cannot make it independently and without technical assistance. Consequently, the members of well-established agricultural cooperatives/PGs have the capacity to increase their competitiveness due to the quality and safety standards applied,

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negotiate better prices for their products, strengthen their position in the existing markets and expand into new ones. From this point of view these farms may better cope with market changes increasing their resilience.

6.4. Farm Comparisons

GENERAL DIFFERENCES BETWEEN FARM GROUPS

The main differences between the farm groups are associated with the agro-ecological farming practices applied. Consequently, Integrated Farming and sexual confusion methods influence the soil and water quality as well as diversity of flora and fauna species on the farm due to better management of natural resources and replacement of chemical insecticides. Moreover, farms that do not apply proper crop protection methods have usually reduced crop yield and increased production costs.

GENERAL SIMILARITIES BETWEEN FARM GROUPS

In general, all farms are characterised by their small size and are highly fragmented resulting in increased production costs. In addition to the farm structural characteristics, the case study area has experienced extreme weather conditions (strong winds, heavy rain and hail in summer) the last three years that have considerably impacted the quantity and quality of produce. All of the farms seem to be vulnerable to the impact of climate change.

6.5. Trade-offs / Synergies Between Focus Topics

Synergies can be identified within the environmental dimension, as the agro-ecological farming practices applied may have a positive effect on the water and soil quality as well as on biodiversity enhancement. Besides the environmental issues, such farming practices ensure that the products fulfill the requirements for quality and safety standards, having therefore an opportunity to get higher selling prices contributing to improving economic dimension (product competitiveness against the conventionally grown products). On the contrary, as a trade-off among the various environmental and economic dimensions, drip irrigation could be mentioned since it impacts positively on saving water, but it seems that by consuming more electrical energy, it leads to higher production costs as well as higher GHG emissions.

6.6. Synthesis of Task 3.2 Results in the Case Study

In general, investigated farms have many differences in terms of land area and economic size. Nevertheless, based on the results, it seems that farms that apply eco-efficiency and input substitution farming practices perform better considering the environmental dimension (water and soil quality, diversity of species) which in turn may impact beneficially on economic dimension (food safety and quality, net farm income). Having in mind that farmers who are engaged in agro-ecological farming practices are principally members of agricultural cooperatives/PGs, it can be argued that these farmers are better informed and advised on policy and environmental issues, new technologies and innovations, thus more open to adopt farming practices related to sustainable agriculture.

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7. HUNGARY (BELSŐ SOMOGY REGION – ARABLE FARMS)

By Alfréd Szilágyi, László Podmaniczky, Katalin Balázs, Geonardo Ltd.

7.1. Description of Case Study Dilemma

In the Hungarian case study we studied medium and large-scale, profit oriented, conventional arable farms which adapted soil conservation practices to overcome soil erosion. Our main question was how to integrate agro-ecological practices on arable land in highly market-oriented arable farming systems to maintain and improve soil quality without significant negative impacts on the economic viability of farms. To answer this question first we assessed the farm-level sustainability of each selected farm with the three DST tools.

7.2. Description of Investigated Farm Groups

Within the above mentioned farm selection we could experience a transition trend. There were farms that used only reduced tillage, which means they invested in new machinery and they apply soil loosening and do not plough all fields every year, only every 2-3 years in line with crop rotation. Others were more innovative and used no-till system, but do not apply direct drilling, neither cover crops nor complex crop rotation. And there were a few farmers who applied one or more of these latter techniques, or modern GIS based precision tools to reduce pesticide and fertiliser use. Apart from that, regarding their market position, economic strength, social impacts, they were more or less similar.

7.3. Focus Topics

DIRECT AND INDIRECT GREENHOUSE GAS EMISSION

In general, in the SMART they got similar results ranging from 43 to 58 all in medium level (40-60 %). The variation between the results is explained on firstly by the variation in soil cultivation methods (see above) secondly by the amount of used fertilisers and also by the farm structure whether they had temporary or permanent grassland. The transport of inputs also matters as indirect GHG emission but regarding this, there were no major differences among the farms, they all buy from the few main suppliers using the same supply chain.

The results of the Cool Farm Tool assessment are summarized in Table 1.

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Table 1. Results from Cool Farm Tool

CFT results	G008	G010	G005	G002	G004	G006	G009	G001
	Total t CO2e							
Seed production	0	0	0	0	0	0	0	0
Crop residue management	88	32	46	27	102	85	35	113
Fertiliser production	113	32	104	339	83	624	28	316
Soil/ fertiliser	97	22	81	242	79	342	27	183
Paddy methane	0	0	0	0	0	0	0	0
Crop protection	32	5	26	59	40	91	13	55
Carbon stock changes	-134	-12	-201	-174	-476	-91	-87	-290
Energy use (field)	41	18	39	57	51	42	12	118
Energy use (processing)	0	0	0	0	0	0	0	0
Water waste	0	0	0	0	0	0	0	0
Off-farm transport	12	256	7	10	11	10	4	15

The figures in Table 1 confirm the results obtained at SMART: the biggest differences in CO_2 emissions were due to differences in soil cultivation practices.

BIODIVERSITY

Regarding biodiversity, the SMART subtheme results show a negative picture on the farms which comes from the fact that these are highly specialised crop production economic units. The economic performance is the most important factor in their success. Generally they grow only 3-4 main crops and nothing else. There are exceptions, that produce seeds of different crops for sowing, or some farms that entered Agri-environmental Schemes and converted some arable land into grassland or implemented bee pasture stripes etc. Those farms have better results and also in the CFT biodiversity scores which also mirrors the above mentioned features of these farms in general. But the applied soil conservation techniques make differences, as well, in general they get best results, and the transition pathway described before can be observed on the results: the farms integrating more techniques (no-tillage, cover crops, organic manure etc.) got better results in the soil fauna scores. The other results are explained by the pest management techniques: modern farms, normally they have advisor on plant protection or the farmers are themselves plant protection experts, also by the agro-environmental schemes: they implemented green fallow, bee pasture stripes etc.

SOIL QUALITY (SOIL AS A MEAN OF PRODUCTION)

This is one of the most important qualifiers of these farms. In general they got medium results. The more innovative farms closer to the “good” benchmark (60 %), the farms using the most complex conservation farming got 65%. Soil quality subtheme considers physical, chemical and biological quality on the same level in the SAFA. As shown before in CFT they also got good results in soil fauna.

WATER QUALITY

In this subtheme, farms got medium scores ranging from 50 to 63. Two farms fell into “good” category (60 and 63). This result is due to the fact that these are all rainfed farms. Waste water is well managed and if there are water bodies adjacent to their parcels, farmers always leave a few meters wide, non-cultivated, grassy margins (normally used as a road) to hinder any contamination. Soil conservation practices have also an impact on this topic, as e.g. cover cropping or residue leaving protect soils from erosion which would lead to water

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contamination and sedimentation. These techniques also help to maintain good soil quality and increase or at least maintain soil organic matter which apart from other functions is also an important factor for preventing leaching of nutrients and pesticide residues in the ground water.

PRODUCTIVITY

For the 'Stability of Production' subtheme all scores are between 60 and 80 which is in the "good" category. That is due to the medium or large size of farms with a capacity to invest in modern technologies, machinery etc. They try to use the best available inputs, seeds, technologies and services available on market in order to maximise production and profit. That is why their average yields are far better than the national averages even though they are not on the best quality soils, and they are also exposed to the climatic hazards. This is one of the main drivers for them to adapt to conservation practices, so that they can mitigate climate change.

FARM INCOME

For the subtheme 'profitability', the average scores are also quite high, several times close to the "excellent" (from 80) category. This is the main purpose of their activity, they are regarded as economic units and thus profitability is the most important indicator of their performance. The results come mainly from their size and market position. Apart from that yield dryers and storage capacity are the two main possibilities for those who have a position in the discussions with wholesalers. The results of the subtheme 'liquidity' also shows that these farms have no financial issues of that nature. For them the long term profitability rather lies in the market changes (pressure from large scale agrobusiness), in the input prices, subsidy system changes and finally in the production factors where climate change and soil are key topics as discussed before.

QUALITY OF LIFE

For this subtheme the selected farms got good results (ranging from 64 to 77) which is linked to the previously described economic performance and size. Therefore, farmers have a reasonably good quality of life and because of the nature of their production type, as wintertime is normally quite relaxed for them. Also it is given by their size that these farmers are mostly managers of the farm not the ones working on the land continuously. The workers also have a relatively good standard of living, as there is a serious lack of trained labour, they are in good position, farmers must compensate and respect them so that not to lose them. Other relevant explanation is the mechanisation rate, as almost everything is automated, workers do not have to lift heavy weights or do other inconvenient work. The new, modern machines are climatized and easy-to-handle.

OTHER, CASE-STUDY SPECIFIC SUSTAINABILITY ASPECTS

Besides soil quality the other case-study specific relevant subtheme is the 'Land Degradation', where the scores show a very similar trends and values than soil quality, or even better. It is due to the same relevant indicator set which affects the result in SMART and also because the effect of soil conservation practices is even more visible. Soil erosion is one of the most pressing drivers for these farmers to change their soil cultivation practices, mainly to leave ploughing.

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The other interesting subtheme is ’Water Withdrawal’ as they do not apply irrigation at all, they must rely on rain-fed production. In this subtheme all farms fall at least into the “good” category, two of them even in the “excellent”, and a few also close to the “excellent” (4 got 78 %). This is a relevant topic as well, because besides soil erosion, droughts also affect these farms quite painfully, so the adaptation of new cultivation methods also serves water conservation in the soil.

Finally, ’Energy Use’ is also a topic relevant subtheme, in general the farms have moderate results, this is due to the high rate of mechanisation which leads to considerable diesel consumption. Even though that there is a pattern in the results that the more innovative farms have slightly better scores which they claim to be due to the soil conservation techniques, and the reduction of the number of operations by using multiple machinery in one operation.

7.4. Farm Comparison

GENERAL DIFFERENCES BETWEEN FARM GROUPS

Looking at the results there are three identifiable groups in the farm sample as described at the beginning and then topic-wise in the followings. Farm G001 and G010 fall into the least innovative and conventional farms that apply ploughing as taught in the old school. Farm G004 is the one applying soil conservation in its whole complexity, not only no-tillage but also leaving all residues, using cover crops, crop rotation etc. The rest of the farms, all identified as reduced tillage farms, are between these two categories, farm G005 and G009 closer to the most innovative farm category, while farm G008, G002 and G006 closer to the less innovative farm category.

GENERAL SIMILARITIES BETWEEN FARM GROUPS

There are a few subthemes and topics worth describing in more details, as the results show general patterns and similarities in the farm sample, given by their regional location, also by their similar size, operation and other socio-economic context.

Firstly, as described before, these are large farms that apply to some extent soil conservation practices, but above that they are profit oriented, conventional farms with more or less quite simplified concept about sustainability and sustainable farming. Some subtheme results in the Good Governance dimension, like ’Mission Statement’, ’Civic Responsibility’ and ’Sustainability Management Plan’ reflect on this feature. Other subtheme scores (mostly drop into ’Limited’ category (21-40%)) from the Social Well-being dimension, like ’Non Discrimination’, ’Gender Equality’, and ’Support to Vulnerable People’ clearly show that the importance of social aspects of sustainability is underrepresented in their attitude and decisions.

Secondly, there are a few good subtheme scores resulted from their general characteristics, in case of subtheme ’Legitimacy’ they were relatively good, due to their size, they must obey the legislations, they cannot risk using black labour etc. The other relevant subtheme is ’Waste Management’, where they had good scores, as they must have contracted waste manager who audits how they handle with their wastes. Finally, due to the above reasons for the subtheme ’Workplace Safety and Health Provisions’ they also got scores close to the “excellent” category, all above 70%, as they must have also an official trainer who trains workers and conducts a risk assessment every year.

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Finally, for the subthemes 'Stability of Supply' and 'Stability of Market' it is a relevant context, that there is a fixed value chain, which is dominated by large agrobusiness corporations. These farms have normally less than 5 long-term clients to supplying and also for selling. Several times these are the same companies. This gives them a certain convenience and safety but also a pressuring issue as the prices are more or less dictated by the companies. For the subtheme 'Local Procurement' they got relatively bad results ranging from 26% to 46%, which comes from the fact that most of their used inputs (fertiliser/ pesticides/machines) are not produced in the country and also partly from the fixed, long value-chain that has been built up in the agricultural sector.

7.5. Trade-offs / Synergies Between the Focus Topics

There is a general trade off trend between biodiversity scores and profitability. It is not farm specific, but true for the whole farm sample, that they have relatively good profitability and in the same time bad performance regarding biodiversity. Except for soil fauna scores in Cool Farm Tool, which are relatively good, thanks to the soil conservation practices and to the agro-environmental measures.

Looking at the effect of soil conservation practices on 'Energy use" and 'Material use', the results demonstrate that there is a synergy between these subthemes and the mentioned practices as farms (Farm G004, G005, G009) applying more soil conservation practices scored higher in those subthemes. SMART subtheme 'Greenhouse Gases' results also demonstrate this synergy. The result of 'Farming practices' topic in Cool Farm Tool is in synergy with the biodiversity topic scores in Cool Farm Tool and also with the SMART biodiversity subthemes.

7.6. Synthesis of Task 3.2 Results in the Case Study

As described and demonstrated before there is a clear evidence from, this case study that farms applying more soil conservation practices, scored better in most topics, which underlines the importance of case study dilemma. It has to be considered that this is not a representative sample. The adaptation and transition of these practices is a complex issue. There are a lot of other factors influencing the decision of farmers and also the results of such assessments. In the Socio-ecological System (SES) and SNA analyses we tried to map and evaluate the topic in even more depth and complexity. The results of this farm-level assessments are best understood with these findings.

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8. ITALY (CHIANTI REGION – WINEGROWERS)

By Francesco Galioto, Davide Longhitano, Letizia Rossignolo, Andrea Povellato

8.1. Description of Case Study Dilemma

To develop a more diversified cropping system in a highly specialised and market-oriented winegrowing area while maintaining the profitability of farming is the dilemma of the Chianti Case Study. Several environmental issues are addressed in the case study, including soil degradation, water pollution, biodiversity loss, landscape disrespect. Agro-biodiversity loss is considered the environmental issue around which most of the others environmental problems develop. Indeed, agro-biodiversity loss in the area is increasingly exposing the local agricultural system to pests, pathogens and soil degradation. Beside farm management practices, agro-biodiversity is threatened by the uncontrolled growth of the population of wild animals (ungulates) that raid out the agricultural land with considerable damages. To put remedy, farms are forced to fence vineyards and to abandon the cultivation of arable crops. The uncontrolled growth in the number of wild animals (ungulates) is also documented to be a threat for the forest biodiversity (Blasi *et al.,* 2014). The above motivations claim for the need of coordinated actions among institutions, farms and the civil society to improve agro-biodiversity in the area.

8.2. Description of the Selected Farm Groups

FARM SETUP

The selection of the farms investigated through the DST was driven by the necessity to represent the different stages of the transition pathway mirrored in the CS area. The selected farms were divided in different groups in relation to three stages of the mirrored transition pathway:

Stage 1 – Not sustainable farming systems (generally conventional). Very low agrobiodiversity, problems of soil degradation, highly dependent on chemical inputs.

Stage 2 – Low input farming systems (input substitution). Low agrobiodiversity, problems of soil degradation, using only organic fertilisers and pesticides.

Stage 3 – Compatible farming systems (redesign). High agro-biodiversity, also thanks to the introduction of inter-row grassing, selection of local varieties, green manure, maintenance of semi-natural features.

Although more than 30% of the UAA in the area is under organic farming, most of the farms limits their practices to comply with basic rules (input substitution), with no significant benefits for the cultivated soil (stage 2). See Table 1 for an overview of some structural characteristics of the selected 12 farms.

4 farms were classified at the first stage of the transition. On average the farms included in this group are relatively small in size and in the economic dimension compared to the farms included in the other groups. 2 of the 4 farms classified in the first group are not specialized in vineyard production (one is specialized in olive grows and the other in livestock), all of the other farms specialize in vineyard production. For the farms classified at the first stage of the transition, the share of fallow land on the UAA is very high. Half of the farms belonging from this group are conventional farms, some of them do not process the grapes, and half

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of them do not take advantage of related activities (farm housing) to supplement farm income.

The farms classified at the second and third stage of the transition process produce wine by their own and their principal activity is supported by farm housing. The production method is organic farming for both groups.

The 5 farms belonging to the second group are more specialized than the ones belonging from the first group and less specialized than the ones belonging from the third group. Few farms support crop production with livestock, but the livestock size is limited and used to supplement farm housing.

The 3 farms belonging to the third groups are the most specialized farms but they also own forests and others natural features that contribute to counterbalance the relatively low agro-biodiversity. The farms belonging to this group exploits scale economies to implement advanced management techniques to support fertilization with manure from their own livestock and compost (usually from pruning residues).

Table 1. Position of the selected group of farms in the transition curve

	Transition stages		
	1	**2**	**3**
Number of Farms	4	5	3
UAA	27	23	96
LU	5	15	19
Land use share on the THA	51%	43%	24%
Vineyards land use share on the UAA	22%	38%	60%
Fallow land share on the UAA	48%	12%	22%
Percentage of farms with livestocks	25%	40%	67%
Percentage of farms with transformation	75%	100%	100%
Percentage of farms with agriturisms	50%	100%	100%
Percentage of conventional farms	50%	100%	100%

Note: UAA = Utilized Agricultural Area (ha); THA = Total Holding Area (ha); LU = Livestock Units

SIZE OF THE SELECTED GROUPS OF FARMS

The criterion used to identify the group of farms selected to implement the DST was driven by the necessity to represent the main stages of the mirrored transition pathway. Farms where not selected with the aim of obtaining a representative sample of the population of farms operating in the CS area.

The area under study is Chianti Classico, a highly specialised and market-oriented winegrowing area in Tuscany (10,000 hectares of vineyard on 28,000 ha of utilised

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agricultural area), with a special focus on Chianti Biodistrict, namely on 8 municipalities where around one third of agricultural area adopts organic methods.

The selected group of farms represent around 0.5% of the total population of farms (Table 2). The land managed by the selected group of farms cover around the 3% of the UAA of the region. The dimension of the selected farms is about six times the average farm size in the area. The coverage of the selected group of farms increases if we compare it with farms specialized in vineyard production. For instance, the coverage of the number of farms reach around 2% of the population, while the coverage of the agricultural area reaches around 4% of the UAA. The dimension of the selected farms is around 2 times the average farm size of the farms specialized in vineyard production in the area. However, it has to take in mind that a very large number of farms has a limited holding area (481 farms out of 1,113 have less that 5 ha of UAA) that only represents 5% of the total UAA of these specialised winegrowers' farms.

Table 2. Coverage of the selected group of farms in the CS area: Comparison between the selected group and the population of farms in the area (consistency of farms)

	Number of farms	Total UAA
Farms' Population (A)	2,016	28,525
Population of specialised winegrowers (B)	1,113	21,449
Farms selected for the DST (C)	12	893
C/A	0.6%	3.1%
C/B	1.1%	4.2%

By considering conventional and organic farms (Table 3), the coverage of the conventional farm selected for the DST is very low for conventional farms (around 0.1% of both the number of farms and the UAA). Differently, the coverage of the organic farm selected for the DST is quite high (around 7%of the number of farms and 45% of the UAA).

Table 3 - Coverage of the selected group of farms in the Case Study area: Comparison between the selected group and the population of farms in the region (consistency of farms)

	Number of farms	Total UAA
Population of conventional farms (A)	1,416	20,001
Population of organic farms (B)	600	8,524
Conventional Farms selected for the DST (C)	2	31
Organic Farms selected for the DST (D)	10	862
C/A	0.1%	0.2%
D/B	1.7%	10.1%

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With respect to land allocation, the land use of the selected group of farms is similar to the land use of the Case Study area (Table 4). The main discrepancy is about the percentage of the holding area covered by wood (this is around 60% for the selected group of farms and 40% for the region), the percentage of UAA covered by fallow lands (this is around 25% for the selected group of farms and 14% for the region) and the percentage of UAA covered by vineyards (this is around 60% for the selected group of farms and 40% for the region). The prevalence of woodland in the area dominated by the selected group of farms might explain the highest incidence of fallow lands on the UAA with respect to the average (high risk of damages caused by wild animals).

Table 4. Coverage of the selected group of farms in the Case Study area: comparison between the selected group and the population of farms in the region (land allocation)

	Land use distribution in the region	Land use distribution in the selected group
UAA/HA	49%	26%
Arable Crops / UAA	17%	15%
Fallow land/UAA	14%	25%
Permanent tree crops / UAA	64%	81%
of which vineyards	38%	58%
of which olive grows	25%	19%
Woodland/HA	42%	62%

LIMITATION IN THE DATA COLLECTION

- Not all the DST instruments are customized for some of the agricultural activities carried out by the farms populating the Case Study area. For instance, permanent crops (vineyard and olive groves), that constitute the backbone of the sample, do not have detailed coefficients in Cool Farm Tool.
- The three DST are not well combined overloading data collection and, consequently, threatening their integrated application in the real world. The parallel data collection for the Farm Accountancy Data Network (FADN) allowed to minimised the request of economic and financial data needed for the implementation of COMPAS.
- Most of the factors influencing agro-biodiversity in the Case Study area are external to the farms (wild animals and market conditions). A farm might perform better than others not because of its managerial capacity or its environmental friendliness. This is, in our understanding, the main limitation envisaged in the application of the three instruments. A farm level assessment misses to account key external factors that are of considerable importance in influencing the typologies of dominant farming systems in a given region.

Cool Farm Tool demonstrated to qualify the Greenhouse Gas emissions and the Biodiversity issues better than other instruments (at least in our Case Study region). Water footprint was

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not implemented because this indicator is not optimized for perennial crops in Cool Farm Tool. SMART revealed to be particularly effective in analysing the environmental, governance and social dimension. COMPASS offered a more detailed analysis of the economic dimension but at the expenses of very complex and time consuming data collection.

8.3. Focus Topics

GREENHOUSE GAS EMISSIONS

Analysis of the context

In general, GHG emissions are not considered a threat for the environment in the Case Study area. For vineyards and olive grows the use of machineries is mainly limited to pruning and harvesting. Livestock farming is widespread in the area but livestock are of limited dimension, scattered in the countryside located at appropriate distances from villages.

Differences/Similarities between farms' groups

In general, emissions decrease from the group of farms classified at the first stage of the transition to the one classified at the third stage (Table 5). The differences in emissions recorded for the farms classified between the second and the third stage are mainly attributed to the carbon sequestration and it can be explained on the fact that farms classified at the third stage implement conservative farming techniques differently to farms classified at the second stage.

Both farms classified at the second and at the third stage of the transition have more than 10 years of experience in organic farming and of green cover management compared to about 5 years for the farms classified at the first stage. This is reflected in the higher carbon sequestration level recorded for the second and third stage with respect to the first stage. For most of the processes, emissions are higher in the second and third stage with respect to the first stage (Table 5 provide per hectare emissions calculated by computing the weighted averages of the wine grapes and olives processes). This is mainly attributed to the extensive nature of the production. For most of the farms belonging to the first stage, extra-business activities contribute integrating farms' revenues. Because of the low financial capacity, the farmers classified at the first stage are forced to simplify the management of the growing at the expenses of the production.

Table 5. Results of the DST GHG emission indicators: average values for the farms' groups classified at each stage of the transition pathway

	Transition stages		
	1	2	3
SMART indicators			
Atmosphere	0,60	0,66	0,63
Greenhouse Gases	0,57	0,61	0,59
Air Quality	0,63	0,70	0,67
CFT indicators			

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General information			
GHG emission (kg CO2e/ha)	2054	1554	794
Carbon loss or gain (kg CO_2e/ha)	-272	-681	-1828
Years of organic production (number)	6	12	13
Years of green cover management (number)	6	12	13
Percentage of intergrowing with green cover (%)	13	84	83
Processes (kg CO_2e/ha)			
Seed production	0	0	0
Residue management	98	111	65
Fertiliser production	40	0	0
Soil / fertiliser	108	131	93
Paddy methane	0	0	0
Crop protection	102	155	156
Carbon stock changes	-266	-733	-524
Energy use (field)	294	453	688
Energy use (processing)	0	0	0
Waste water	0	0	0
Off-farm transport	2	4	3
TOTAL	378	120	480

Mirrored transition pathway

With the transition from the first to the third stage of the system, an increase in emissions due to the rationalization of the production is counterbalanced by an increase in the carbon sequestration obtained by introducing advanced sustainable management techniques and by integrating vineyard production with livestock farming that compensate the use of external input for fertilization.

BIODIVERSITY

Analysis of the context

We compared data from the latest National census of farming systems at the municipal level with the data collected from the selected group of farms. Permanent tree crops and, especially, vineyards, are the dominant crops followed by fallow land and arable crops. The incidence of fallow land in the region is very high. The high incidence of fallow land is influenced by the presence of wild animals while the strong specialization in vineyard production is influenced by market forces. Thus, both the presence of specialized export-oriented markets and wild animals contribute differently in threatening biodiversity in the region. Market forces, in one hand trigger the growing expansion of vineyards at the expenses of other crops and with negative impact on of biodiversity, in the other hand allow the cultivation in an area that otherwise would probably face land abandonment.

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Differences/Similarities between farm groups

With regard to the biodiversity indicators calculated using both SMART and Cool Farm Tool, it appears that biodiversity is relatively homogeneous in all farms' groups (Table 6). This is not surprising considering the high specialization of the area in winegrowing. The biodiversity scores obtained with SMART are generally higher than the ones obtained with Cool Farm Tool and do not vary significantly among the farm groups. The level of biodiversity is lower for the farm groups classified at the first stage of the transition and higher for the one classified at the third stage. Livestock and crop varieties, small habitats, aquatic flora and fauna indicators are higher for the farms classified at the third stage of the transition, while arable birds and flora indicators are higher for the farms classified at the second stage of the transition.

Table 6. Results of the DST Biodiversity indicators: average values for the farms' groups classified at each stage of the transition pathway

	Transition stages		
	1	**2**	**3**
SMART indicators			
Biodiversity	59%	60%	56%
Ecosystem Diversity	55%	60%	52%
Species Diversity	61%	64%	60%
Genetic Diversity	61%	56%	57%
CFT indicators			
Per-Component Scores			
Farmed products	29%	29%	37%
Farming practices	36%	47%	46%
Small habitats	21%	23%	26%
Large habitats	29%	29%	29%
Per-Species-Group Scores			
Livestock, crop and variety	19%	18%	26%
Arable flora	17%	37%	33%
Wetland or aquatic flora	3%	7%	12%
Woodland flora	54%	54%	57%
Grassland flora	17%	17%	22%
Soil fauna	20%	37%	39%
Beneficial invertebrates	25%	30%	34%

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Arable birds	13%	27%	28%
Grassland birds	17%	22%	24%
Woodland birds	21%	26%	25%
Aquatic fauna	23%	25%	33%

Mirrored transition pathway

The transition pathway is necessary and possible both improving agro-biodiversity and woodland biodiversity. The increase in the woodland biodiversity is not necessarily required to be addressed by farms but also by public bodies. Agro-biodiversity can reasonably be improved by adopting more sustainable land management practices, protecting wetland areas and reducing fallow lands with the cultivation of arable crops or pasture, while maintaining the farming specialization.

SOIL QUALITY

Analysis of the context (to be updated with CFT)

Soil quality is strictly related to the type of land use management techniques implemented by farms. The use of green cover/green manure/manure/compost and minimum tillage techniques instead of traditional tillage and the use of chemicals for weed control play a crucial role in influencing the quality of the cultivated soils, especially for cropland characterised by deep slopes that are particular sensitive to soil erosion. Sustainable soil management techniques are quite spread among the farms populating the Case Study area.

Differences/Similarities between farm groups

Soil quality is really not an issue in the selected group of farms (Table 7). Not appreciable differences emerge among the selected group of farms.

Table 7. Results of the DST Soil quality indicators: average values for the farms' groups classified at each stage of the transition pathway

	Transition stages		
SMART indicators	**1**	**2**	**3**
Land	67%	71%	67%
Soil Quality	67%	70%	69%
Land Degradation	67%	70%	65%

Mirrored transition pathway

Not particular issues to be addressed, at least for the selected group of farms. However, the CS area is experiencing a degradation of the hydraulic infrastructures/arrangements in the olive grows being abandoned. As a consequence, soil erosion is increasing in the area.

WATER QUALITY

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Analysis of the context

Conventional farms, and especially vineyard producers, apply massive dose of pesticides, including glyphosate for weed control. Residuals of pesticides have been recently found in the Greve river (Bianco *et al*., 2017).

Differences/Similarities between farm groups

Although half of the farms belonging from the first group apply chemical fertilisers and pesticides, water quality is not an issue (Table 8). Water is of good quality for all groups, except for water withdrawal in the second group. Such a low score is mainly depending on the fact that most of the farms classified at the second stage use fossil water for treatments and washing machines while other farms are equipped with tanks to store rainfall water with more or less limited use of fossil water. All the growing cultivated by the selected group of farms are rain fed.

Table 8. Results of the DST Water quality indicators: average values for the farms' groups classified at each stage of the transition pathway

	Transition stages		
SMART indicators	**1**	**2**	**3**
Water	72%	67%	72%
Water Withdrawal	70%	56%	68%
Water Quality	74%	78%	75%

Mirrored transition pathway

Conventional farming practices are particularly dangerous for agricultural lands located next to water courses. The conventional farms selected to test the DST are not located next to water courses. In addition, the DST investigates the water used by the farmer, that not necessarily match with the water body that is polluted by farming.

PRODUCTIVITY

Analysis of the context

The region is characterized by a long-standing tradition in winegrowing productions. The wine produced is of high quality and it guarantees high revenues, well above the average of farmers' revenues in Italy. Many farmers process the grapes and sell wine bottles by their own through private label, increasing their market power. The agricultural activity is also supplemented by farm housing that it guarantees a more stable cash flow.

Differences/Similarities between farm groups.

The difference in farm productivity among the farms' groups classified within the three stages of the transition reflect the differences in the degree of specialization addressed by farmers (measured in agricultural area covered by vineyards/UAA). The productivity increases from the first stage of the transition to the last stage (Table 9). The difference in productivity is attribute both to the level of specialization and to the size of the growing

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(scale economies) that increases from the farms classified in the first sage to the ones classified in the last stage.

Table 9. Results of the DST Productivity indicators: average values for the farms' groups classified at each stage of the transition pathway

	Transition stages		
	1	**2**	**3**
SMART indicators			
Profitability	58%	66%	69%
COMPASS indicators			
Total Output / AWU (euros/AWU)	50,011	132,421	130,673
Net Farm Value Added / AWU (euros/AWU)	38,323	77,830	89,000
Net Farm Value Added / Total Output (%)	77	60	41

Mirrored transition pathway

The size of the holding seems to play an important role in triggering changes in the management practices as it favours investments for new facilities to compost pruning residues and livestock waste and investments for new machineries for land use management.

FARM INCOME

Analysis of the context

Same as in Section 2.5

Differences/Similarities between farm groups

Same as in Section 2.5

Table 10. Results of the DST Farm income indicators: average values for the farms' groups classified at each stage of the transition pathway

	Transition stages		
	1	**2**	**3**
COMPASS indicators			
Net Farm Income (euros)	50,449	230,458	1,455,503

Mirrored transition pathway

Same as in Section 2.5.

QUALITY OF LIFE

Analysis of the context

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In general, the quality of life is very high in the region. Cooperation and inclusiveness guarantee the support of the less favoured groups of the society, providing the required services and assistance. With respect to farming, few large farms increase their investments and expand their activity at the expenses of smaller farms.

Smaller farms face problems of liquidity that affect their investment capacity.

DIFFERENCES/SIMILARITIES BETWEEN FARM GROUPS

The quality of life increases from the first stage of the transition to the last (Table 11). The role played by the owner/manager of the farm is exclusively of managerial nature at the third stage, whilst it includes both managerial and operational responsibilities at the first stage. One aspect that distinguish the farms grouped in the first stage of the transition from the others is the capacity development. The capacity development for the farms grouped at the first stage is influenced by the limited liquidity that constraint their investment capacity (elder orchards and machineries, absence of supplementary activities (transformation and farm hosing), necessity to integrate revenues with extra-business activities).

Table 11. Results of the DST Quality of life indicators: average values for the farms' groups classified at each stage of the transition pathway

	Transition stages		
	1	**2**	**3**
SMART indicators			
Decent Livelihood	69%	66%	69%
Quality of Life	77%	81%	83%
Capacity Development	53%	69%	58%

Mirrored transition pathway

The improvement of the quality of the environment from the first to the third stage of the transition might come at the expenses of the quality of life of the smallest farms if this is driven by scale economies.

8.4. Synthesis of Task 3.2 Results in the Case Study

GENERAL DIFFERENCES AND SIMILARITIES BETWEEN FARM GROUPS

The case study dilemma is already addressed by some of the selected farms. Contrary to what it might be expected, the most specialized farms are also the most sensitive to environmental problems in the selected group of farms (these are the ones classified at the third stage of the transition). Considering the marginal nature of the CS region, less specialized farms are also the less equipped to implement advanced sustainable management techniques.

The main difference among the selected group of farms is related to the economic dimension. This is also considered the force that drives the investments required to implement sustainable management techniques. Sustainable management techniques impact mainly soil biodiversity and the biodiversity of the aquatic fauna.

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TRADE-OFFS/SYNERGIES BETWEEN ABOVE TOPICS

As above addressed, the main synergies among the topic investigated with the present report are about the Economic dimension and biodiversity. A trade-off might emerge with respect to the Environmental dimension and the Quality of life if the transition is pursued solely through scale economies at the expenses of small producers.

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9. LATVIA (COUNTRYWIDE – DAIRY FARMING)

By Andis Zīlāns (BEF-LV)

9.1. Description of Case Study Dilemma

The Latvian case study deals with the dairy sector. The challenge facing the case study is how to increase the economic viability of conventional and organic dairy farming without intensification of practices. The dilemma associated with the farm assessment is:

- How to increase the economic viability of conventional and organic, largely grass-based, dairy farms while preserving biodiversity in grasslands and water resource quality?
- How to ensure that all organic milk is processed into organic dairy products?

Key features of the case study area in Latvia are:

- Final agricultural output: crop products – 57.2%; animal products – 42.8%; milk – 24.2%;
- Average gross monthly wages and salaries in agriculture: 775 EUR/month;
- Average size of farm - 36.6 ha;
- Average agricultural area per farm - 25 ha;
- The dairy sector is highly fragmented: there are many small dairy farms with a small herd size and a small number of large farms with large herd size;
- >50% of dairy farms are less than 10 ha in size = account for only 6.7 % of dairy cattle;
- 5% of dairy farms with a farm area of >100 ha account for >50% of dairy cattle;
- Total milk production in 2018 - 1 million tons;
- Average milk production per cow/year - 6525 kg/cow/year;
- Average milk production per cow/day - 18 l/cow/day;
- Share of organic dairy cattle of total dairy cattle - 5.5%;
- Share of organic milk of total milk production - 10%;
- 38% of organic milk processed into organic products;
- Some farmers receive approximately 30 % price premium for organic milk vs conventional milk (30 and 20 eurocents accordingly in 2016).

9.2. Description of Investigated Farm Groups

The case study farm assessment specifically deals with FADN 450. Specialist Organic Dairying versus 450. Specialist Conventional Dairying on grassland and arable land. The plan was to assess five farms from each of the two groups. Farms to be assessed were identified by a two NGO farming organizations, one representing mainly conventional farms (NGO Farmers Parliament) and the other organic farms (NGO Association of Latvian Organic Agriculture).

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The farm identification/ selection was undertaken on the basis of criteria defined by the research team.

The selected farms are distributed throughout Latvia. The process of selecting the farms was prolonged as during the summer cropping season dairy farmers are doubly busy and are pressed to devote extended hours to interviews and additional time for follow-up questions and verification of data. The farms that agreed to participate in the research did so reluctantly and only upon being offered an honorarium. All of the farms, except one, that agreed to participate for the duration of the research were small family specialized dairy farms with between 14 and 48 milking cows with grazing. One of the participating farms is a conventional farm with 115 milking cows without grazing. The area of agricultural land on the surveyed farms ranges from 50 to 300 ha.

Initial visits were made to two farms, but subsequent multiple attempts to collect farm survey data from these farms were not successful and further work with these farms was discontinued. Due to time constraints, securing replacements for the two drop-out farms was not feasible. Consequently, the farm assessment results presented herein relate to 8 dairy farms – 5 organic dairy farms and 3 conventional dairy farms. The 5 organic dairy farms are thought to be representative of small specialized organic dairy farms in Latvia. The 3 conventional dairy farms are representative of two types of conventional dairy farm groups in Latvia. Two farms are considered representative of typical small conventional family dairy farms whereas the conventional farm with 115 milking cows (without grazing) is more typical of larger production-oriented dairy farms in Latvia. The conventional farms provide a good representative overview of the different types of conventional dairy farms in the case study area and valuable insights regarding the similarities and differences between these two conventional groups.

All of the assessed farms are specialized dairy operations where meat calves are not retained on the farm for an extended period of time prior to selling for immediate slaughter or meat production. A few meat calves are kept of some farms for own consumption. No other farm animals were excluded from the assessment except for a few laying hens and pigs that were intended solely for the farm household consumption. Almost all feed (roughage and grain concentrate) fed to the dairy herd on organic farms is grown on the assessed farms. Only minor amounts of supplemental grain feed (and some mineral feed) are purchase as feedstuff by the organic farms. Conventional farms also produce most of their own roughage and a large share of grain, but overall conventional farms purchase a greater share and variety of concentrate feed. All feedstuffs fed to dairy herds on both organic and conventional farms were assessed in COMPAS and Cool Farm Tool.

The selected year for the farm assessment was 2018 which was characterized by an exceptionally dry growing season. Consequently, all farms in the case study area and assessed farms experienced significant decreases in roughage (hay, silage) and grain yields (50% lower yield). This consequently impacted on overall farm productivity and in some cases necessitated the purchase of roughage and concentrate feed that would not have been necessary in a more typical precipitation year.

Most of the assessed farms were established nearly 30 years ago during the land reform following re-establishment of independence. Only one farm (organic) was established within the last five years by a young energetic couple that has long-term plans for the development of their dairy farm. Four of the organic farms are operated by farmers who have reached or are approaching retirement age and are considering whether to continue dairy operations,

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transition to a less labour intensive farming practice or to hand the dairy farm over to the next generation. All of the conventional farms are operated by farmers who are still growth oriented. These factors in part explain some of the noted results of the farm assessment.

9.3. Focus Topics

DIRECT AND INDIRECT GREENHOUSE GAS EMISSION

There are no clear distinctions in greenhouse gas emissions from the two farm groups in relation to the sources. In both farm groups emissions from the dairy livestock operation are many times higher than the emissions from the cropland. For both farm groups enteric fermentation is the major contributor of emissions for all farms (that have grazing) with animal grazing and manure management contributing less.

The greatest difference in GHG emissions is related to emissions from feed production which are higher for conventional farms due to a greater amount of feedstuff being purchased instead of grown on the farm. The large conventional non-grazing farm has particularly high emissions related to feed production as it feeds its dairy herd a large amount and variety of purchased feedstuff.

Emissions from soil and crop fertilization are higher for conventional farms due to the additional use of mineral fertilisers. Similarly, the use of plant protection products on some of the conventional farms results in higher GHG emissions.

In relation to the intensity of emissions from cropland, GHG emissions per hectare are higher for the conventional farms than the organic farms.

BIODIVERSITY

SMART and Cool Farm Tool are used to assess different aspects of biodiversity on the surveyed farms and to compare and contrast similarities and differences between conventional and organic dairy farms. In relation to the SMART subthemes Ecosystem Diversity, Species Diversity and Genetic Diversity the organic farm group scores higher than the conventional farm group. On all three subthemes organic farms score “moderate” and/or “good” whereas all conventional farms score “limited” to “moderate” with only one farm scoring “good” on the subtheme species diversity.

In terms of number of farmed products in the CFT Biodiversity assessment, particularly the number of different crop varieties, surveyed organic farms have a slightly greater diversity of crops that are grown as feed for their dairy herd. Although both groups of dairy farms grow their own hay and silage, most of the organic farms also grow most of their own feed grain. All organic farms have a greater share of perennial grassland and mixed clover/ grass grassland that is used for grazing and hay and/or silage feed production.

In relation to farming practices, surveyed organic farms score considerably higher than conventional farms. Although both organic dairy farms use manure fertiliser, conventional farms also apply mineral fertilisers to crops and grassland. Additionally, conventional farms use plant protection products for weed and disease control, whereas organic farms rely more on nitrogen fixing crops, crop succession and intercrops to maintain soil fertility and control weeds. The use of mineral fertilisers negatively impacts on soil fauna and beneficial invertebrates on conventional farms compared to organic farms.

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Neither conventional nor organic dairy farms implement a variety of measures on agricultural land, both cropland and grassland, to promote flowering plants and to provide seeds and habitats for birds. However, as organic farms typically have a larger proportion of perennial grassland than do conventional farms, organic farms offer higher biodiversity in terms of grassland flora and bird biodiversity. Similarly, but to a lesser degree, arable land flora and bird biodiversity are slightly higher on organic farms as a greater number of crops, including intercrops are cultivated, and plant protection products are not used.

Ponds and water courses on both organic and conventional farms are not specifically managed to encourage aquatic, wetland and terrestrial flora and fauna. A difference in the rating of aquatic and wetland flora and wetland fauna between the two farm group types was not noted. Differences between farms in aquatic and wetland flora is largely linked to the total area of drainageways and ponds present on farms rather than management measures. Similarly, the scoring of woodland birds and flora is more closely related to the size of large woodland areas on the farm than any specific management practices implemented by farmers.

SOIL QUALITY (SOIL AS A MEANS OF PRODUCTION)

The scoring in the subthemesubtheme Soil Quality is only slightly higher on the organic farms than in the conventional farms. Both farm groups have one farm with a score in the “good” range, whereas the remaining farms in both groups score in the “moderate” range. The main indicators that contribute to a slightly reduced score in the conventional farms are the use of mineral fertilisers and plant protection products (herbicides and fungicides), whereas the organic farms rely entirely on cattle manure fertiliser and more often use intercropping, mixed crops to address weeds and include perennial grass with clover/ legumes in the crop succession to replenish soil fertility. However, conventional farms more than organic farms undertake soil analyses to determine fertilization requirements.

The scoring for soil quality in organic farms is negatively impacted by the absence of manure storage facilities on four of the farms and leakage from a structurally defective manure storage facility on one farm. Additionally, on two of the organic farms manure storage on unprotected soil is undertaken within 30 metres of groundwater taking wells. Additionally, antibiotic drying agents are used by two of the conventional farms which could impact on soil quality through wastewater discharges and manure handling/ spreading.

The soil quality score on both organic and conventional farms is negatively impacted by the following issues:

- Mulching is not practiced and catch crops are not planted between main crops;
- Soil analyses for humus balance and heavy metals are not undertaken on a regular basis;
- Water quality in well water is not regularly analysed;
- No till ploughing and direct seeding are not practiced.

Both organic and conventional farms have sizeable areas of permanent extensively managed grassland that has not been ploughed/ renewed in the last five years which helps to maintain soil structure and fertility. Also, both farm groups maintain sizeable areas with temporary extensively managed grassland cover. Similarly, outside the growing period green cover is maintained at greater than 50% on both organic and conventional farms. On

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cropped areas crop residue is left on the fields and incorporated into the soil which increases soil organic content and fertility. In both farm groups waste is generally well managed with recycling being practiced when available. Veterinary medicines and pesticides when used on conventional farms are stored and handles safely. Measures are taken to proactively counter soil erosion. Flowering regulation is not undertaken by both farm groups.

WATER QUALITY

In the subtheme Water Quality the organic farms have a slightly higher score than the conventional farms. All of the organic farms have scores in the range of "good" whereas the scores for the conventional farms fall in the range of "moderate" and "good". Within the conventional farm group the dairy farm without grazing has the lowest score – "moderate"

The subtheme Water Quality score is lower for the conventional farms based on the indicators related to the use of plant protection products (herbicides, fungicides) and mineral fertilisers. The organic farms do not use plant protection products or mineral fertilisers. Two of the conventional farms use antibiotic drying agents and one uses prophylactic treatments which impact negatively on the water quality score for conventional farms.

On the other hand, all of the surveyed conventional farms have manure storage facilities with impermeable bases that inhibit the out-migration of contamination into surrounding soils. Only one of the organic farms has a manure storage facility, however its outwardly sloping base allows surface seepage from the manure pile to drain into surrounding soils. On four of the organic farms manure is stored adjacent to the dairy barn on open soil. On two of organic farms the distance to the farm water well to the manure storage location is not more than 30 metres. However, the wells are described as being deep wells. Slurry that is applied to fields in both organic and conventional farms is not applied via a drag-hose system which potentially impacts negatively on water quality.

Wastewater generated on both farm types is mainly infiltrated into the soil. On one organic farm wastewater is collected in holding wells and later transported to a wastewater treatment facility, whereas in one of the conventional farms wastewater is stored in a manure storage lagoon until it is spread on fields.

PRODUCTIVITY

Subsidies make up a significant part of the Gross Farm Income of both organic and conventional farms. In the case of organic farms, subsidies can be as much as 50% of total output whereas for conventional farms this is somewhat less – 25%. Consequently, subsidies can make up more than 50% of Net Added Value for both organic and conventional farms.

Farm Labour Productivity is somewhat higher for conventional farms, however one of the organic farms (BIO 5) has the highest labour productivity of all the surveyed farms, even exceeding that of the largest conventional farm (CON 3) with 115 highly productive milk cows without grazing. Overall the Gross Margin per dairy cow is higher for the conventional farms than organic farms except for the organic farm (BIO 5) with the highest Farm Labour Productivity. As all surveyed farms are specialized in milk production Total Output and therefore Gross Margin is linked to the amount and value of the milk sold and the production costs for the milk.

FARM INCOME

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Net Farm Income is highest for the largest conventional dairy farm (CON 3), however, Net Farm Income in two organic farms (BIO 2, BIO 5) is higher than two of the conventional farms (CON 1, CON 4).

QUALITY OF LIFE

Limited differences exist in the scoring of organic and conventional farms on the subtheme of Quality of Life. All farms in both groups score “good” except one conventional farm scoring in the “moderate” range. Farm income and wages are low on both organic and conventional farms. Only the largest farm that has 115 non-grazing milk cows is earning a “normal” living wage. Weekly working hours on most farms exceed the typical 42 hour work week and on many farms farm owners/ managers work almost double this time. Overtime worked by family members or employed workers are rarely compensated. A good work-life balance is not evidenced on most of the organic and conventional farms. Farmer owners/ managers typically do not take holidays away from work on the farm more than one week a year. Clear ownership rights / social protection for partners in the event of divorce / death is clarified only on two of the organic farms. Two of the organic farms do not have a replacement for the farm manager in the event of illness. Most farm managers are of the view that the profitability of the farm is steady or has been improving over the last few years.

Both organic and conventional farms do not have written commitments against discrimination nor undertake specific proactive anti-discrimination measures. However, in relation to wages and opportunities amongst family members and other employees, no differentiation in wage rates occurs for comparable work and skills. Typically, both men and women are expected to do multiple farm tasks for which they receive equal remuneration. Two of the five organic farms and one of the three conventional farms are owned and managed by women. One organic farm has hired a handicapped relative to work on the farm. Hired workers on one conventional and one organic farm are provided with accommodation and meals on the farm in addition to being paid a wage. On most of the organic and conventional farms employment levels have remained unchanged.

Conventional farms have a higher level of mechanisation in relation to milking, feeding of roughage and concentrated fodder and mucking out the barn. Only two of the organic farms have milking lines whereas all conventional farms have milking lines or milking rooms. Similarly, only one organic farm has a mechanized manure mucking system, whereas in all other organic farms barn mucking is carried out by hand. Mucking of all conventional farms is mechanized.

Systematic identification of potential safety hazards is rarely undertaken by both farm groups. None of the farms have realistic management systems in place for workplace safety and health. All organic farms produce at least 50% of all consumed food on the farm, whereas conventional farms are less self-sufficient.

Other indicators that have a low rating for both groups of farms include:

- Social responsibility in procurement;
- Environmental and social involvement outside the farm;
- Prevention of social conflicts;
- Workers working without official permits.

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ANIMAL HEALTH

On the subtheme of Animal Health the overall scores for both farm groups is largely in the "moderate" score range. Only one organic and one conventional farm has a score in the "good" range. The overall moderate score on the subtheme across all farms is related to low scoring on the following indicators:

- inadequate lighting in most organic and conventional farm group dairy housing;
- the low level of cleanliness in many dairy barns;
- the high stocking density/ crowding in the dairy barns during the winter months;
- the limited access to the outdoors during winter months, the relatively short grazing season on some of the farms and the lack of grazing altogether on one of the conventional farms;
- the limited measures taken on many farms for hoof care;
- the absence of maternity pens in both groups of farms;
- the lack of separated quarantine space for sick animals;
- animals on all organic farms and two conventional farms animals are tethered in separate stalls during the winter months;
- the standing and lying areas for dairy cattle are insufficiently large in both farm groups;
- in many organic and conventional farms the lying area for dairy cattle is hard;
- the duration of transport to the abattoir is quite lengthy for all farms;
- knowledge by farmers of the welfare/ slaughter standards at the abattoir is limited;
- complaints have been registered by both farm types regarding excessive cell counts in milk.

The following differences in performance on the animal health issues were noted between the farm groups:

- all of the dairy cows in the conventional farm group are dehorned whereas none are on organic farms;
- feed grain storage quality on all organic farms is inadequate to limit losses and contamination;
- none of the organic farms have materials to keep animals busy whereas one of the conventional farms does (e.g. scratching brush);
- organic farms do not use antibiotic drying agents, whereas they two of the conventional farms do.

9.4. Farm Comparisons

GENERAL DIFFERENCES BETWEEN FARM GROUPS

Generally, the organic farm group scores higher than the conventional farm group in the Environmental Integrity themes of the Biodiversity and Water, but lower with respect to

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Animal Welfare. In the Social Well-being dimension, the organic farm group scores higher than the conventional farm group in the in relation to the themes of Equity and Human Safety and Health, whereas conventional farms score higher in Labour Rights and Decent Livelihood.

Differences exist in the scoring of the conventional and organic farm groups in the Economic Resilience dimension. Conventional farms score slightly higher in the themes of Local Economy, Vulnerability and Investment. In the theme of Product Quality and Information, differences and similarities in score are noted across the subthemes:

- In the subtheme Food Safety, organic farms score considerably higher than conventional farms. The lower score for conventional farms is related to the use of synthetic chemical herbicides, the greater use of prophylactic antibiotic treatments and antibiotic drying agents and the use of nitrogen mineral fertilisers, chemical seed dressings and pesticides with acute and chronic toxicity.
- Conventional farms have a slightly greater score on subtheme Stability of production due to fewer issues with staff shortages and availability of adequate replacement of farm manager, having a better knowledge of market and policy challenges and better insurance coverage for fire and natural disasters.
- Conventional farms score higher on the subtheme Profitability than organic farms due to greater long term investments, greater profit stability, greater mechanisation in milking operations and a positive yield tendency. The organic farm group scores higher on the subtheme of Product Information due to greater involvement in direct sales, greater transparency of production and better knowledge of the origin of bought-in farm inputs.

Family AWU is higher for the organic farm group as these farms are less mechanized with respect to milking and barn mucking machinery.

GENERAL SIMILARITIES BETWEEN FARM GROUPS

Overall, both farm groups do not score high on any of the sustainability dimensions. Both farm groups score higher on Environmental Integrity and Social Well-being, but lower on Good Governance and Economic Resilience.

In the context of Economic Resilience both the organic and conventional groups show a low score on the Stability of Markets which is related to the unstable milk market and a moderate to good score on Local Procurement as most inputs to the farms are sourced locally within the Latvia.

Overall, both farm groups score uniformly low on the themes and subthemes of Good Governance and demonstrate strengths and weaknesses on similar themes and subthemes. Both farm groups show:

- moderate to good scores on the themes of Participation and Rule of Law,
- moderate and limited scores on Corporate Ethics,
- limited and unacceptable scores on Accountability and Holistic Management.

9.5. Trade - offs / Synergies Between Focus Topics

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Possible synergy is demonstrated between the Environmental Integrity themes of Biodiversity and Water and the Economic Resilience theme of Food Safety. A higher score on these three themes is evidenced by the organic farm group in part due no mineral fertilisers, seed treatments, plant protection products and antibiotics being used by organic farms in the production of crop feedstuffs. Similarly, whereas organic farms grow most of their own organically grown feedstuffs (roughage and feed grain) conventional farms use a greater diversity of feed, more of which is purchased and grown using mineral fertilisers and plant protection products. In lieu of mineral fertilisers and plant protection products organic farms more often use perennial grassland with nitrogen-fixing legume admixtures to maintain the fertility of soils, thus allowing for the production of feed grain crops that require higher levels of nutrients in the next crop rotation. Similarly, organic farms more often use intercropping of grain crops and legumes to maintain soil fertility and for weed control.

9.6. Synthesis of Task 3.2 Results in the Case Study

The farm assessment results reveals substantial similarities between the farm groups across all sustainability dimensions. Many Good Governance dimension themes and subthemes are weak for both organic and conventional groups particularly with respect to Corporate Ethics, Accountability and Holistic Management themes. Issues addressed by the Good Governance dimension are not a priority to the typical family farm in Latvia. These issues can be considered to be more relevant to larger EU commercial farming operations.

The Environmental Integrity dimension scores moderately well for both farm groups due to the overall extensive nature of farming practices and the presence of large natural habitats and wetlands that are an integral part rural agricultural landscape in Latvia. The abundance of natural habitats contributes to biodiversity, water quality and somewhat to soil quality on agricultural land.

Overall Environmental Integrity themes score slightly higher for organic farms mainly due to the avoidance of mineral fertilisers and plant protection products. However, the Animal Welfare theme is slightly weaker for organic farms due to limited investments in animal housing infrastructure and cattle manure storage facilities. Within the conventional farm group the large non-grazing operation ranks lower on Environmental Integrity due to more intensive fodder production practices - greater mineral fertiliser and plant protection product inputs. Furthermore, the use of large and diverse amounts of external feed inputs on the non-grazing conventional farm results in a large GHG emissions compared to the organic and conventional grazing dairy operations. The largest GHG emissions are related to the production of off-farm produced feed inputs.

The Social Well-Being dimension scores moderately and variably within both farm groups. Many assessed social issues do not rank high in priority for the small family farms in Latvia. The organic farm group scores higher than the conventional farm group in relation to the themes of Equity and Human Safety and Health themes, but lower on Labour Rights and Decent Livelihood themes as the assessed organic farms are small family operations oriented to self-sufficiency.

Conventional farms score slightly higher on Economic Resilience, but both the organic and conventional groups show a low score on the Stability of Markets which is related to the unstable milk market. Although Labour Productivity is overall slightly higher in the conventional farm group, the highest Labour Productivity in all the surveyed farms is with an

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organic farm, even exceeding that of the large non-grazing conventional farm. A large part of the Net Value Added for both farm groups is from CAP subsidies – contributing up to 50% of Gross Farm Income for organic farms and 25% Gross Farm Income for conventional farms.

Addressing the case study dilemmas (How to increase the economic viability of conventional and organic, largely grass-based, dairy farms while preserving biodiversity in grasslands and water resource quality? How to ensure that all organic milk is processed into organic dairy products?) is largely contingent on ensuring that most/ all of the organic milk produced on farms is delivered to organic dairies and processed into organic milk and dairy products. If the market for organic dairy products does not continue to grow, to take up the surplus organic milk production, there could be a risk that the existing level of RDP support/ subsidies for organic dairy farming will not be continued at present levels and will not expanded. As RDP support payments to organic dairy farms are critical for the economic viability of these farms, policy changes that reduce support payments to organic dairy farmers could prompt existing organic dairy farmers to revert to conventional dairy production and could dissuade existing conventional farmers from making the transition to organic farming. In the context of the present 2014-2020 RDP, there were more conventional farmers that wished to transition to organic farming practices, but could not receive support payments because the amount of funding allocated to organic farming in the RDP was limited.

As farming, including the dairy sector, in Latvia is experiencing a generation change with many existing farmers approaching retirement age, support for this transition process would help ensure that existing organic dairy farms continue to be operated as such by the next generation. A key issue to be addressed is the need to increase and upgrade mechanisation on dairy farms with respect to milking and mucking-out operations and preparation and distribution of feedstuff. This would reduce the amount of physical labour and working hours for dairy farmers resulting in a healthier work-life balance and thus would serve to encourage the next generation of young farmers to pursue dairy farming.

Likewise, upgrades in animal housing infrastructure are needed to provide a healthier and less stressful environment for dairy cattle during the winter months when grazing is not possible and cattle must be kept indoors. Similarly, an upgrade in manure storage infrastructure and manure spreading machinery is required to increase the environmental performance of dairy operations. Additionally, upgrades in farm field machinery would increase the efficiency of on-farm feedstuff production including encouraging environmentally friendlier soil tilling and crop cultivation and diversification approaches.

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10. LITHUANIA (COUNTRYWIDE – DAIRY FARMING AND CHEESE MAKING)

By Gražvydas Jegelevičius (BEF-LT)

10.1. Description of Case Study Dilemma

Lithuanian case study dilema addresses the current tendencies the country of decreasing small dairy farm size and intensifying agriculture in general that has a negative effect to the environment. The two main questions raised are: How to maintain and encourage extensive management (grazing) of grassland habitats? How to become (or remain) competitive for dairy farms in the market without intensifying the farming practice?

10.2. Description of Farms Investigated

In the case study 10 farms have been selected belonging to the dairy sector and were chosen either with cooperation with several Lithuanian municipalities, case study champion or through search by project experts. They are a part of 4 farm groups that belong to 2 FADN principal farm types. The envisaged farm grouping reflects the transition pathway towards agro-ecology. It is not entirely linear in terms of evolution (in time) but rather stem from FG2 that reflect most common dairy farming practice in the country. Farm as such are more or less low input with aspects of traditional practices and are relatively small in size (except for some applying mixed farming practices with arable). From there two directions are possible – either towards intensification (FG1) or towards more environmentally friendly farming (FG3 and FG4) as addressed by case study dilemma.

Farm groups are described below and their order reflects the transition pathway towards agroecology.

FG1: Conventional, specialist dairy (FADN 45)

This farm group encompasses 2 conventional dairy farms, that can be characterized by their large scale, input (and output) intensive farming practices. These two farms along with dairy farming practice arable agriculture in large scale to produce a large share of feed needed for dairy farming.

FG2: Extensive, specialist dairy (FADN 45)

This farm group represents most commonly found dairy farms in Lithuania. Usually of small scale – from 1 and up to 20 livestock units. Mixed farming practice is a common characteristic with dairy being not the only farm enterprise, but also intensive arable farming, fattening beef cattle or keeping other livestock. With regards to dairy farming these farms are mostly practice extensive grazing and need little input. In this group two farms are investigated.

FG3: Extensive, mixed grazing livestock/dairy (FADN 48 and 45)

For farms in this group some agroecological practice is characteristic. Usually small in size with some interest in all sustainability topics most of these farms are relatively newly established. The economic sustainability downsides of farms of this size is addressed by improving value chain (processing and direct sales). In this group 2 dairy cattle farms and 2 other dairy livestock (goat/sheep) farms are investigated.

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FG4: Organic, specialist dairy (FADN 45)

Investigation of this farm group covers 2 organic dairy farms. Alongside dairy farming organic dairy farmers in Lithuania commonly farm arable crops as well, either for own fodder or for selling. Some do keep beef cattle alongside. Grassland management can also vary from extensive permanent meadows to intensive temporary grasslands.

10.3. Focus Topics

DIRECT AND INDIRECT GREENHOUSE GAS EMISSION (GHG)

To account for farm impact of GHG emissions CO_2eq is assessed with Cool Farm Tool. With regard to animal rearing, highest direct CO_2eq share in all farms comes from enteric fermentation. All investigated farms use concentrate feed or silage, which increases overall emissions from enteric fermentation. This partially but not fully reflect correlation between concentrate feed proportion and GHG emissions according to the farms investigated. The second highest share is related to manure management practice. According to the model, manure-related emissions are less of an issue in FG3, where dairy goat/sheep is kept as opposed to cattle. However, it very much depends on particular manure management practice. Emissions for deep bedding (FG2, FG3) are much higher than in farms where manure is removed periodically (FG1, FG4). Overall, FG4 farms have shown lower emissions per kg FPCM with regard to dairy enterprises, the actual reasons are good manure management and most likely correct rationing.

With regard to arable agriculture highest releases direct emissions are due to fertiliser use (soil erosion) in all farm groups and in organic where manure is used. Intensive farms do show higher releases due to more fertiliser use, but as important are indirect emission from chemical fertiliser production, which is not an issue in organic farms.

SMART GHG subtheme also revealed tendencies in GHG emissions, where farms using fertiliser (FG1), one farm in (FG2) and one farm in (FG3) scoring by 5-10 % lower than farms that average at around 58%. Air quality trends revealed by Air Quality subtheme show that FG4 farms score the highest – 73 and 82%, fertiliser users score the lowest, but air quality is dependent on many factors, thus this trend cannot be explained by farm categories solely, but there is correlation with the characterised transition pathway.

BIODIVERSITY

Regarding Cool Farm Tool biodiversity assessment FG4 had an overall lead when assessing “Species group” score as well as consistency between the groups. It is mostly because of mixed farming (dairy + arable) and organic practice. However, very much depends on case by case basis, if a farm has diverse landscape elements that are common to Lithuanian country. In terms of score regarding “farming practices” FG2, FG3 and FG4 were pretty close in score, as well as “farmed products”, since no farms especially focused and aimed for crop/animal diversity between and within species. It can also be said, that in all farm groups farmers hardly engaged in organised measures to improve biodiversity or habitats for either for own benefit or for benefit of nature, besides grazing practice or maintaining permanent grasslands or some elements of what nature has created (e.g. pieces of dead wood on the ground). Overall due to these reasons, it should be noted that only one farmer had a score above 50% in large habitat category, while 3 had score above 50% within one species group

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each. Several 2 farms in FG3 and 2 in FG4 had an overall score around 40%. It can be noted that two farmers in FG3 and one in FG4 owned (or even rented) forest or wetland habitat without monetary interest in it.

SMART biodiversity theme score reveal correlation in all 3 subthemes. 3 farms in FG3 that conceptually and to some degree practically oriented themselves to sustainability (at least the environmental aspect) scored the highest with scores in Ecosystem Diversity, Species Diversity and Genetic Diversity respectively 74, 81, 73 averaged between these 3 farms. This score was higher than organic farmers in FG4 with scores of 61, 69, 65 to respective subthemes. Other farmers in FG1, FG2 and one farmer in FG3 without particular focus to biodiversity protection or even using agricultural practices that disturb and disrupt ecosystems scored the lowest.

Thus it can be concluded that in Lithuania the concept of particularly caring for biodiversity due its benefits for own farm and ecosystem health is still not widespread and farmers that have not been seriously interested or have not been trained in maintaining on-farm biodiversity or even crop diversity will most likely not apply relevant measures regardless of farm group, but it can also be said more extensive farming practices as found in FG3 and FG4 revealed a higher score thus somewhat mirroring the pre-defined transition pathway.

SOIL QUALITY (SOIL AS A MEANS OF PRODUCTION)

With regards to Soil Quality, lowest results are found in farms that grow arable crops and use fertiliser and pesticide inputs. Much higher score 77 to 81% is obtained in FG3 (by 3 farms), where no arable farming is practiced and in FG4 scoring 70 to 72% with some organic fertilisation and arable farming.

With regards to Land degradation subtheme similar tendencies are seen. FG3 farmers that do not practice arable agriculture score the highest – between 79 and 86%, followed by FG4 (67-69%) and farms that more intensely work the land (58-59%). However, it must be noted, that no farmer has said that he/she has noticed any signs of lands degradation or soil compaction. None of them have done soil organic matter/carbon content analysis on a regular basis to have a well grounded opinion. All in all, tendencies seen in soil quality results correlate to some degree to transition pathway.

WATER QUALITY

In Lithuania ground water is commonly used in countryside locations for own or for farm needs. Some farmers count on shallow sub-surface wells, some do have a deep well, while others use both. Furthermore, irrigation is very irregular practice in Lithuania for cereal fields or for grasslands, except among vegetable growers. Most farms investigated have a deep well and use it for farming needs, no irrigation is used. It is known that groundwater resources in Lithuania are renewable, but not necessarily their quality, which may be affected by intensive agriculture over longer periods. With regards to Water Quality of farms investigated a score from 59-91% is seen, which is generally very good. Farms with more conventional practice were rated at the lower end of score interval noted, whereas farms in FG3 and FG4 performed similar. In Lithuania water pollution has been increasing in recent years due to nutrient runoff from arable fields mainly, thus most likely the lower score does not reflect the real situation of fertiliser-intensive farms that cause real water pollution problems.

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In terms of Water Withdrawal – score varies between 58% and 75% regardless of the farm type, but more can be related to personal habits of farmers or to the fact that in Lithuania water scarcity is very uncommon.

PRODUCTIVITY

With regard farm productivity from one cow – it was the highest in conventional farm (FG1) investigated at around 10t per cow per year, whereas farms in FG2 and FG4 produced around 5t and even less was produced in FG3 at around 3-4,5 tonnes. It should also be noted that (FG1) have better chance of increasing their productivity due to economy of scale as opposed to small dairy farms (FG2) that would require to spend significant share of income to increase the productivity. From a broader SES context, it is known that small dairy farms (FG2) are decreasing in numbers at a very fast pace, mainly because of increasing input costs that they are unable to deal with and the two years (2018 and 2019) of unfavourable weather that caused pasture productivity to plunge and as a result farmers are unable to produce sufficient quantities of feed by themselves.

Interesting to note from the interviews, that farmers in FG3 do not orient towards productivity volume-vice but rather towards quality needed for processing and producing high quality dairy products. Thus explaining the high share of hay in winter ration of animals. Therefore, here different strategies must be noted. Although farms representative in FG3 may or may not orient towards volume production of raw milk and then process it, the investigated farms in FG3 creates added value to their production and do not specifically orient towards volume of production but quality of production.

FARM INCOME

All farms reported they had a profit scoring very close in subtheme Profitability – between 61 and 71%. However, all farms reported that cost of inputs are increasing steadily in recent years. Farms that have fewer inputs as FG4, are much less dependent. Farmers in FG3 were all considering increasing the price of their produce soon in response to this (3 of 4 farms in this group purchased larger share of their feed) and none in FG3 reported problems with demand of their products with score being from 70 to 78%. Whereas, FG4 had doubts about organic milk market scoring 46 and 63% as their cooperative has to export the milk to neighbouring country, as the price offered domestically are unsatisfactory. FG1 reported dependence on one main customer with doubt of having another one at an acceptable rate per tonne of milk. This reflects the concentration in milk processing in LT, where 5 dairy companies dominate the market, while FG2 reported that raw milk prices they receive are below average, but said there are no problems to sell milk scoring 63%. Farmers in FG2 are in doubt about the future of small scale dairy farming taking current economic (and political) tendencies into account. Even FG1 group said that the economic situation is becoming challenging for them, even though, they reported profit.

Regarding Internal investment subtheme farms scored between 55 and 67%, with FG2 scoring the lowest as it did with regard to Long-Ranging Investment, where it scored 38% compared to other farms ranging from 56 to 75%. It is partially reflected by what farmer has said during the interview, that he plans to cease dairy farming, thus no investments into infrastructure are being made.

Almost all farms were heavily dependent on direct payments, except for 2 farmers in FG3, whose proportion of direct payment to overall income was the lowest. FG4 farmers say they are uncertain about future, if direct payments cease farming may become much more

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difficult or may cease. It is also worth noting that FG2, FG3 (2 farmers of 4) and FG4 did not take their labour costs into account when assessing farm economics.

QUALITY OF LIFE

Socio-economic differences with regard small farms (FG2, 3, 4) vary but the relationship between different socio-economic aspects it very much non-linear. Well-being depend on how the farming system is set up. Ideal balance would be to have a decent amount of spare time and sufficient resources, which would bring satisfaction in life, this may result from family members engaging in farm activities or would encourage family members to engage thus better ensuring continuation (inheritance) of farming practice. If a farm is well organised and sufficiently profitable it may employ additional workers, that would free-up time and allow to improve quality of life.

Investigated farms scored between 68% and 84% and two farms scored lower 57 and 65% with main reasons being poor attention to work safety, did not engage in activities to influence the quality of life externally or not paying attention to non-discrimination. It's interesting to note that the highest scoring farm had 5 family members engaging in farming activities and sharing work, so that everyone works half a day on average for most. Overall no tendencies in transition pathway could be drawn regarding quality of life but it more depends on a personal approach and degree of education.

With regard to labour rights in FG1 farms some forms of forced labour are still existent in

Lithuania. It was not discovered in the farms investigated but are known from broader SES context. It is in a form of unlimited workday or lack of equal pay. Cases are known where a salary of employees can be cut with no reason by half. With regard small farms (FG2, 3, 4), where family workers are concerned there are usually no problems. However, in cases, where there are employed people rarely there can be forced labour cases (longer workdays without compensation). This however is independent of transition pathway but can be more of a problem in larger farms (FG1).

Case-study specific sustainability aspect: Balancing between environmental integrity and economic resilience

The aspects that are particularly interesting with regards to case study dilemma are the low intensity and environmental sustainability of farms (e.g. maintaining extensive farming practice, thus protecting grassland and other habitats and traditional landscape) and also having economic sustainability. These two aspects are discussed.

With regard to environmental aspects, FG4 and 3 farms in FG3 scored green in almost all environmental subthemes in SMART, whereas other farms score significantly lower. Biodiversity score in CFT reflect similar overall trends. With regard to economic resilience particular aspects need to be looked at, such as value chain creation in which FG3 was clearly leading by engaging in on farm processing and creation of products with added value. Whereas FG1, FG2 and FG4 did not engage in raw milk processing and even FG4 farmers are exporting their raw milk produce to foreign country. With regards to other important aspects of taking part in local food systems none were particularly leading, with some aspects fulfilled by FG3 such as local direct sales of part of the produce.

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With regard to economic resilience it is relevant look if farmers engage in other income generating activities besides farming, however in investigated farms only 1 farm in FG3 had this aspect fulfilled. Finally, degree of cooperation is also important and it was clearly more fulfilled in FG4, but also partially in FG3. From broader SES context it is known that small proportion of farms reflected by FG2 engage in cooperation.

Overall, it can be concluded that FG3 and FG4 were most environmentally sustainable and FG3 had most aspects of economic integrity fulfilled.

10.4. Farm Comparisons

GENERAL DIFFERENCES BETWEEN FARM GROUPS

Main differences with regard to environmental aspects of sustainability such as GHG and biodiversity among the farm groups arise due to the farming practice. Generally, low input farms in FG3 and FG4 farms performed better with FG3 farms leading some aspects of sustainability. As for social aspects no conclusions can be drawn with respect to the transition pathway and more depend on case by case basis or general social context of the country. To name a few economic differences, FG2 is the least economically sustainable as known from broader SES context when taking economic and political tendencies into account as is also reflected by SMART analysis. FG2 is in almost every aspect of economic sustainability behind other farms in FG1, FG3 and FG4.

GENERAL SIMILARITIES BETWEEN FARM GROUPS

Most similarities between farms investigated could be seen between social aspects and could most likely be attributed to socio-cultural aspects or individual aspects, but not so much related to place within transition pathway. As a rule, most of the farm scored lower in between equity subthemes while scoring higher in Human Safety and Health and Labour rights. Also it is interesting to note that all farms score below 20% with respect to Mission statement subtheme and quite low on Holistic Audits and Full-Cost Accounting and all scored quite decently within Rule of Law and Participation themes, except for Civic responsibility theme, where some farms scored low due to accidents of animals escaping and causing damage, etc. Although, environmental performance varied between farm groups, all score relatively high (within green colour) in maintaining Animal Welfare. Generally, some similarities of Economic Integrity pattern can also be seen between all farms (with a bit lower score in FG2), where Food quality and Food safety scores were quite consistent from farm to farm as were scores of theme Vulnerability that also aligned well between farms, with just a few exceptions.

10.5. Trade-offs / Synergies Between Focus Topics

To look at the aspect of Soil Quality it can be said that results between farm groups are inversely proportional to farm productivity of arable crops. The mentioned 3 farms in FG3 grow no crops and buy fodder for their cattle, FG4 are organic farmers with relatively lower yields than conventional arable farmers, wheareas farmers engaging in more intensive farming of arable crops had higher yields but lowest score in soil quality. In this study no farms investigated practice no-till farming and none use cover crops, besides growing winter crops, thus it would be interesting to see what would be the reciprocally beneficial relationship between farmer obtaining good yields and maintaining good soil health at the same time.

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Furthermore, it should be noted that even though the social patterns were very similar with largest difference between farms were within Decent livelihood. It should be noted that the farms where two or more family members from different generations engaged in farming practice had the highest score. It cannot be particularly related to farm type but it was the case with FG4 although it could possibly relate to economic situation that makes farming seem attractive for farmers' children. Organic farms (FG4) were relatively supported by government for quite some time now.

10.6. Synthesis of Task 3.2 Results in the Case Study

The pre-defined transition pathway towards agroecology is reflected well by the environmental aspects of farms as investigated with SMART and Cool Farm Tool, with FG3 and FG4 taking a clear lead as compared to FG1 and FG2. At the level of subthemes FG3 scored higher within some and FG4 score higher with other subthemes. Although of course chemical input free farming practice is much more biodiversity-friendly, it should be noted that biodiversity species group results do not entirely reflect farming practice itself but would generally be higher with diversity of farming enterprises.

Furthermore, some aspects of biodiversity are fulfilled by certain landscape elements in the Lithuanian country, which has diversity of landscape elements. In terms of social wellbeing it should be noted that the patterns observed are similar with some variations between individual farms and cannot be attributed to farming practice but rather individual basis and socio-cultural context. With regards to economic integrity FG2 scored the lowest and from a broader SES context it is known that farms representing FG2 are economically most vulnerable, while FG4 are somewhat uncertain about the future due to uncertainty with regard direct payments as is F1, but mainly due to broader economic and political reasons. Whereas FG3 reported they have to increase prices of their produce due to inputs becoming more extensive. Thus, it can be said that economic sustainability does not follow the transition pathway directly.

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12. ROMANIA (TRANSYLVANIA AND MARAMURES REGION – MIXED FARMS)

By Mihaela Frățilă (WWF Romania)

12.1. Case Study Dilemma

The case study dilemma for the Romanian Case Study is to investigate how to increase the economic viability of small-scale farming that is representative of Romania's food production system, while preserving the cultural landscape and biodiversity through agro-ecological principles.

The case study in Romania is focused on Maramures and Transylvanian Highlands, two distinctive geographic regions but located in close proximity and having multiple commonalities in terms of landscape and socio-economic elements (e.g. fragmented agricultural landscape, mosaic patches of semi-natural grasslands created and maintained by traditional livestock grazing systems: cattle and sheep, small plots of cultivated land mixed with forested areas and orchards, under a generally low intensity/extensive management). The case study area is officially defined as, and qualifies for HNVF support for the continuation of low-intensity, and often traditional farming practices. In addition to such practices supporting a diverse mosaic, they also have essential benefits for biodiversity, climate change resilience and opportunities for diversified income and economic development. Firstly, the input of pesticides and fertilisers is relatively low, while the amount of manual labour to work the land is still high. Many farmers still plough their land with the help of horses, weed their crops by hand and through grazing, and manually cut hay for their livestock. While being labour-intensive, these techniques enable plants to spread their seeds and animals to thrive on the managed land, while soil resources get to regenerate and provide good premises food security and quality. Secondly, traditional silvo-pastoral techniques have created wood pastures, which host diverse ecological communities and act as carbon sinks. In wood pastures, both forest species and grassland species thrive because of the combination of woody vegetation and grassland. Thirdly, traditional livestock herding techniques are adapted to mitigate the risk of predation from bears and wolves. The use of specialised guarding dogs, in particular, reduces livestock predation and thus facilitates a relatively peaceful co-existence of humans and carnivores. Additionally, longstanding transhumance traditions, where sheep herds are alternately moved between alpine meadows and lower altitude grasslands have helped in creating or maintaining ecological corridors between different natural areas, while lowering the pressure on single plots of grazing land.

12.2. Investigated farm groups

Production:

- **Specialist Cattle**
- **Mixed crops and livestock**

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The farm selection was conducted as proposed by the UNISECO guidelines in cooperation with our local stakeholder champion. The farm visits were conducted between July and September 2019.

Ten farms are included in the case study, divided between two FADN farming groups, namely:

- **Cattle – dairying (FADN 470)**

This group consists of four dairy farms divided into two categories with two farms each: organic and conventional (two farms each) -organic dairy farm 2, Maramures, and farm 9, Transylvanian Highlands, and the conventional farms 3 and 6.
The organic dairy farms derive all revenue from milk and use their crop production to produce feed.
Generally, farms which manage more than one production type usually own a mix of arable land and grassland. Income usually comes from the sale of milk as raw material and from CAP subsidies. Organic farms have less acreage - up to 30 hectares and approximately 30 animals per farm, unlike conventional farms which own large plots of land, exceeding 100 ha and 100 animal heads/farm.

- **Cattle - rearing and fattening (FADN 460)**

This group consists of four farms that primarily focus on cattle rearing and fattening, and also handle crop production to produce feed (lucerne, maize, maize silage, wheat, etc). The farms are divided into two categories: transition (on the transition pathway - no pesticides, and no fertiliser) and conventional (two farms each).
More than half of the managed land is permanent grasslands/meadows used for grazing and feeding the animals. Most of the animals are allowed daily access to pasture.
The farms buy some additional feed, usually protein-based readymade mixes and sell all or most of the beef calves.

- **Permanent crops and grazing livestock combined (FADN 842)**

One farm specialises in breeding and processing of pigs and chickens and in addition has a fruit orchard, and the other is a combination of growing cattle and chickens, haymaking, managing orchards and medicinal plants.
The farms are divided into two categories: transition (on the pathway - no pesticides and no chemicals) and organic.
The grasslands are used for grazing and feeding the animals.

Livestock breeding is specific for Transylvania and Maramures. Sheep farming was replaced by livestock breeding to balance the grazing in areas with a lot of sheep. As milk prices and

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the number of milk collection points have drastically decreased in recent years in Romania, it is estimated that the number of milk cattle and milk volumes will continue to decrease as well, the largest portion of milk produced by the farmers is gathered by the large dairy farms. As an indication of the negative evolution of the Romanian milk production sector, the number of dairy cattle and the volumes of milk have steadily decreased starting 2007, when Romania joined the EU – e.g. from 2934k cattle in 2006 to 2164k cattle in 2012, and from 58307k hl of milk in 2012 to 42036k hl in 2012[14].

In the case study areas local farmers don't have access to collection, storage and processing facilities and are thus forced to sell their raw materials (fruit, milk, vegetables) at very low prices to few industrial processors in Romania or abroad, who then mix them together, wasting all the qualities of produce obtained from environmentally-friendly farming, while the producers remain anonymous and at semi-subsistence level. In terms of types of trade, over 50% of the Romanian market has been penetrated by hypermarkets and supermarkets, leading to Romania being deemed the "friendliest" country in the EU towards these retail chains[15].

All animals roam freely on the low altitude grasslands for most of the time, including winter as they are not very harsh and the temperatures not too low. 80% of the livestock is made up of local breeds.

The data in the UNISECO project was collected from the 10 farms mentioned above, but their interpretation in Compass is missing for the farm 2, and we encountered issues with the farm 5 in CFT.

[14] Ministry of Agriculture and Rural Development statistics regarding the bovine sector - HTTPS://WWW.MADR.RO/CRESTEREA-ANIMALELOR/BOVINE.HTML

[15] *The hypermarket country: one third of Romanian consumers' money for day-to-day shopping go towards big shops*, Ziarul Financiar, 22 July 2015

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	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6	Farm 7	Farm 8	Farm 9	Farm 10
Farming System	Specialist Beef cattle	Specialist Dairy	Specialist Dairy	Specialist Beef Cattle	Specialist Beef Cattle	Specialist Dairy	Mixed crops and livestock	Specialist beef cattle	Specialis t dairy	Mixed crops and livestock
Farming Practices	Transition	Organic	Conventiona l	Conventiona l	Transition	Convention al	Transitio n	Convention al	Organic	Organic
Arable (ha)	0	0.87	260	98,66	23.17	62	0	12	0	15
Grassland (ha)	179	7.13	0	98	148.97	15	2	109,72	35	20
Forest (ha)	0	1	0	0	0	0	0	0	0	
Number of livestock types	1	1	1	1	1	1	2	2	1	2
Number of crop types	2	3	6	4	4	3	4	4	2	6
Labour working units	3	0	3	1	3	5	18	4	3	3

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12.3. In-depth topic analysis

DIRECT AND INDIRECT GREENHOUSE GAS EMISSIONS

Results for *Greenhouse gases* from SMART vary for the Romanian case study. For the first-mentioned, the subtheme score varies from 56 to 73 with an average of 64,5. There is a slight tendency that the more extensive (organic) farms receive higher scores (corresponding to lower emissions). Conventional farms moreover have slightly lower scores, however with very little variation from the average and the dairy farms.

For *Air quality* the scores vary from 49 to 75 with the lower range of the spectrum primarily explained by lower scores among the conventional farms. The average score for the case study overall is 62. For this subtheme there is no discernible pattern of the results mirroring the pre-defined transition pathway.

Small-scale farms with a small number of animals, or with no animals release the least amount of CO2. Emissions increase considerably and proportionally with the size of the farm. The farm 2 has an acreage of 7 ha and 9 milk cows, as compared with farm 8 with an acreage of 172.6 ha and 285 milk cows. The latter is 24 times bigger than the other, but still can't consume the total of 2273.24 tons as they don't use such a large amount.

BIODIVERSITY

Biodiversity on CFT:

1) Farmed products: 35% 35% 35% 47% 29% 29% 25% 50% 29% 15%
2) Small habitats 6% 22% 18% 17% 2% 10% 22% 22% 10% 2%
3) Farming practices 25% 43% 17% 49% 49% 36% 50% 25% 35% 17%
4) Large habitats 43% 14% 71% 14% 14% 14% 25% 40% 25% 65%

Even if the score it's quite medium in percentages, most of the grasslands benefit from the presence of trees on the pasture and flowering plant habitats are a characteristic of the area (Natura 2000 and HNVF), thus sustaining a diversity of insects including pollinators, and birds. The area is characterised by the presence of natural and semi-natural vegetation (grasslands), generally very species-rich, and in some cases they are integrated into a large scale continuous mosaic landscape which includes natural structural elements (such as field margins, hedgerows, stone walls, patches of woodland or scrub, small rivers) and patches of arable land and orchards.

One of our conclusions regarding the CFT is that the instrument is not adapted to the local specificity and some of the proposed solutions from which we had to choose do not apply in Romania. Many of the solutions are old traditional practices that has been preserved over time and are based of the farmer knowledge.

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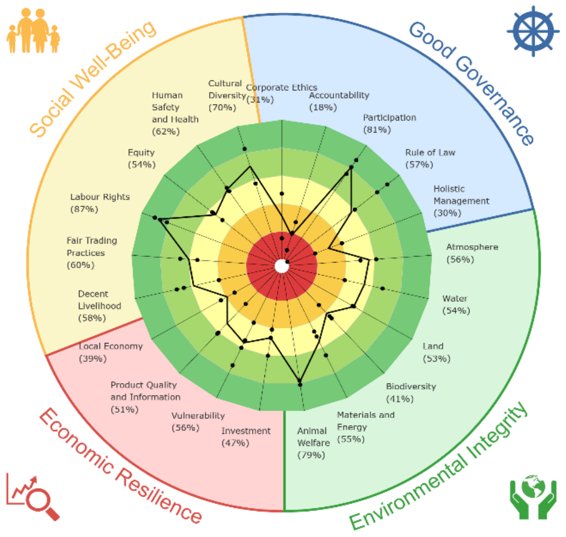
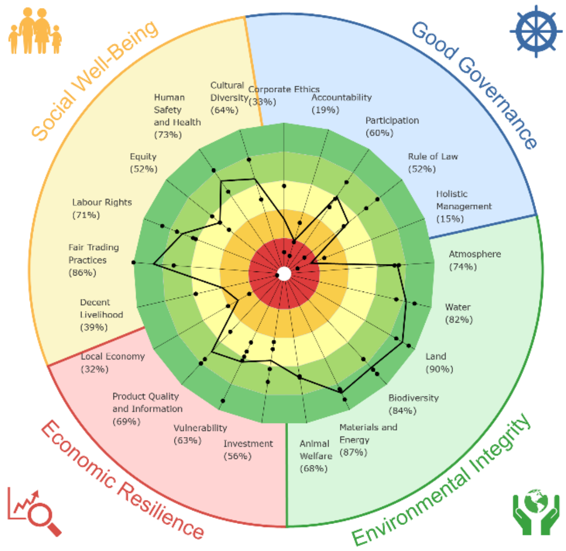
As for the results for *Biodiversity* from SMART, the average scores for the three key indicators are around 63.56, with *Ecosystem diversity* at 61.2, *Species diversity* at 66.5, and *Genetic diversity* at 63.



Farm 6- Lower score on biodiversity



Farm 2 – Higher score on biodiversity

All the results from "Environmental integrity" are on the green lights and are having the biggest score in the Sustainability Poligon, except 2 farms: farm 2 and farm 6, conventional farms. The reason is the same as above and means that apart from 4 conventional farms (2, 4, 6 and 8) the rest of the farms do not use any fertilisers for soil or plant protection. The results are evidenced by the SMART data where the lowest biodiversity is found at the farms 2 and 6 that are using fertilisers and plant protection. However, even if conventional farms are using chemicals and fertilisers **the results are situated in the yellow lights** which means there is nothing critical in terms of biodiversity at the moment. While most villages are situated in valleys, the hilltops are covered by forest that is home to wildlife such as deer, wildcats, bears and wolves. Specific risks for biodiversity lie in both the intensification and the abandonment of traditional land uses, as well as in the erosion of the social structures that have upheld diverse ecosystems to date.

Agricultural intensification often entails the increased use of agrochemicals, including artificial fertilisers and pesticides. Artificial fertilisers alter soil conditions, favour faster growing plant species, which as a consequence outcompete plants that are adapted to less fertile conditions. Thus, the resulting nutrient-rich locations ultimately become dominated by very few species. Importantly, fertilisation may also cause eutrophication of non-target areas surrounding arable land, for example through run-off by rainwater, thereby affecting the species pool across the entire landscape. Similarly, pesticides are used to control undesired species, such as arable weeds, pest insects and fungi that may damage crops. However, pesticides may also non-selectively kill species that have no negative effects on crop production, again, with negative flow-on effects on the entire ecosystem

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For *Ecosystem diversity,* the lowest score is 27 and the highest score is 95. Again, the trend seems to be that the conventional farms (dairy farm 2) score at the lower end of the spectrum and the main explanatory factors for the lower scores seem to be the use of pesticides and small shares of land under woodland and the focus mainly on productivity without taking into account any environmental perspective. The organic farms score at the higher end of the range of percentages for this subtheme (farm 1 with 95%, farm 2 with 85%, farm 9 with 78%, and farm 10 with 73%). The result is primarily explained by the same factors as listed above; apart from the use of pesticides, surface area characteristics are as follows: small plots and more diversified in crops in organic farming, and large areas and poor diversification in the conventional ones. The results show two different directions: one, focus on productivity and the other - more diversified, high biodiversity but less economically viable.

For *Species diversity* the lowest score is 44 (farms 3 and 6) and the highest score is 86 (farms 1 and 2), with the same farms achieving these results as for *Ecosystem diversity*. One clear pattern is that all organic farms receive scores labelled as green by SMART while all conventional or transition farms receive scores labelled as yellow by SMART. The explanation for the lowest score would be the same as in *Ecosystem diversity,* including the use of pesticides, no shares of land as permanent grassland and no riparian strips. The farms in between the lower and highest score – "the transition farms + conventional" are following the same pattern (not many diverse crops but still having permanent grasslands and old varieties of fruit trees/oak/wicker/beech, etc). One important aspect contributing to a higher score for this subtheme which is common for all farms is the extensive management of grassland.

Genetic diversity shows a larger spread, with the lowest score at 46 and the highest score at 79. Again, all conventional farms score in the yellow category as determined by SMART while organic farms and "transition farms" fall within the green span of results. Overall the scores (61, 50, 59, 46, 63, 56, 75, 65, 76) show us that the biodiversity and sustainable use of genetic resources is somewhere in the middle, in a kind of equilibrium. It is essential to maintain and enhance the efficiency and the resilience of production systems through even more genetic diversity (crops, plant, forests, animals). The high scores are partially explained by the diversification level in two farms (permanent grasslands, the farm keeps a number of different livestock types, orchards on the pasture, etc).

SOIL QUALITY

For *Soil quality* the outcome is generally quite good for the Romanian case study area. All farms except one fall within the score range labelled as green by SMART. The scores range from 49 to 85 with the average score at 64.2 (all but one score above 60).

The predominant soils within the studied area are part of the luvisols class: preluvosols 21%, luvosols 68%, alluvisols 11%. These soils are specific to the areas of hills and plateaus, in which the forest vegetation is dominated by oak, especially gorse and oak. In the northern area of the studied region one can find the following soil types: forest brown, podzolic and clay, podzolic clay-iluvial, poorly developed soils - regosols and alluvion. One farm – Farm 1 "conversion farm type" carried out a pedologic study last year and the following information came out on the soil composition: PH 6,98, P=6, K=102, humus=1.79, N=0,070. The

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dominant character of the slopes of the terrain varies between 6º and 12º. The farm also conducted a study on integrated management recommendations on agro-biodiversity within the Agro-ecosystem in the area.
Our farmers didn't carried out any soil analysis and they don't know the exact soil composition.

One aspect which revealed itself as a beneficial factor for all farms is the absence of degraded lands on the farms. During the interviews, no farmers stated to have any real difficulties with soil degradation, maybe this is why some of them, especially conventional ones, don't even realise what unproductive and damaged soil really is. Since Romania is part of the EU, there are no longer abandoned plots of land and in the area the competition on the landmarked is extremely high due to subsidies for EU and national level.

WATER QUALITY

All farms score high for the sub-domain *Water quality,* ranging from 67 to 88 and averaging at 77.5 in SMART score. The water levels and quality are generally high and problems with water amounts or contamination only occur locally but still we don't have any recent results.
Many farms are supplied with groundwater, some of the localities having facilities for water abstraction. There is currently no comprehensive study on water sources and their quality, although it would be important to conduct a study which correlates the abundance and quality of water with the consumption in agriculture areas.
The specialised organic dairy farms (farm 6) score on the lower side of the spectrum and all conventional farms score lower than the worst-performing organic farm. The highest score is achieved at the mixed farm 2, with organic dairy production.
We don't have information about irrigation system in the area.

PRODUCTIVITY

COMPAS data is incomplete for one of the 10 farms and hence it is not included in the analysis.

The *Net value-added* and the *Labour productivity* of all farms are positive. One should however consider that the "true" AWU may differ between farms that have formal employees and those that are run as family farms. Most of the employees on the farms are working 8 hours/day, 48 hours/week, 2920h/year and 52 weeks/year, according to the legal contract, but actually work double the hours during the planting and harvesting periods.

One farmer that declared the real hours worked on the farm without taking into account the actual working hours written in the contract admitted to: 3200 hours/year, 63 hours/week.

Most of the farmers were reluctant to state the exact working hours of their employees as they fear possible fines and unwanted inspections from the labour inspection authorities. In fact, there are several workers (day workers or seasonal) who do not have employment contracts, just a verbal agreement with the farmer/farm manager. Also, the farm manager together with the family works on the farm more than 8 hours/day.

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Most farms have approximately 4 AWU, only two farms have 18 and 10 AWU respectively (farm 7 - mixed farm with conventional livestock) and farm 6 - conventional specialised in cattle beef.

In terms of *Net value-added* there are big differences between the conventional, transition and organic farms: with a net value-added of 213,703 Eur, 191,266 Eur, 172,417 Eur, and one "transition farm" with a net value-added of 27,983 Eur, even smaller than the organic ones which actually are smaller-scale farms - 97,715 Eur, 64,648 Eur.

A large part of the *Net Value Added* for both farm groups is from CAP subsidies – contributing up to around 80% to the Gross Farm Income for organic farms and 50% Gross Farm Income for conventional farms.

FARM INCOME

COMPAS data is incomplete for one of the 10 farms and are hence it is not included in the analysis.

The *Net farm income* varies for the farms included in the Romanian case study. All the farms income is positive, starting with the lowest income: 5,867 Eur/year and ending with the highest income at 119,393 Eur/ year. The explanation for the lowest income could be that the owner of the farm receives the main income for other off-farm activities or the farming in generally is not profitable.

The average income is around 50,500 Eur/year which means a profit of 4,208 month/farm (lefts that should also cover compensation for farm administrators that are not employees on the farm). Actually, the income in this case means a salary/month for the farm administrator, which is far above the average for farmworkers in Romania and one could hence say that the farm is economically sustainable. Moreover, it should be noted that several of the farm managers/owners receive their main income from off-farm activities (farms 1, 4, farm 5 and 8) and to some extent currently or permanent operate their farms without an aim to make a living wage from their enterprises.

However in Romania overall, particularly in the areas used in the study, the farms are not economically viable beyond the information declared by farmers (which should be taken with a pinch of salt). Farmers don't keep any financial records and don't count in their work on the farm and all the information presented to project representatives were mere estimates on the top of their heads. They don't have a "business approach" in terms of farming. All farms, except one (farm 4) still hold the animals because they can receive the payments/subsidies for the animals and plots of land – which constitutes regular and substantial income. If they don't keep animals and don't work the land, they don't qualify as active farmers to apply for subsidies (conditionality requests). Unfortunately, the subsidies don't encourage farm profitability, nor the diversification of the products or the search for better processing solutions. Out of all visited farms, only one processes pork meat, and the others keep livestock only. The livestock is sold and bought to maintain a certain number of livestock animals or even bread to receive more state subsidies. Unfortunately, the subsidies may not encourage farm profitability but keep alive the agriculture in Romania

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(farmers statement). Out of all visited farms, only one processes pork meat, and the others keep livestock only.

The SMART results in terms of profitability show an average of 55.5 for all farms. It is very noteworthy to mention that the results from the accountability section range between 5 to 35, with an average of 20. The results have situated all farms on the red side except for one (farm 1 – transition farm), which suggest that the farmers might have not provided all the correct information.
Overall, farmers don't have access to **storage and processing infrastructure** and are thus forced to sell their raw materials (fruit, milk, vegetables) at very low prices to industrial processors in Romania or abroad, who then mix them together, thus wasting all the qualities of produce obtained from environmentally-friendly farming, while the producers remain anonymous and at semi-subsistence level. In terms of types of trade, over 50% of the Romanian market has been conquered by the distribution through hypermarkets and supermarkets leading to Romania being deemed the "friendliest" country in the EU towards these retail chains. The storage and processing infrastructure and the support to traditional types of trade should be addressed promptly and through an integrated vision, as they may be the key to a revival of local agriculture on traditional and sustainable grounds, to the preservation of the endangered artisanal know-how, and to the creation of a thriving rural economy.

QUALITY OF LIFE

For *Quality of life* the outcome is generally good. All farms receive scores that are within ranges labelled as light green in SMART. The average score is 59.3 from a range from 58 to 72. Workers take regular breaks, have access to toilet facilities and received fresh food and drink. The average score for the Romanian case is also explained by lower workplace standards in terms of safety - there is no safety equipment used when handling hazardous materials, and there is a general lack of awareness of on-farm safety. Even on the farms which received an above-average score, the employees complained and seemed to be under stress and overworked. Agriculture in rural Romania is closer to a way of life, rather than a business. Actually, the quality of life in Romania in a way is not reflected by the score received but rather in farmers' statements.
The quality of life in Romania especially in the countryside should be analyzed by taking into account the existing infrastructure in rural areas and other important aspects that were not found in any instruments (CFT, COMPAS and SMART). From our point of view the scores obtained for the quality of life are not relevant given the poor infrastructure (streets, irrigation systems, collection / processing of raw materials, etc.) because it's not part of a wider context

12.4. Case study specific topics in Romania

Farmer's perspective: Farm 1

1) How to increase the economic viability of the small-scale farming system while preserving the cultural landscape and biodiversity?

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“We need an integrated approach. We need to develop new rural tourism activities, didactical tourism and improving the farming systems, sustainably. We are losing traditional land management because of the pressure of the market. New branding strategies need to be developed for products and services. The social component is also very important because rural areas need to be attractive also for young farmers and their children. Rural communities need to be proud of their region and they need permanent access to local markets or direct marketing.”

“If the agricultural farm activities will be combined with other types of activities (tourism, didactical etc) the cultural landscape will bring not only economical benefits but also social benefits for the farm staff, local farmers and local communities. To maintain the cultural landscape we must maintain the cultural activities that are mostly linked with haymaking and managing the agricultural land in an extensive approach.”

2) How can we create economic benefits and reward smallholders for their contribution to biodiversity?

“With a clear compensation payment system. Farmers needs to be payed according to their biodiversity results. This could be agri-environment payments or N2K payments. Also the payment system for small farmers needs to be much simpler and attractive if they provide good biodiversity results.”

3) How can Transylvania continue to provide its people with quality and healthy food, a cultural identity, as well as harbouring ecological treasures? Are smallholders longing for modernisation, or would they prefer to maintain local customs and traditions?

“The small farmers in Transylvania are interested in a simple life. With less bureaucracy, clear application system (EU funds) and with efficient support from the local authorities. We need small farmers associations that are working together to be able to survive with all changes in policies and strategies. If we have functional small farmers associations, these can process together, sell together and manage land on a landscape level, as neighbours. We need quality schemes for a group of small farmers and not only for individuals.

All farmers like modernisation, but for the small farmers it is difficult because of the small land parcels. Managing small land parcels with big machinery is very difficult in Transylvania. We are mostly a grassland region (hilly region) with small arable parcels, wood pastures and old orchards. The grazing systems are also changing and under threat is the communal grazing.”

4) Does the farmer use one of these traditional practices identified in the case-study areas? If not, what kind of practices are you using?

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"Yes. We are using for grazing an LVU of about 0,3 LVU/ha and we are grazing with beef. We are mowing with small machinery (max weight 350kg) with double-cut blades. We are also mowing after the 15th of June each year and in different periods of the year. Only for balling we are using tractors. On-farm level we have over 400 sp. of flora and 5 Natura 2000 habitats, from which one is priority habitat."

12.5. General differences between farm groups

The organic farms perform better than the conventional in relation to themes of equity, human safety and health, but they seem to be weaker on labour rights and decent livelihoods, as they are small family operations oriented to self-sufficiency.
ll farms, but especially organic and transitions farms, contribute to the overall environmental integrity of the region, due to the enduring extensive farming practices and the presence of large natural habitats and trees that are an integral part of the rural agricultural landscape in Romania. The abundance of (semi)natural habitats contributes to biodiversity, water quality and somewhat to soil quality on agricultural land. Organic farms and transition farms also contribute to genetic and ecosystem diversity. Their stronger environmental performance is also due to the avoidance of mineral fertilizers and chemical plant protection products; on the other hand, they do not perform equally well on animal welfare due to limited investments in animal housing infrastructure and cattle manure storage facilities.

The use of large and diverse amounts of external feed inputs on non-grazing conventional farms results in large greenhouse gas (GHG) emissions compared to the organic and conventional grazing dairy operations. The largest GHG emissions are related to the production of off-farm feed inputs.

Other differences observed were related to the farmer's attitude towards nature. The farmers doing conventional farming don't have any interest in maintaining biodiversity or the landscape.
The organic farmes are more open for discussion about finding solutions for nature conservation and biodiversity than conventional ones. Some of them consider that the subsidies are not the solution to make agriculture in Romania if we want to focus on profitability area. They also believes that we need more activities on raising awareness regarding the benefits of organic products and healthy food. Farming in Romania is not something you should be proud of, so we've got the impression that just 3 farmers are convinced that they do something good and meaningful with their work and being proud of what they are doing. Others actually complained about stress and workload and mentioned that agriculture in Romania is not actually profitable and all the farmers are depending on subsidies
In terms of income, there are differences between small and large farms. The explanation is simple, both rely on subsidies quite heavily and the amount of subsidies increase with the area of land and the number of animals. Subsidies contribute up to around 80% to the gross farm income for organic farms and 50% of the gross farm income for conventional farms.

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12.6. General similarities between farm groups

Overall, all farm groups have higher score on any of the sustainability dimensions. All farm groups score higher on *Environmental Integrity* and *Social Well-being*, but lower on *Good Governance* and *Economic Resilience*.

In the context of *Economic Resilience* both the organic and conventional groups show a low score on the *Stability of Markets* which is related to the unstable milk market (for dairy farms) and a moderate to a good score on *Local Procurement* as most inputs to the farms are sourced locally.

Livestock farms produce the feeding basis and also some concentrates on their own farms; pig farms keep breeding sows and produce piglets for their own pig fattening branch. Extensive grazing is another obvious similarity to all the farms (except for 2 conventional dairy farms) have a permanent grassland and the animals roam freely at least 180 days a year/10n hours a day.

The other aspects relate to the fact that neither keeps any records, thus scoring low, from 5 to 35, on the accountability *Sustainability Management Plan* scale. Another similarity between the farms is related to the fact that there are no investments made on the farm, even if the farmers receive subsidies.

Overall in Romania and particularly in the project area of Transylvania, small and medium-scale farms are struggling to be economically viable (dilemma of the UNISECO project). The economic resilience of farms is affected by the instability of markets and the poor access to these markets and this is especially true for dairy farms and the milk market in Romania. In general farms do not show a business approach to their activity and a symptom of this fact is that they rarely keep financial records; they also complain about the lack of workforce and about the fact that agriculture in Romania is not actually profitable. Actually "Accountability" received the lowest score in the whole Sustainability dimension. Overall, there is no difference between farms "in transition" and organic farms, except for the organic label. Both categories have a genuine interest in maintaining the balance between productivity and a healthy eco-system.These "transition farms" don't seem to specifically want an organic or ecological certification but they are genuinely interested in the diversification of their farming activity, in gaining additional income, while also ensuring ecosystem resilience.

12.7. Trade-offs / synergies between above topics

The farming system in Romania is still dual, with small-scale, family farming amounting to a rough 90% of the total number of farms, but occupying approximately half of the total agricultural area, and large, industrial farms occupying the other half of the productive land. The first class of farms delivers wider societal goods apart from food, but it has been strongly eroded and it is now endangered by market dynamics, the lack of rural infrastructures and resources (including through agricultural subsidies), and the lack of

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willingness to work together to instill economic competitiveness into their operations, and so to ensure a future for their farms. The second class of farms is overall not ready to make the change due to the availability of area-based subsidies with weak environmental conditions and which don't encourage the diversification of the products or the search for processing solutions. Change is also hindered by an adamant mindset rooted in outdated education programmes that places the responsibility towards the environment, but also towards the quality of food produced on the last level of concern.

Small and medium-scale farms are struggling to be economically viable and maintaining in the same time biodiversity high (dilemma of the UNISECO project). Applying a more environmentally-friendly management method usually means a decrease in revenues or increase the costs. At least it always requires a change from established practices - that means more energy and capacity from the farm management.

SMART and COMPAS models have confirmed that higher farming efficiency affects economic performance (profitability). Similarly, increasing mechanization at farm level improve farm competitiveness, reduce labour demand and labour costs, but negatively affect Ecosystem and Species Diversity.

12.8. Synthesis of Task 3.2 results in the case study

This project looked at 10 farms belonging to three major groups - cattle for dairy (four farms), cattle for meat (four farms), and mixed farms with livestock and permanent crops (two farms)

The farms represent different management approaches, from conventional systems to farms in transition to sustainable practices (in general substitution of chemical substances), and organic.

The economic resilience of farms is affected by the instability of markets and the poor access to these markets and this is especially true for dairy farms and the milk market in Romania. In general farms do not show a business approach to their activity and a symptom of this fact is that they rarely keep financial records; they also complain about the lack of workforce and about the fact that agriculture in Romania is not actually profitable.

The farm assessment results reveal substantial similarities between the farm groups across all sustainability dimensions. Many *Good Governance* dimension themes and subthemes are weak for all farm groups particularly with respect to *Corporate Ethics*, *Accountability* and *Holistic Management* themes. Issues addressed by the *Good Governance* dimension are not a priority to the typical family farm in Romania.

The *Environmental Integrity* dimension scores high for all farm groups due to extensive farming practices and the presence of large natural habitats and trees that are an integral part of the rural agricultural landscape in Romania. The abundance of natural habitats contributes to biodiversity, water quality and somewhat to soil quality on agricultural land.

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In particular, *Environmental Integrity* themes score slightly higher for organic farms rather than conventional ones mainly due to the avoidance of mineral fertilizers and plant protection products. However, the *Animal Welfare* theme is slightly weaker for organic farms due to limited investments in animal housing infrastructure and cattle manure storage facilities. Within the conventional farm group the large non-grazing operation ranks lower on *Environmental Integrity* due to more intensive fodder production practices - greater mineral fertilizer and plant protection product inputs. Furthermore, the use of large and diverse amounts of external feed inputs on the non-grazing conventional farm results in large GHG emissions compared to the organic and conventional grazing dairy operations. The largest GHG emissions are related to the production of off-farm produced feed inputs.

The *Social Well-Being* dimension scores moderately and variably within all farm groups. Many assessed social issues do not rank high in priority for the small-scale farms in Romania. The organic farm group scores higher than the conventional farm group in relation to the themes of *Equity* and *Human Safety* and *Health* themes, but lower on *Labour Rights* and *Decent Livelihood* themes as the assessed organic farms are small family operations oriented to self-sufficiency.
One of the problems identified and received a low score on all farms is "Holistic Management". Both results “Holistic Management” and "Accountability" shows that farmers in Romania do not have an integrated approach.

One conclusion from the brief analysis is that: A category interested in approaching the agri-environmental concept is the so-called “transition farms” which don’t want an organic or ecological certification but are genuinely interested in the diversification of their farming activity, in gaining additional income, but also in ensuring the ecosystem resilience. Organic farmers still can’t grasp the concept of agroecology and how this should be implemented, they don’t have any knowledge of that, and the transition period might last for more than 5 years. Conventional dairy farms could be slowly replaced by beef farms, as the latter receive higher subsidies/animal head, and beef is higher in demand. Moreover, the price for the collected milk is low - 1.5-2 lei/litre at most, and the farmers don’t process the milk, they just sell the raw materials.

Our research also revealed that we need more activities on raising awareness regarding the benefits of organic products and healthy food, so that larger swathes of consumers support policy improvements and make purchasing decisions that favour such products.

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13. SPAIN (BASQUE COUNTRY AND NAVARRA – CEREAL FARMS)

By Uxue Iragui Yoldi (GAN), Carlos Astrain Massa (GAN), Jon Bienzobas Adrian (INTIA)

13.1. Description of Case Study Dilemma

"How to reduce the fragility of agro-ecological farms while maintaining the social, economic and environmental sustainability?"

This case study gathers a holistic view of agro-ecological farming systems, and is inspired on the farms that are part of the EHKO association, which is present in the areas of the Basque Country and Navarra. There are about 150 farmers close to the association. These farms include a wide range of production types, but all of them share the objectives of promoting agro-ecology, being organic systems, with diversification of crops and additional environmental practices, commercialization at local level with short marketing channels, principles of solidarity economy, and being locally based and small sized rural farms. The association of EHKO emerged as a need to share experiences in a farmer to farmer approach and to a wider public, and to create a movement around agro-ecology in different administrative regions of the north of Spain and south of France.

This is the dilemma that farmers of the case study wanted to address in UNISECO. In this case farmers are already in a farming system redesign and are already at an agro-ecological stage. However, those farms consider themselves as "fragile". Due to this fragility, the proportion of conventional farmers who consider implementing changes towards agro-ecological transition is rather low. Therefore, reducing the fragility of agro-ecological farmers is crucial to encourage agro-ecological transition.

Among the wide range of production types, the farm survey focused on farms of mixed cropping with mainly field crops, because it was one of the few categories among the list of farm types where at least 3 farms of EHKO could be classified. The rest of the farms of the association belong to different farm types, and it would not have been possible to compares them under the same criteria. Despite the great diversity of the farms belonging to EHKO, they share common problems that will be analysed through the case study dilemma.

13.2. Description of Investigated Farm Groups

In this case study, participating farmers are divided into 3 groups:

-Agro-ecological: organic cereal combined with organic mixed cropping; agro-ecological farmers (members of the afore-mentioned association EHKO).

-Mixed: conventional cereal combined with mixed cropping, some of which are organic; "mixed" farmers with a very small part of their production organic but their main production still conventional.

-Conventional: conventional cereal combined with mixed cropping; conventional farmers without organic production.

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13.3. Focus Topics

DIRECT AND INDIRECT GREENHOUSE GAS EMISSION

In this section, there are notable differences between the agro-ecological group and the other two, but no relevant differences between the mixed and conventional groups.

Greenhouse gas emission per hectare is 56% bigger in the group formed by mixed and conventional farms comparing with the agro-ecological group. This is due to the lower use of fertilisers and plant protection products. The use of diesel (the biggest conditioner, along with fertilization) does not show significant differences between groups (individually yes).

Individually, there is a big variability between farms in all groups, caused by fertilization amount and diesel consumption; here, farms that subcontract harvesting or some works have less consumption than farms that do everything on their own.

BIODIVERSITY

The agro-ecological group gets much higher scores than the other groups in biodiversity. Specifically, the conventional group gets 31% of score, mixed group 36% and agro-ecological group 69%.

Multiple factors determine this score; principally, the use of chemical fertilisers and plant protection products, since they go against diversity, specially provoking a reduction in the number of species.

More variety of crops, crop rotation, biodiversity promotion areas and several factors of the same nature explain also the higher score of agro-ecological farms.

SOIL QUALITY

All the farms studied get a positive score here, but there are differences between groups. As expected, the agro-ecological group gets a better mark, 71%. Mixed and conventional groups get 56% and 53% respectively.

It is necessary to point that agro-ecological farms base their system on an appropriate soil management, with good levels of SOM, promoting biodiversity in the soil…

Soil management is highly important for all the groups, but this special attention given by the agro-ecological group results in a better score, united again to the use of fertilisers and plant protection products.

About residues management, almost all farms in all the groups handle with this correctly.

WATER QUALITY

To begin with, it should be noted that in 2 of the 10 farms participating in the project there is no irrigation. There are different reasons for the absence of irrigation in these farms, one because of its location in a region with no need of irrigation (further north than the others) and the other one for refusing it, despite its availability.

In the farms with irrigation, only part of the surface is irrigated (in different proportions), there are no farms with all the area under irrigation.

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In terms of quality, most of the farmers are not very concerned about this issue due to the fact that the water is supposed to be of good quality in the most part of the region. There have been no problems with the quality of water in any of the farms.

Some of them are irrigated by the “Canal de Navarra“. The “Canal de Navarra” is a hydraulic infrastructure located in Navarra. It is an irrigation canal to drive the waters of the Irati River (high quality water from the north of Navarra) to the central and southern areas of Navarra (more arid regions). In its full development it is estimated to cover the irrigation of 59,000 hectares.

PRODUCTIVITY

Several factors affect the productivity of the farms analyzed, but some of them are more remarkable. In this case study. Among the farms investigated, cereal production is the basis of the farmers, combined with other type of crops (especially in the agro-ecological group, the most diversified one).

Location and irrigation of the farms appear as the most important factors. Farms located in more arid zones are less productive in their rain-fed crops, and farms located in more humid zones have less differences in productivity between irrigated and rain-fed crops (annual rainfall is crucial in both cases). The more arid is the area, the more important it is to have more proportion of irrigated land, in terms of productivity.

No relevant differences are noted between groups, due to the fact that farms are divided into groups for their production system. The most differentiated group is the agro-ecological one (between the conventional and mixed one there are not many differences because farms of the mixed group are starting the agro-ecological transition by implementing organic production with a little proportion of their area), their crop diversification is much higher than in the other groups, and their productivity is not comparable. Nevertheless, in the common crops (cereals principally) the productivity of the organic farms it is usually a little bit lower. In this last group the objective is not so much to maximize productivity as to give added value to their products.

In conclusion, all the farms of this case study have a productivity level in line with the regional average, being irrigation and geographical location the most conditioning factors.

FARM INCOME

A farm cannot be sustainable without sufficient benefits to have an adequate quality of life, so this is an issue of vital relevance.

The positive profit of all the farms analysed should be stressed here, despite the big differences between farms.

Nothing can be concluded about the differences between groups, the limited sample size and the incomparability due to the variety of crops in the agro-ecological farms. There are farms with high farm income in all groups, so it cannot be expected that other farms within the same farm group will perform similar.

All farms show a high dependence on public subsidies, in the line of the agricultural sector. There are no remarkable differences between groups.

One aspect that should be emphasized here is the difference in the model of business of the agro-ecological group with the other groups. Conventional and mixed farms base their

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activity on increasing productivity and hectares to subsist. By contrast, in the agro-ecological farms analysed, dimension and productivity are not so important; in this business model providing added value to their products is the key factor. Agro-ecological farms of this case study are usually smaller, but their products are commonly better paid.

QUALITY OF LIFE

Overall, all of the participants of this case study have a great quality of life. SMART bases this score, to a large extend, on employees work conditions. In this case study, there are some farms without external workers and the farms with employees do not have more than one employee, excepting seasonal ones.

There are no relevant differences between groups; in this theme the whole group is quite homogenous. All coincide in the difficulties of finding temporal or seasonal workers (minimally qualified) and this worsens the quality of job.

There have not been severe accidents in the farms that have provoked large periods of time off work, beyond the usual extent.

Almost all the farms have an advanced degree of mechanisation that reduces to a large extent physical workload and all the employees have the basic rights.

About the quality of life of the family workers/owners, the majority has a high workload but they also have considerable free days in average. Maybe in this point agro-ecological farmers have less days in average, due to their greater diversification of crops.

In terms of the feeling of the interviews, most of the farmers seem to be happy with their quality of life, for the reason that they work in the activity they want.

It must therefore be concluded that the farms taking part in this project have an adequate quality of life, not without difficulties to move forward.

OTHER ASPECTS

With regard to commercialization, this seems to be the biggest trouble of the agro-ecological group, resulting in a huge time investment and effort of the farmers to market their products. Most of the conventional and mixed farmers are members of cooperatives of producers (almost in every village there is one), to commercialize the production together. This is associated with less risk and less workload (they do not have to search buyers by themselves). On the other hand, agro-ecological farmers have to face the challenge of the lack of structuring of the organic products market. For this group, is not possible to bring their products to the cooperative, they have to search for buyers, try direct sales, and process products.

Essentially, agro-ecological farms are more fragile in the commercialization of their products, but the increasing demand of organic products provides an opportunity to improve this issue to ensure their sales.

13.4. Farm Comparison

GENERAL DIFFERENCES BETWEEN GROUPS

The biggest difference in the general performance of the farmers is between the agro-ecological group and the others. In this group, farmers transfer their philosophy and personal beliefs to their business model, putting emphasis especially in environmental

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sustainability. Differences between the mixed and conventional groups are not notable, beyond the efforts they have made to start to produce organic crops, due to the small proportion of organic production in these farms. Farmers belonging to the mixed group showed differences in their sensitivity and environmental awareness, but this has little reflection on the indicators. The changes they have made in their farm model is rather recent, and it is likely to increase in the coming years.

As mentioned above, commercialization is one of the biggest differences between groups (agro-ecological vs. the other two groups), together with biodiversity and GHG emissions. However, it is important to note that this case study is based in a highly small sample, so conclusions about the performance of similar farms couldn´t be drawn, with the exception of the fragility of agro-ecological producers in marketing their products since the organic market is not as organized as the conventional one.

GENERAL SIMILARITIES BETWEEN GROUPS

The analysed farm groups have relevant similarities among them. Most of them are family farms, without or with few employees.

All of them present, as is written before, a high dependence on public subsidies in order to be profitable. There are differences on the degree of dependence between farms, but nothing can be concluded between groups.

Concerning social wellbeing, the quality of life is quite good in the farms studied, without significant differences between groups. No discrimination, forced labour or children labour related problems have occurred in any of the farms.

Regarding to economic resilience, in all the farms surveyed, farm income resulted positive, there have been no serious liquidity problems and benefits have been stable or increasing.

Some indicators, especially relating to good governance, have the same result for all the farms due to the fact that they are family farms, and they do not usually have written commitments about transparency, sustainability management or conflict resolution. This is something common to all groups.

Finally, it is necessary to point that all the producers agree to criticize the high bureaucracy for any procedure they need to do.

13.5. Trade-Offs/Synergies Between Focus Topics

In this case study, and taking into account the small sample size analysed, not a lot of remarkable synergies have been noted.

Biodiversity and GHG emission are, in any case, two of the issues that seem to be related. Farms with marks over the average in biodiversity have resulted in less GHG emissions than the average.

13.6. Synthesis of Task 3.2 Results in the Case Study

Recalling again the limitations of this case study due to the small sample size, several conclusions emerged.

With regard to environmental integrity, agro-ecological farms practice a better performance resumed in less GHG emissions, more biodiversity at farm level and better soil quality.

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In terms of good governance, no big differences have been observed. As it is said before, these farms are usually familiar farms without written commitments or future management plans.

In economic resilience, the variability between farms is elevated, but there is not an evident trend between the groups. It is noteworthy that all the farms have positive income, and the importance of the subsidies for their profitability, as in the whole sector.

With respect to social welfare, all the farms studied have a good quality of life, no relevant accidents happened during them labour and the farms with employees respect their rights.

To end, the principal difference in the performance of the 3 groups analysed could be highlighted. Organic producers traditionally assume a multifunctional profile. In addition to agronomic work, marketing and commercialization labours are carried out with the objective of introducing their products in the market. This lack of specialization is one of the causes that reduces their competitiveness, united to the low stability they can provide individually as producers to a prospective client. This would be the principal reason for the fragility of the agro-ecological farms of this case study.

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14. SWEDEN (COUNTRYWIDE – RUMINANT FARMS)

By Kajsa Resare Sahlin and Elin Röös (SLU)

14.1. Description of Case Study Dilemma

The case study dilemma for the Swedish case is to investigate the challenges and possibilities to diversify 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.

14.2. Description of Investigated Farm Groups

The Swedish case study investigates farms producing primarily dairy and/or ruminant meat from beef or lamb. Farmers were recruited in cooperation with Oatly (key actor in local MAP) who launched a nationwide campaign together with the stakeholder champion in order to find farmers interested in what sustainable agriculture (in Sweden) means. Over 100 farmers reported interest in participating in the project and phone interviews were held with 40 farmers on why they are interested, what plans they have for their farm, if they are interested in sustainability and what challenges the farm is currently facing. The farm selection was then conducted as proposed by the UNISECO guidelines in cooperation with Oatly and the stakeholder champion and 11 farms are invited to participating in a first workshop (13-14th of May) to discuss participation further. Farmers were then asked to send background information beforehand (see Appendix 1) which was used to prepare the assessments using the three DSTs. The farm visits were conducted between May 2nd and July 16th.

Eleven farms are included in the case study, divided between four FADN farming groups, namely:

- **FG2: Organic and/or more diversified dairy farms (FADN 832)**

This group consists of two organic dairy farms that are specialised, derive all revenue from milk and use their crop production to produce feed. Half their cropland or more is perennial (usually 3 year) grass-clover mixes used to produce silage. Other commonly grown crops are barley, wheat, oats and rape seed. The farms buy some additional feed, usually protein based readymade mixes and sell all or most of the beef calves.

- **FG3: Conventional, specialised beef (FADN 460)**

This group consists of two farms that primarily produce beef but that also grow grass-clover silage (for on-farm feed) and some crops, normally wheat, barley or oats that are sometimes kept for feed and sometimes sold, most commonly as feed to other farms. The farms rely on input goods such as chemical fertilisers, pesticides and sometimes concentrate feed mixes. Some animals are allowed access to pasture, but not all and stables usually have slatted floors.

- **FG4: Organic and/or more diversified beef or lamb (FADN 834)**

This group consists of four farms that all produce meat from beef and/or lamb. Two of the farms are organic, one is conventional and one is partially organic and partially

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conventional. All farms use a considerable share of their arable land for grass-clover mixes for silage which is the main or only feed source, and all farms also produce crops – some which are sold as feed and some which are sold for direct human consumption. The level of specialisation varies, as does the dependence on input goods such as fertilisers (organic and chemical) and pesticides. Feed is only very rarely purchased.

- **FG5: Organic diversified production of beef or lamb and crops (FADN 844)**

This group consists of three organic diversified farms – one that produces milk, beef and crops, one that produces beef and crops and one that produces beef, lamb, wool, hides and crops. Revenues are spread across a range of products and the farms primarily use resources produced on-farm and are only dependent on input goods to a limited extent. Roughage is the main or only feed source for ruminants and crops are sold both as feed to other farms and for direct human consumption.

Originally, also conventional dairy farms were selected for participation (FG1) but during the recruitment of farms we were only able to enrol one such farm in the project which later had to withdraw due to circumstances beyond our control.

In the initial farm selection survey, we had placed each of the eleven farms into the farming group we thought most appropriate based on brief descriptions provided by the farmers during the recruitment process and through the phone interviews we conducted with the farmers. After the farm visits and data collection for the DSTs, for some of the farms it has however become clear that another farming group is more appropriate, e.g. for farm 1 which we initially placed in FG5 but which is in reality better suited to be in FG4. In the results overview (Excel file), the farms have been placed in the farming group found most suitable after the farm visits and as a result of this, the number of farms in each farming group differ from the number originally stated in the farm selection survey.

14.3. Focus Topics

DIRECT AND INDIRECT GREENHOUSE GAS EMISSIONS

Results from CFT for the climate impact at farm and product level show that emission intensities for beef per kg live weight vary from 11.3 kg CO_2e/kg live weight to 40.2 kg CO_2e/kg live weight (Table 1). The Swedish average per kg slaughter weight has previously been measured to be around 20 kg CO_2e/kg (SW) (Moberg et al. 2019). For milk, the three farms included in the Swedish case have emission intensities that match average values for Swedish production, around 1.2 kg CO_2e/kg FPCM (Moberg et al. 2019). The numbers can however not be directly compared as the methods of calculation differ but rather give an idea of the correctness of the order of magnitude of results.

Table 1: Emission intensities calculated by CFT for beef and milk for the 10 farms included in the Swedish case study. Grey shaded areas indicate that the farm does not deliver this product.

	SE001[x]	SE002	SE003	SE004	SE006	SE007	SE008	SE009[X]	SE010	SE011[X]
BEEF kg CO2e/kg live weight	20.5		13.4	22.5	18.5	17.4[a] 12.6[b]	11.3	40.2		23.3
kg CO2e/kg slaughter weight*	41		27	45	37	35[a] 25[b]	23	80		47

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MILK kg CO2e/kg FPCM		1.02					1.11		1.28	

X: Farms increasing their herd size. No adjustments to match a stable herd. See further explanation below.
*: Conversion factor, live weight -> slaughter weight = 0,5
a: Beef, finishing, b: Beef, suckler

In terms of sources of emissions, methane emission from enteric fermentation and emissions associated with feed production are the two main contributors of greenhouse gas emissions for beef and milk (see CFT aggregation sheets and Appendix 2). This is expected and in line with previous scientific reports (e.g. (Gerber et al. 2013)). For the third largest source of emissions, results vary slightly more. On all dairy farms and one of the more intensive beef farms, manure management is the third most important source. For the remaining farms, except one, soil emissions of nitrous oxide associated with grazing is the third largest emission source. This is explained by longer grazing periods on the more extensive farms. For one farm however, transport is the third largest emission source which was expected for this farm because it had a very large animal number but a production system that relied on rotating animals between several stables at different farms located quite far apart. For this farm, transport contributed 20% of total emission from livestock production, which is far above the global average for beef where less than 1,5% of emissions can be attributed to post-farm transport and processing (Gerber et al. 2013).

Results for emission intensities for crops produced at the ten farms participating in the Swedish case study show some variation but average around 200 – 300 kg CO_2e/ton product (Figure 1); results which are in line with Swedish averages (Moberg et al. 2019). In terms of emission sources, energy use, crop residue management, soil fertilisation and fertiliser production are the three most important contributors for all farms, the order of sources however vary some between farms. Emissions per hectare are 260 kg CO_2e/ha on average. It should be noted that we have not used the function in CFT Online to estimate carbon sequestration from reduced tillage and/or cover-cropping because of the large uncertainty of actual sequestration taking place (Meurer et al. 2018); the impact of this function in CFT Online on emissions from crops and in extension emissions from livestock, was judged to be too drastic in relation to probable real outcomes on local level.

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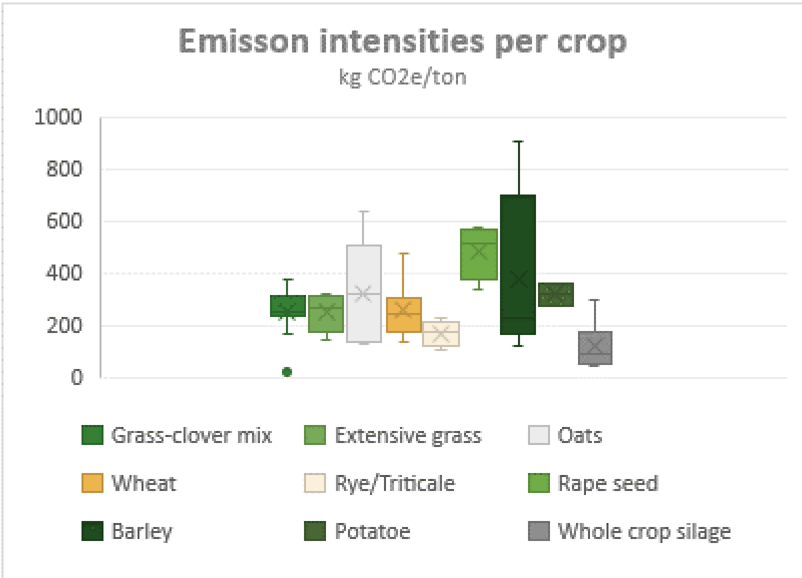

Figure 1: Emission intensities for different crops in kg CO_2e/ton product. Bars show the variation between results with the average noted.

Total emissions from the entire farm of course vary greatly depending on the size of the farm – the largest farm emit nearly 6000 tonnes in total while the smallest farms emit below 100 tonnes. Comparison without reference to emissions per hectare or ton of product is not relevant for assessing the sustainability of farming practices. In terms of relative contribution of different sources of emissions, methane from enteric fermentation is the main source for all farms. Other key sources of emissions on farm level are soil and crop fertilisation, production of feed for livestock, soil emissions from grazing and manure management. The vast majority of total emissions can be attributed to the rearing of ruminant livestock; roughly 90 % on average (range between 68 % and 100 %).

Some methodological aspects of Cool Farm Tool necessitate caution when interpreting results.

- Farmers were asked to provide information about the total fuel and electricity consumption of the whole farm and were also asked to specify the share of bio-diesel in fuel and the share of renewables in the electricity mix. The farmer was additionally asked to allocate the use between farm enterprises using the logic applied in COMPAS. The total use of fuel and electricity was thus allocated to arable and livestock enterprises on the farm, e.g. 90 % of diesel use to arable farming and 10 % to livestock. The farmer was also asked to specify the name of the diesel

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product and the electricity package they buy. When entered into CFT Online, the sources of energy were further specified, e.g. if the diesel used on farm contained 5 % biodiesel and the share of renewable electricity[16]. To further divide emissions between different crops produced on the farm, all amounts of different energy types were divided per hectare, e.g. kwh solar energy/ha, litres of diesel/ha, litres of biodiesel/ha etc. In CFT Online, emissions from the different energy sources were then calculated based on the area of each crop, thus omitting to account for that some crop could require more diesel than another.

- Generally, the farmers participating in the Swedish case study do not feed their animals (except for dairy cows) according to strict feeding rations and they therefore don't have information regarding daily intakes per animal. Several of them moreover do not monitor the exact amounts of silage they harvest but rather have a notion of how much feed they need to get them through the winter season. This has affected calculations of feed intake for all animal categories - except for dairy cows where daily intake is more strictly monitored. Based on the reality that most of the farmers in the case give their livestock free access to silage during the winter season we have estimated daily feed intake for CFT Online in three steps; 1) farmers were asked to state or estimate the total use of silage and other feed sources for a whole year. For those who just had a number for the total cost of a feed type, we calculated the total amount using the price per kg stated either by the farmer or found online. 2) Daily intake was calculated by dividing the total amounts by number of animals in each age category, roughly accounting for probable intake differences depending on size. Full grown suckler cows were e.g. assumed to have a higher intake than calves below one year. If the total amounts stated by the farmer did not result in plausible daily intakes for different age categories, we have double-checked the information and in some cases made adjustments, e.g. in one case the total amounts of silage allocated to beef and lamb were adjusted to make better sense and in another, the total amounts allocated to two different beef herd were adjusted. 3) Lastly, the daily intake from grazing had to be assumed because of a malfunctioning of the CFT Online grazing module. Using the daily feed intake for the winter season estimated in

[16] If a farmer didn't know the exact sources in their electricity mix, the option 'Electricity (grid)' was used. All organic farmers in Sweden are required to use 100 % renewable energy, if they didn't know the exact sources, a 50/50 mix of hydropower and wind power was assumed. For those who produced their own solar power, this was calculated as a share of their total use.

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the previous step, we added daily intake[17] from grazing up to plausible total feed intake per animal per year based on literature (Röös et al. 2017). Full-grown cattle (suckler cows and bulls) were e.g. estimated to eat around 5 tonnes of all feed per year, calves below one year around 1-1.5 tonnes and steers and heifers around 3 tonnes. By doing this, inconsistencies of feed intake following the two previously mentioned steps which could affect the correctness of the calculations of methane from enteric fermentation were partially amended.

- One major methodological limitation which affect the results presented here is that in order for CFT to provide a result that is representative for the individual farm and its production system, a high degree of stability in production is necessary. In reality however, the production (at least at the Swedish case study farms) differ, often substantially, between years, e.g. in terms of the number of animals purchased and sold. This has very large impact on calculations and the results should therefore only be viewed as snapshots of this particular year, i.e. not of the system characteristics. To account for this and to obtain emission intensities that more generally are accurate for a particular farm, we have made adjustments so that the herd in CFT Online matches a plausible stable herd where this has been possible. For example, farm SE007 had a mixed suckler and heifer herd that in the reference year had nearly twice the number of animals that were sold because they had purchased animals from a neighbour that was forced to close down his farm. The imbalance between purchased and sold animals resulted in an extremely high emission intensity for their beef but not as a reflection of their production system in general but instead a onetime event. To adjust for this, we have calculated the figure in Table 1 based on what a stable suckler herd on their farm would look like, hence obtaining a result that better inform about the production system generally used on this farm. This decision was made based on that the information would not be relevant for on-farm decision-support if it primarily reflects one-time events.

- A second issue of un-representative results due to unstable herds and productions is that for those farms that are currently investing to increase their herd size, emission intensities also come out as higher because of the larger number of animals

[17] Animals are not outdoors all througout the year but to match the input format of CFT Online, intake from garzing was divided equally between 365 days.

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purchased than sold. We have however not made adjustments to herds for these farms because, a) we do not know what a plausible, future stable herd would look like, b) to exemplify the key dilemma addressed in the Swedish case, there is some explanatory power in illustrating the large effects that a bigger herd has on the climate impact of the farm.

All in all, results from CFT should be interpreted carefully and one cannot draw any general conclusions based on them, neither for the individual farms nor for farming groups as the calculations are much too affected by methodological issues, use of estimations and lack of clarity around accurateness of the online tool.

Results for *Greenhouse gases* and *Air quality* from SMART vary for the Swedish case study. For the first-mentioned, the subtheme score varies from 42 to 65 with an average of 56. There is a slight tendency that the more extensive beef farms receive higher scores (corresponding to lower emissions). The conventional farms moreover have slightly lower scores, however with very little variation from the average and the dairy farms.

For *Air quality* the scores vary from 54 to 76, with the lower range of the spectrum primarily explained by lower scores among the conventional farms. The average score for the case study overall is 67. For this subtheme there is no discernible pattern of the results mirroring the pre-defined transition pathway.

BIODIVERSITY

We were unable to collect the data for Cool Farm Tool biodiversity assessment as farm visits were already started when the joint data collection sheet for this part became available and it was not possile to incorporate another part of the data collection procudure agreed with the farmer. We aim to collect the data before the end of the year and then update this section of the results template.

As for the results for *Biodiversity* from SMART, the average scores for the three indicators are around 55; with *Ecosystem diversity* at 54, *Species diversity* at 61 and *Genetic diversity* at 58.

For *Ecosystem diversity* the lowest score is 25 and the highest score is 70. Again, the trend seems to be that the conventional farms (FG3 and FG4) score at the lower end of the spectrum and the main explanatory factors for the lower scores seem to be lack of efforts for interconnection of areas to promote biodiversity, use of pesticides and small shares of land under woodland and/or permanent grassland. One slightly unexpected result is the low score (51) of one of the farms in FG5 as this stands out from the general pattern that the organic farms score at the higher end of the range of percentages for this subtheme. The result is primarily explained by the same factors as were listed above, apart from the use of pesticides. The other two farms in FG5 score above the average, at 70 and 62 while the scores in FG2 is 62 and 63, FG3 is 41 and 55 and quite mixed in FG4: 25, 43 and 70 (data for the last farm in this group is not yet complete). Hence, one cannot say that the results follow the transition pathway.

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For *Species diversity* the lowest score is 34 and the highest score is 77, with the same farms achieving these results as for *Ecosystem diversity*. One clear pattern is that all organic farms receive scores labelled as green by SMART while all conventional or semi-conventional farms receive scores labelled as yellow by SMART. The pattern is not explained by lack of efforts for interconnection of areas to promote biodiversity as this comes out as a negative feedback for all farms. The other factors explaining the lower scores of the conventional farms vary, including use of pesticides, low shares of land as permanent grassland and no riparian strips. FG2 score 69 and 66. FG3 score 42 and 58. FG4 score 77, 55 and 34. FG5 score 68, 68 and 71. There is hence somewhat of a pattern of the meat producing farms scoring in line with the pre-defined transition pattern, apart from the farm scoring at 34. This farm is however placed in FG4 because it is diversified and not because it is organic which may explain the deviation. One somewhat unexpected result for the organic group is that there is little variation depending on intensity of production; a highly intense dairy unit score similarly to very extensive beef producing farms. One aspect contributing to a higher score for this subtheme which is common for all farms is the extensive management of grassland. This is to be expected in Sweden where perennial ley is a corner stone in all ruminant production. Leys make up 40% of all arable land in Sweden (Jordbruksverket 2017) and these lands are seldom treated with pesticides.

Genetic diversity shows an even larger spread, with the lowest score at 31 and the highest score at 81. Again, all conventional farms score in the yellow category as determined by SMART while 5/6 organic farms fall within the green span of results. FG2 score 64 and 59. FG3 score 36 and 57. FG4 score 64, 48 and 31. FG5 score 70, 74 and 81. The high scores for this group are partially explained by the diversification level at two of the three farms in the group where the farm keeps a number of different livestock types of rare or endangered species and grows endangered agricultural crops. The outcome for the group is moreover explained by that they don't grow hybrid crops (this is however generally the case among the 11 farms) and that no pesticides are used.

SOIL QUALITY (SOIL AS A MEANS OF PRODUCTION)

For *Soil quality* the outcome is generally quite good for the Swedish case; all farms except one fall within score ranges labelled as green by SMART. The scores range from 53 to 75, with the average score at 67 (all but one score above 60). It is the same farms receiving that bottom and top score as for *Ecosystem* and *Species diversity*. One aspect that may explain the good outcome is the overall absence of steep slopes in the agricultural landscape in Sweden. Slopes >15% were only identified at some of the farms and then always for a small share of a limited number of fields. One aspect that also comes out as a beneficial factor for all farms is the absence of degraded lands on the farms. During the interviews, no farmers stated to have any real difficulties with soil degradation. If it was the case, it was only for particular parts of fields, e.g. wet corners, strokes of heavy clay or strips that had been problematic "since forever". There are two aspects that might serve as explanations for this. One is, again, the large share of perennial leys on the Swedish arable land which is highly beneficial for soil formation and retention, erosion control, maintaining or increasing humus content and maintenance of soil fertility (Cederberg et al. 2016). Another aspect that may explain the outcome is the fact that competition for arable land is generally low in Sweden – the area of arable land in the country has in fact been reduced by one million hectares since 1950 (SCB 2013). This general "abundance" of land may result in that if a piece of land

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become degraded or less fertile, one would “simply” leave it and move production to another field and hence not experience slow soil quality loss in the same way as one may if there is no other land available. These aspects may in fact be important for explaining why Farm 1 score 53% as it stands out from the rest of the sample with a crop rotation that does not integrate perennial leys and annual crops to the same extent as the other farms and because it is located in an area where the competition for land is extremely high, much more so than for the other ten farms.

WATER QUALITY

All farms score high for the subtheme *Water quality,* ranging from 64 to 86 and averaging at 77 in SMART score. This is to be expected in Sweden where water levels and quality is generally high and problems with amounts or contamination only occur locally.

The specialised organic dairy farms (FG2) score on the lower side of the spectrum and all conventional farms score lower than the worst performing organic farm. The highest score is achieved at farm 9 that belongs to FG5 (system re-design according to the transition pathway), but the second farm in that farming group score lower than two farms in FG4. The lowest score is seen at farm 7 (FG3), but the second farm in that farming group score above the group average. One discernible pattern is that the water quality score seem to increase with how extensive the farm is, but raging across farming groups. It is hence not possible to say that the results mirror the pre-defined transition pathway.

PRODUCTIVITY

COMPAS data is incomplete for one out of the 11 farms and are hence not included in the analysis.

The *Net value added* and the *Labour productivity* of all farms is positive. One should however consider that the “true” AWU may differ between farms that have formal employees and those that are run as family farms. It was not uncommon among the farmers in the case study that they stated that they work 12-14 hours per day, seven days a week, essentially all throughout the year (around 4700 hours/year) which would mean than they work more than twice as much as one employed full-time worker in Sweden (around 2100 hours/year). For farms with several employees, e.g. 1, 7 and 10, having collective agreements, 1 AWU will truly match 1 AWU for a larger share of the people working on the farm and hence, their *Labour productivity* could have larger explanatory power. To some extent, this hypothesis is supported by results for *Quality of life* in SMART where all farms but three got notes of that working hours do not comply with ILO recommendations. For the three farms who proposedly do not work too much it is moreover interesting to note that one is Farm 7 with 15,5 AWU and very formalised employment contracts which goes in line with the hypothesis stated above. The second farm, Farm 11, whose hours are within ILO recommendations in reality work full-time away from the farm, hence much more than 40 hours per week all in all. Lastly, Farm 3 which also works reasonable hours is indeed a full-time farmer and moreover receives among the highest figures for *Labour productivity* and this result could perhaps in truth tell us something about the economic and social sustainability of this farm.

One perhaps interesting pattern is that despite large difference between them, the three dairy farms far out-perform the other farms which in turn receive quite similar figures

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(around 200 000-300 000 SEK). There is however no observable pattern of results mirroring the pre-defined transition pathway, neither for the dairy farms nor the meat producing farms. It should moreover be noted that the results for Farm 6 should be interpreted carefully as he has just started his production and purchased all his animals during the reference year and did not sell any to slaughter and the accurateness of the results for this farm are hence uncertain.

FARM INCOME

COMPAS data is incomplete for one out of the 11 farms and are hence not included in the analysis.

The *Net farm income* vary for the farms included in the Swedish case study. Most are positive, except two farms, 1 and 7. This outcome is unexpected as these are two farms run more as companies/businesses and the results from COMPAS do not reflect the reality described by the farmers during the farm visits. For Farm 7, one possible explanation to the results is how COMPAS handles how value of livestock is transferred from one year to the next. It is possible that because Farm 7 purchased a larger number of animals than slaughtered that year (for slaughter either the year after or even the following year depending on when they arrived on the farm) the *Net farm income* for this particular year is negative.

Why Farm 1 looks like it is turning a considerable loss is less clear but could be explained by that data has only been collected for the farming enterprises on the farm (and making of potato chips) and not for the on-farm shop as this is operated as a separate business. We are digging deeper into these results to investigate if the figures could be an effect of some error in the data collection or registration and/or model functioning.

There are differences between the eleven farms in if and how they take out salary for their work. For some, *Net farm income* therefore show the profit (including changes in the value of livestock) made at the farm while for others, it's the value left that should also cover compensation for their work. For Farm 2, all family workers are paid salaries and the positive *Net farm income* hence has some merit in showing the economic sustainability of the farm. For Farm 3, 4, 6, 7, 9, 10 and 11, family workers are not paid salaries and the *Net farm income* should hence be enough to cover living wage/s in order to tell us something about the economic sustainability of the farm. With the laws and regulation around farming business in Sweden considered, the *Net farm income* for e.g. Farm 3 would be sufficient to give the farmer a salary of around 11 300 SEK/month, which is far below the average for farm workers in Sweden[18] and one could hence say that the farm is economically

[18] HTTPS://WWW.LONESTATISTIK.SE/LONER.ASP/YRKE/LANTARBETARE-3455

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unsustainable. Notably also with value changes in livestock is included in this figure. The farmer himself however stated that the profit of his business was 350 000 SEK which would cover a salary of around 22 500 SEK/month which is above the average.

Performing the same calculation for some of the other farms show that Farm 4 would be able to cover a salary of 14 100 SEK/month when considering the profit he stated, and a salary of 15 300 SEK/month when considering his *Net farm income.* Both are below standard wages in farming in Sweden. During the interview however, the farmer clearly stated that he was content with his economic situation and did not strive for making a profit within his farming business which shows that in some cases, the *Net farm income* is alone not enough to say something about the economic sustainability of a farm.

It should moreover be noted that several of the farm managers/owners receive their main income from off-farm activities (Farm 6, Farm 9 and Farm 11) and to some extent currently or permanent operate their farms without an aim to make a living wage from its enterprises. Notably for the Swedish context is also that most farmers, including the majority in the case study, run “side-businesses” that are financially very important but that have not been considered in the analysis here. This is e.g. revenues for forestry which is often key for the finances of a farming company in Sweden, machine rental services (often snow clearing in winter) and performing contract work for other farmers. The *Net farm income* here hence says something about the economic sustainability of the farming operations isolated from other enterprises on the farm, which hence affects the outcome, but is on the other hand motivated as it could highlight how viable farming is.

The SMART results for show an average of 68 from a range of 58 to 78 and it perhaps interesting to note that the two farms turning considerable losses according to the COMPAS results (Farm 1 and 7) receive high scores for profitability in SMART, 73 and 77% respectively. Again, there is no observable pattern in neither COMPAS nor SMART figures that the results mirror the pre-defined transition pathway.

QUALITY OF LIFE

For *Quality of life* the outcome is generally very good for the Swedish case. All farms receive scores that fall within ranges labelled as green by SMART. The average score is 82 from a range from 75 to 89. This is explained by a few factors that are most likely true for a lot of European countries, namely that workers can eat and drink sufficiently, take regular breaks and have access to toilet facilities. For the Swedish case additionally, the high scores for *Quality of life* are also explained by nation-wide high standards of work place safety, strict regulation and enforcement of rules regarding use of safety equipment when handling hazardous materials, low occurrence of work-related accidents, large awareness of on-farm safety and general equality in pay between men and women. Several of the farms also have collective agreements that apply to all employees and regulate wage, working hours, overtime compensation and vacation time. One thing that should be noted is however that during the DST interviews, it became clear that several of the farmers work hours that go way beyond ILO recommendations of 40 hours a week and that most of them, if not all, experience considerable stress in their work life because of this. This is not entirely reflected in the scores for *Quality of life,* however noted as an area for improvement for many. Also somewhat surprising, considering the before-mentioned, is that the farm receiving the lowest score of 75% is one where the interviewer (albeit subjectively) experienced that the

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family on the farm where among the happiest and most content with their life situation. They seemed to not experience work overload and stress to the same extent as some of the other farms that receive higher scores which point to the (obvious) that *Quality of life* is of course explained by a range of aspects which as extremely difficult to capture using these types of tools.

NUMBER OF PEOPLE THAT CAN BE FED PER HECTARE (CASE STUDY SPECIFIC ASPECT)

In the analysis for the case study specific indicator of how many people can be fed, in terms of calories and protein, per hectare of land used for the farm operations we made three scenarios; one where the farm does not keep animals and hence sell everything they produce to direct human consumption, one where they grow crops and rear animals just like today and where all crops that are not kept for on-farm feed is sold as animal feed and the last scenario where they grow crops and rear animals just like today and where all crops that are not kept for on-farm feed is sold for human consumption. The third scenario best addresses the key dilemma of the Swedish case and those figures are hence included in the results overview sheet together with the figures for scenario one for reference.

Results clearly show the inefficiency of using crops to feed animals to produce edible energy (calories). For all farms, the scenario where they produce exactly what they grow today but do not keep animals and instead sell everything for direct human consumption result in more people that can be fed per hectare. For several of the farms, the number of people more than double compared to when they grow exactly what grow today, keep feed and rear animals as today but sell all excess crops produced for human consumption instead of feed. These results are expected, especially considering findings for the stakeholder champion's farm that was the foundation for the focus of the Swedish case study[19].

Results for the number of people that can be fed per hectare in terms of protein are more diverse and for six out of the 11 farms, one can observe two things; a) that ruminants can be net generators of protein if fed largely roughage and only limited amounts of grain or other human-edible crops. This is in line with previous studies (Mottet et al. 2017; Swensson et al. 2017); and, b) seeing as most farms in our case study use such large shares of their arable land for perennial leys (20-90%), keeping animals to produce milk and/or meat is an efficient land-use strategy if only protein is considered. The reserve is true if only energy is considered. One interesting result here is that of Farm 5 that shows that 10,3 people could be provided with their daily need for protein per hectare if no animals were reared and all crops were sold for direct human consumption while 7,4 people/ha could be provided with

[19] https://www.slu.se/globalassets/ew/org/centrb/fu-food/publikationer/publikationer-fr-l/den-hallbara-garden--juni2017_webb.pdf

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protein when using the animals as well. This is explained partially by the use of maize whole crop silage on this farm that is here considered as human-edible (if harvested differently) and partially also because this is the only farm that grows and sells beans. The considerable potential for providing a large number of people per hectare with protein when growing leguminous crops is particularly relevant for our case.

14.4. Farm Comparisons

GENERAL DIFFERENCES BETWEEN FARM GROUPS

As was noted previously, there are no clear differences between farm groups. This is however to be expected as there is large variation between the farms in each group in terms of size, geographical location, local climatic conditions, type of land, diversification, organic or conventional, how long they have been operating etc. One can hence observe some similarities for some farm groups for some topics, but there is no consistency in the patterns and we have not identified any instances where all four farm groups can be clearly differentiated from one another.

GENERAL SIMILARITIES BETWEEN FARM GROUPS

One interesting pattern is that when analysing a range of SMART subthemes that can all be argued to capture how actively the farm participates in and contributes to the surrounding community, such as *Value creation, Civic responsibility, Mission statement* and *Responsibility*, all farms perform quite “badly” with SMART scores below 50% and these indicators somewhat stand out from the rest of the SMART results. The average for *Value creation* is e.g. 40, for *Civic responsibility* it is 31, for *Mission statement* it is 42 and for *Responsibility* it is 47. When compiling lists of areas where the farms have potential for improvements for each of the farms (will be used during the focus group meeting), we found that for most farms, one such recommendation was to begin working more strategically with purchasing from local actors and increasing awareness of the origin of input goods in order to become a more active member of the local community (this is however affected by access to such businesses in services in rural areas and we do not know as of yet how feasible such a recommendation is). Another common pattern for all farm groups related to this is that most farmers stated that they spend very little time on social activities beyond the farming activities. All in all, this highlights that all farm groups, and perhaps farms in Sweden in general, are similar in that they could or should undertake efforts to contribute more actively to the local community.

Another similar pattern for the farm groups is that they perform very well in terms of having freedom of association and collective bargaining, there is no occurrence of child labour or forced labour, they have fair access to means of production, mostly have stable suppliers and buyer relations and score highly for gender equality. These are characteristics which can be said to apply to Swedish society overall and should hence be interpreted as common to farms overall in Sweden rather than something specific for these farm groups or case study. One can likely expect the same pattern for several of the European countries included in UNISECO.

14.5. Trade - offs / Synergies Between Focus Topics

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There is an observable trade-off between Soil and Water quality for two farms whose results for the case-specific indicators stand out. Only three farms – when growing exactly what they grow today but keeping no animals – would be able to feed more than 10 people per hectare both in terms of protein and energy (Farm 1, 5 and 7). SMART scores for Soil and Water quality for two of these (data for third farm is missing) are however below the case study average, indicating a trade-off between increased cultivation of human-edible crops and some environmental aspects; this is to be expected due to lower shares of land used for perennial ley (20 and 40% respectively) which were identified above as an important explanation above.

One trade-off which we would expect to see is that between animal welfare and emission intensity for meat and dairy (Gerber et al. 2013, Gerssen-Gondelach et al. 2017). When only analysing the SMART results, the opposite seem to be observable; some of the more extensive farms receive high scores for animal welfare and climate indicators simultaneously. It is however not possible to draw any clear conclusions based on this as CFT results are not included here and it should also be noted that the above-mentioned trade-off regard emissions per kilo product and animal welfare while SMART scores the entire farm, differences in functional units may hence be the explanation for the pattern described here.

14.6. Synthesis of Task 3.2 Results in the Case Study

The overall expected results for the case study have previously been described as follows:

"Main expected results from the case study include a better understanding of possible pathways for diversifying livestock farms in Sweden, a mapping of challenges to be overcome and a suggestion for actions needed among different stakeholders to make a transition to a food system within planetary boundaries possible."

Results from Task 3.2 have provided the following insights with relevance for the expected outcome:

- Two farms were found to be better categorised into FG5 as they were found to be more diversified than previously thought and hence particularly address the case study dilemma. Better understanding of these farms can provide valuable input to the "possible pathways for diversifying livestock farms" stated above and could therefore be particularly interesting for more in-depth analysis in Task 3.3.
- Farm 5 that is the only one that grows protein crops (bean) for human consumption and show notable difference between the scenarios considered for our key indicators could also provide valuable input to understanding "possible pathways for diversifying livestock farms".
- All farms would improve their outcome in the key indicator people (kcal)/ha by increasing their sales of crops for direct human consumption instead of feed. Results for protein are more mixed.
- The general performance for a range of environmental and social indicators is high for all farms, likely because of generally good performance of Swedish farms overall.

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- Five out of ten farms analysed do not generate wages that match average wages for farm workers in Sweden (which is additionally a very low wage level) which is a key challenge for the case.

One conclusion from the brief analysis is that the results do not mirror the pre-defined transition pathway, i.e. those farms within the Swedish case study that are organic and more diversified (system re-design farming group) do not generally perform better for the key topics listed above compared to conventional and/or less diversified farms. For some of the environmental indicators, all organic farms however perform better than the conventional farms.

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1.1. Swedish case study report: appendix 2

Material för hållbarhetsutvärdering inom UNISECO – Del 1

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Bästa UNISECO-deltagare,

Vänligen svara på/fyll i frågorna utifrån det som gällde på gården **år 2017**. Skicka därefter detta till mig på KAJSA.RESARE.SAHLIN@SLU.SE.

Informationen är den första delen av materialet som används i de tre verktygen för att utvärdera nuläget på gården.

Om ni inte har tillgång till någon information, notera detta med ”Vet ej”.

Tveka inte att höra av dig/er om du/ni har några frågor!

____

1) Vem äger gården? Vilken är ägandeformen?
2) Om några delar av gården är KRAV-certifierade, beskriv vilka.
3) Förutom växtodlingen och kött/mjölkproduktionen – har gården någon annan aktivitet som är av betydande ekonomiskt värde? Betydande ekonomiskt värde innebär sådant som utgör mer än 10 % av gårdens intäkter. Om ja, beskriv denna/dessa.
4) Jordmån/-er på gården

5) HEKTAR AV OLIKA MARKTYPER

Notera! Summera den totala arealen (egen-ägda och arrenden) för de olika marktyperna och notera antal hektar arrenden om sådana fanns.

	Hektar år 2017	Varav antal hektar som arrenderades
Total jordbruksareal		
Åkermark (inkl. vall)		
Vall		
Naturbetesmark		
Perenna/permanenta grödor (ex. fruktträd)		

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Skog		
Annat: [specificera]		

6) ARRENDEN

	Antal hektar ni arrenderade 2017	Vad ni betalade totalt	Vad kostade det billigaste per hektar?	Vad kostade det dyraste per hektar?
Åkermark (inkl. vall)				
Naturbetesmark				

7) GRÖDOR

Notera! Om ni t.ex. odlat tre olika sorters havre kan dessa klustras ihop och bara kallas 'havre'. Räkna ihop det totala antalet hektar för varje gröda. Om grödor samodlas, skriv ihop dessa och ange hur mycket av varje, t.ex. ärter/blandsäd (40/60).

Gröda	Totalt antal hektar år 2017	Antal år grödan finns på åkern	Skörd år 2017 (i ton)	Skörde-förluster år 2017 (uppskattning i procent)	Andel balj-växter	Står grödan för mer än 10 % av intäkterna? (Ja/Nej)

8) Beskriv växtföljden

9) DJUR

Notera! Kategorierna är förutbestämda i verktygen. Fyll därför i uppgifter för de kategorier som finns på gården och lämna resterande kategorier tomma. Om kalvarna föds på gården och stannar på gården tills de är över 6 månader gamla (inom år 2017) ange antal för dessa endast i kategorin 'Kalvar 6-12 månader'.

Kategori	**Totalt antal djur år 2017**	Antal djur som köptes in år 2017	Antal djur som såldes/slaktades år 2017	Antal djur som dog eller nödslaktades år 2017	Antal djur som behandlades med antibiotika 2017	Genomsnittlig levandevikt
Kalvar 0-6 månader						

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Kalvar 6-12 månader						
Mjölkkor						
Sinkor						
Dikor						
Stutar						
Kvigor						
Rekryterings-djur						
Avelstjurar						
Tackor						
Lamm						
Baggar						
Grisar						
Höns						
Övrigt [specificera]						

10) ANSTÄLLDA

Notera! Ange bara dem som jobbade på gården år 2017. Bortse från personer som *bara* jobbar i t.ex. gårdsbutik eller med förädling på gården utan ange endast dem som är direkt involverade i driften av själva jordbruket. Befattning kan t.ex. vara växtodlingsansvarig eller dräng. Om du inte tar ut någon lön från jordbruket, notera detta.

Vem? (ange namn och/eller befattning)	Ange om personen är: Lantbrukare/gårdschef Familjemedlem Anställd Timanställd/inhoppare Praktikant Säsongsanställd	Jobbar personen heltid eller deltid?	Vid deltid, ange omfattningen (uppskattning i procent)	Lön (i SEK per månad eller timme)	Har personen ett skriftligt anställningskontrakt?	Ungefärligt antal timmar personen jobbar per vecka

11) TRAKTORER

Notera! Lista samtliga traktorer (inklusive t.ex. fyrhjuling eller hjullastare) som finns på gården. Uppskatta underhållskostnaden mellan tummen och pekfingret.

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Modell	År den köptes in	Inköpspris	Ungefärlig underhållskostnad per år (exkl. diesel)	Antal år den förväntas vara i drift	Ägarandel

12) MASKINER

Notera! Maskiner avser t.ex. harv, vält, plog etc. men inte sådant som motorsågar eller spannmålskvarnar eller mindre verktyg. Tumregeln för om den ska inkluderas är om den kan kopplas på en traktor. Uppskatta underhållskostnaden mellan tummen och pekfingret.

Modell	År den köptes in	Inköpspris	Ungefärlig underhållskostnad per år (exkl. diesel)	Antal år den förväntas vara i drift	Ägarandel

13) **Har gården investerat och byggt någon infrastruktur tillhörande växtodlingen de senaste åren (ex. spannmålssilo). Om ja, beskriv vad ni byggde, vad det kostade och vilka årliga kostnader ni hade för detta.**

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14.8. Swedish case study report: appendix 2

	Livestock			Crop production				Farm level					
	Emission sources			Emission sources			Emissions per hectare	Emission sources			% contribution to total emissions		Total
	1st	2nd	3rd	1st	2nd	3rd	kg CO2e/ha	1st	2nd	3rd	Livestock	Crop	ton CO2e
SE001	Enteric	Feed	Manure	Energy	Fertiliser pro.	Soil/Fertiliser	235,69	Enteric	Soil & crop fertilisation	Fertiliser pro.	68,2	31,8	127,23
SE002	Enteric	Feed	Manure	Residue	Soil/Fertiliser	Energy	230,93	Enteric	Feed livestock	Manure	100	0	580,2
SE003	Enteric	Feed	Grazing	Residue	Soil/Fertiliser	Energy	244,8	Enteric	Grazing	Feed livestock	89,6	10,4	274,04
SE004	Enteric	Feed	Grazing	Residue	Soil/Fertiliser	Energy	342,72	Enteric	Feed livestock	Soil & crop fertilisation	79	21	161,31
SE006	Enteric	Feed	Grazing	Residue	Energy	Soil/Fertiliser	230,58	Enteric	Feed livestock	Grazing	80,1	19,9	65,36
SE007	Enteric	Feed	Transport	Soil/Fertiliser	Residue	Fertiliser pro	256,67	Enteric	Feed livestock	Transport	88,9	11,1	5714,14
SE008	Enteric	Feed	Manure	Residue	Soil/Fertiliser	Energy	194,79	Enteric	Feed livestock	Manure	95,3	4,7	241,14
SE009	Enteric	Feed	Grazing	Residue	Energy	Soil/Fertiliser	429,86	Enteric	Grazing	Feed livestock	93	7	163,16
SE010	Enteric	Feed	Manure	Residue	Soil/Fertiliser	Energy	348,01	Enteric	Feed livestock	Manure	98,8	1,2	1789,62
SE011	Entreric	Feed	Grazing	Energy	Soil/Fertiliser		93,22	Enteric	Feed livestock	Grazing	100	0	99,55
						Average	260,7			Average %	89,3	10,7	

	Emission intensities per crop								
	kg CO2e/ton								
	Grass-clover mix	Extensive grass	Oats	Wheat	Rye/Triticale	Rape seed	Barley	Potatoe	Whole crop silage
SE001	165,24	144,59		207,58			185,5	276,62	
SE002	264,43			135,94			119,58		
SE003	231,45	286,85	127,05	244,21	171,76	537,76			
SE004	254,03		631,79	476,33					
SE006	274,76			171,54			800,44		53,74
SE007	365,15		377,56	306,21	228,52	575,54	275,63		
SE008	236,63		146,04				185,69		40,34
SE009	370,96						907,7	361,78	296
SE010	311,15	318,15			105,78	338,27	157,23		129,14
SE011	22,1								67,16
Average	249,6	249,9	320,6	257,0	168,7	483,9	376,0	319,2	117,3

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15. SWITZERLAND (LUCERNE CENTRAL LAKES REGION – LIVESTOCK FARMS)

By Jan Landert, Richard Bircher, Rebekka Frick (Fibl)

15.1. Case Study Dilemma

The intensive agriculture in the Lucerne Central Lakes region is of high economic importance. At the same time, the high animal densities and the related emissions cause important environmental problems. These include the artificial aeration of two of three lakes in the region due to high phosphorous loads and increased ammonia emissions. The analysis carried out so far suggests that the intensification of animal husbandry and the detachment of animal numbers from agricultural area was fostered by a number of factors, of which the political measures play a crucial role. The system is dominated by strong path dependencies: farmers having invested in large farm buildings and bearing considerable depths; the regional agricultural input market (i.e. fodder industry, barn construction industry) being specialised in the needs of intensive animal husbandry farmers; animal traders and processers being specialised in large-scale production; a knowledge and advisory system specialised in intensive animal husbandry. Finally, the economic situation of farmers will most likely worsen with future regional effects of climate change.

15.2. Investigated Farm Groups

Originally, two agro-ecological transition pathways where intended to be assessed with the decision support tools. One related to specialized pig production as the baseline with a transition towards organic, mixed pig production and specialist horticulture systems with lower animal densities. The other system relating to a typical transition from specialized dairy farming as the baseline to organic suckler cow husbandry.

However, specialized farms were difficult to recruit for the assessments that the farm groups had to be re-defined. The foreseen conventional baselines of the initially two separate transition pathways were combined to farm group 1 (**FG1_ConvMonoDairy**), which contained conventional farms with monogastric husbandry (poultry, laying hens or pigs) *and* a dairy enterprise. The second farm group (**FG2_OrgMonoDairy)** contained organic certified farms with the same farm enterprises as the first farm group. The second farm stand for input substitution as one stage on the agro-ecological transition pathway.The third farm group (**FG3_OrgBerriesFruitsVegetables)** contains organic farms with either relevant berry, fruit or vegetable enterprises. It represents a system-resign were traditional livestock production is substituted with plant-based income alternatives. For the last group (**FG4_OrgSucklerCows**), only one organic farm with suckler cow husbandry was assessed due to problems recruiting additional farms before the deadline for the deliverable. This group represents a stage along the ecological transition pathway with lower stocking rates and higher importance of grazing. The latter two groups can also have a dairy enterprise or monogastric husbandry but with less importance with regard to farm income. In total, eight farms participated.

For the recruitment of farms, the cantonal office for agriculture and forest (lawa) provided addresses of farmers, based on the criteria for the farm grouping mentioned above. FiBL

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then contacted the farmers asked whether they would like to participate in two on-farm interviews and one workshop by receiving a compensation of 500 CHF.

The project team presented the results of the assessment at the workshop and asked them for their judgment on the plausibility and generalizability of the data. Below, this workshop will be referred to simply as *the workshop*.

Rating scores of the farm groups from SMART and Cool Farm Tool- biodiversity module are below expressed in percent and relate to a range from 0% - 100% rating.

15.3. Focus Topics

DIRECT AND INDIRECT GREENHOUSE GAS EMISSIONS

With regard to annual crops and grassland, the CO_2 – emissions varied considerably between farms (Table 1). The variation is primarily connected to the practices of some organic farmers belonging to the groups **FG2_OrgMonoDairy** and **FG3_OrgBerriesFruitsVegetables**. They switched from tillage to no-till or at least reduced till during the last years on some of their fields as a result of active promotion through financial incentives of these practices among organic farmers in the region. The high impact on greenhouse gas emission of a change in land management is also shown in Table 2.

Table 1. Average of CO_2eq- emissions per crop in the case study. Ranges are express as standard deviation. * Only one occurrence of the crop in the sample.

Crop	Average emissions of t CO_2eq per ha (with land management changes considered)	Average emissions of t CO_2eq per ha (land management changes not considered)
Carrots*	- 2.7	2.5
Potatoes*	-3.0	2.1
Cherries*	1.9	1.9
Pumpkin*	1.3	1.3
Blueberries*	1.2	1.2
Wheat	-1.1 ± 4.4	1.1 ± 0.1
Maize silage	-2.7 ± 4.6	1.0 ± 0.3
Spelt*	0.7	0.7
Barley*	0.5 ± 0.3	0.5 ± 0.3
Grassland	-0.4 ± 2.4	0.5 ± 0.3

If the changes land management are not considered, vegetables and perennial crops exhibit the highest CO_2eq- emissions per ha. The cereals spread across a wider range with regard to the CO_2eq- emissions, with wheat having the highest CO_2eq- emissions (changes in land management not considered) and Barley having the lowest carbon footprint per ha. Maize silage has a similar carbon footprint per ha as wheat. Relatively seen, grassland is among the crops with the lowest CO_2eq- emissions per ha assessed in the case study.

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Table 2. Average contribution in percent of different processes to greenhouse emissions from crops. * Only one occurrence of the crop in the sample.

Crop	Changes in land management (%)	Pesticide use (%)	Residue management (%)	Fertiliser application (%)	Fertiliser production (%)	Energy input (electricity/ fuel) (%)	Irrigation (%)	Transport from/to farm (%)
Carrots*	64.4	0	13.7	4.4	0.7	12.4	0.0	1.3
Potatoes*	70.8	0	8.1	7.7	3.7	7.5	0.0	2.1
Cherries*	0.0	11.6	0.0	17.4	0.0	70.4	0.0	0.6
Pumpkin*	0.0	0.0	5.0	61.4	0.0	23.0	0.0	10.6
Blueberries*	0.0	0.0	0.0	48.2	15.2	29.0	0.4	7.1
Wheat	22.5	4.0	0.0	48.5	9.1	14.2	0.0	1.8
Maize silage	44.1	3.6	0.0	40.0	2.4	9.9	0.0	0.0
Spelt*	0.0	3.1	0.0	74.2	0.0	21.9	0.0	0.8
Barley*	0.0	1.3	0.0	31.6	11.9	54.3	0.0	0.9
Grassland	17.0	0.3	0.0	28.5	2.1	52.1	0.0	0.0

The most relevant processes on the farms investigated were, as already outlined above, land management changes, together with fertilization and energy input (mainly diesel use from tractors). Residue management was important for greenhouse gas emissions for some vegetables where the residues were not removed. Pesticide use did not play a major role except for the organically grown cherries in group **FG3_OrgBerriesFruitsVegetables** with a high use of organic pesticides. Irrigation energy had a minor impact on emissions and transport processes where mainly relevant for perennials and vegetables with the exception of cherries.

The SMART scores for the subtheme *Greenhouse Gases* reflect this pattern, where the higher use in N-fertiliser was one reason why the conventional farm group (**FG1_ConvMonoDairy**) is rated low (55%) compared to the other organic farm groups (62% - 71%). In line with that, also the use of legumes in crop rotation was rated positively for organic farms.

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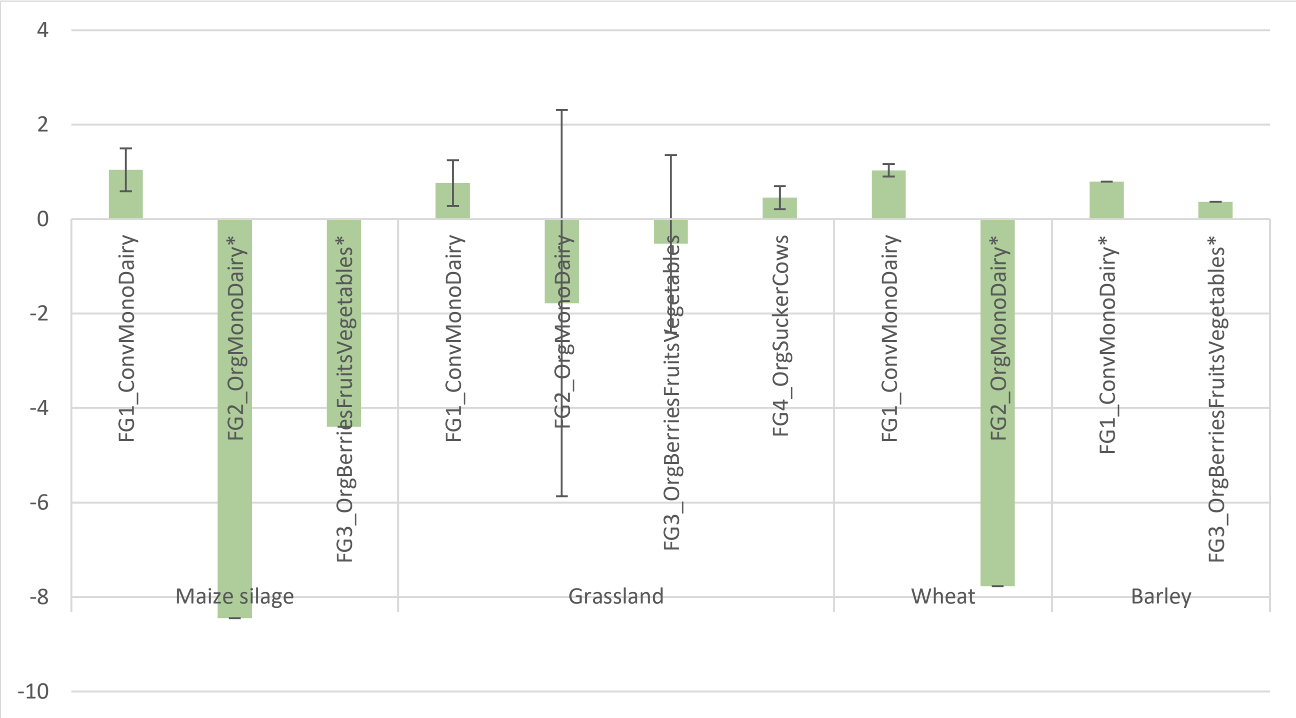

Figure 2. Tons of CO_2eq- emissions per ha for different crops and farm groups. Ranges of uncertainties expressed as standard deviation. *Only one occurrence in the sample.

When comparing the CO_2eq- emissions of different crops between the farm groups in the case study, the averaged emissions of the conventional farms (**FG1_ConvMonoDairy**) are always higher than the organic farms (**FG2_OrgMonoDairy, FG3_OrgBerriesFruitsVegetables** and **FG4_OrgSucklerCows**). These results need to be interpreted with care since the uncertainty connected to the spread of the data in the small sample is high (see Figure 1). However, no-till practices of organic farmers likely contributed to the result (expressed by the negative CO_2eq emissions). Assuming that changes in land management would not have occurred, the mentioned difference between organic and conventional farmers is only true for grassland and barley (Figure 2). For maize silage and wheat, the picture is less clear. The remaining differences in CO_2eq- emissions between organic and conventional farms are likely to be a result of different rates of N-fertiliser: Organic farmers are limited with organic fertiliser application because of legal P fertilization limits (see further below).

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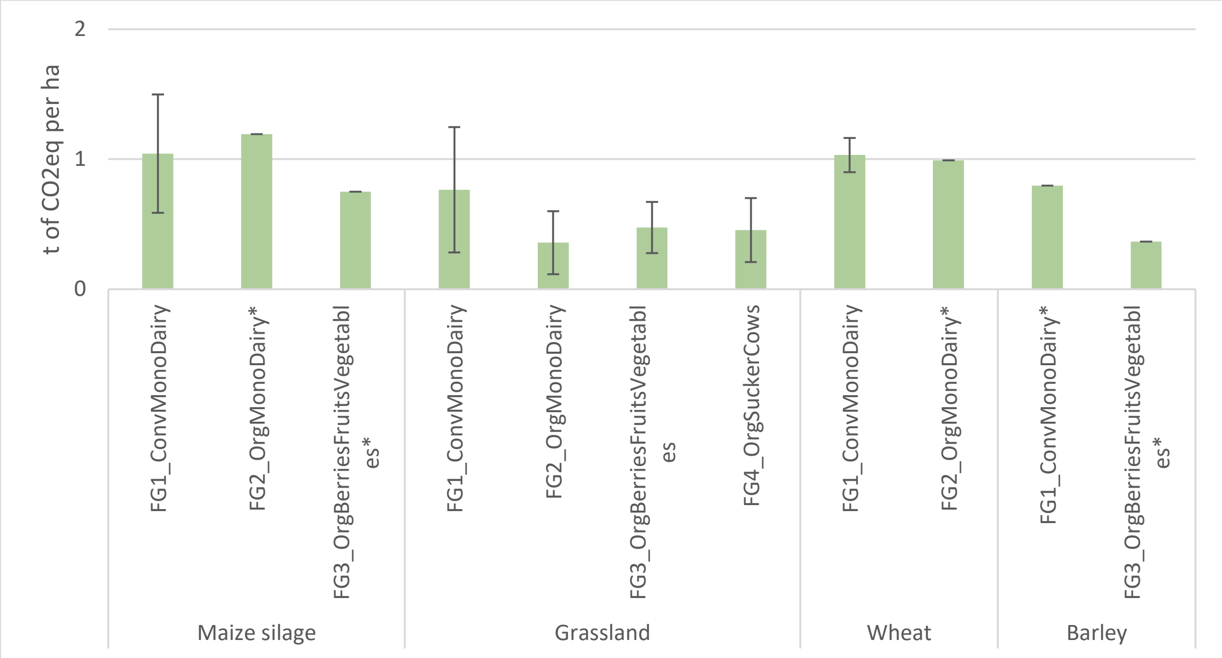

Figure 3. *Tonnes of CO2eq- emissions per ha for different crops and farm groups (changes in land management not considered). Ranges of uncertainties expressed as standard deviation. *Only one occurrence in the respective farm group.*

The emissions of dairy farming are similar for all farm groups. The average emission of CO2eq per kg of PFC milk (fat and protein corrected milk) is 0.86 kg (off-farm processing energy input not included). While the two farm groups with dairy and monogastric animals (conventional and organic) perform similar, the farm in the third farm group **FG_OrgBerriesFruitsVegetables** seems to have higher emissions, caused by the increased grazing time and a similar amount of feed provided to the animals (and therefore an increase in enteric fermentation). This result is difficult to interpret as the grazing duration was entered in Cool Farm Tool as the duration the animals can access pasture. As a consequence, this approach to enter the grazing time may have led to an overestimation of the feed taken up by grazing. The above mentioned SMART for the subtheme *Greenhouse Gases* are also influenced by the higher share of concentrate provided to ruminants on the conventional farms.

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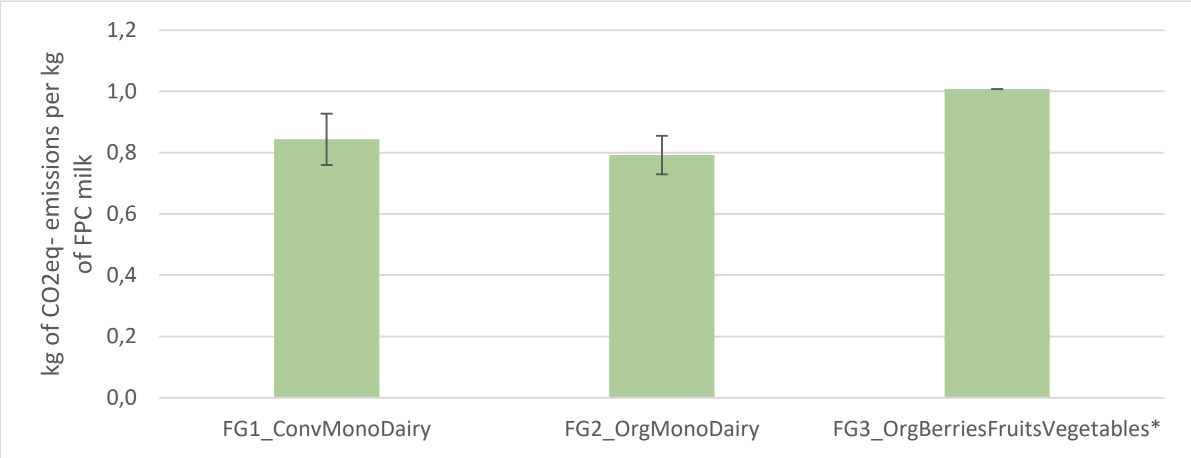

Figure 4. Emissions of CO_2eq from dairy production per kg of PFC milk. Ranges of uncertainty expressed as standard deviation. *Only one occurrence in the farm group FG3_OrgBerriesFruitsVegetables.

For pigs, no pattern between farm groups emerged from the data except for those farms in the groups **FG1_ConvMonoDairy** and **FG2_OrgMonoDairy** where the contribution of fodder to the emissions in comparison to the contribution of the manure management was relatively higher. This can only be explained by combined effects of different feed and manure management. The latter also represents the dominant source of emissions across all farms with pig production, regardless of the production system. On the conventional farms (**FG1_ConvMonoDairy**), it led to a lower rating for the subtheme *Greenhouse Gases* because the slurry storage was not optimally covered.

For both, pigs and dairy, the transport processes to and from the farm play a lesser role. The fact that almost all farms produce their own fresh grass, hay and silage has a positive impact on the SMART score for *Greenhouse Gases* across all farm groups. Farmers added at the workshop that an own fodder production was not the standard in the case study area and is mainly applies to **organic farms** because of corresponding regulations.

With regard to the production of renewable energy, no clear pattern emerged from the assessed farms. Farmer confirmed at the workshop that the production of renewable energy depends mainly on the presence of a stable is not connected to a certain farm group. Newer or renewed stables roofs with the right exposition are more likely to receive solar panels on top.

BIODIVERSITY

Also with regard to the SMART theme Biodiversity, the conventional farms (**FG1_ConvMonoDairy**) scored worse than the organic farms (50% compared to 66 – 75%). One main reason is that there are more tree habitats on the farms belonging to the groups **FG3_OrgBerriesFruitsVegetables** and **FG2_OrgMonoDairy** (both forest and fruit trees).

That farms belonging to the farm groups **FG4_OrgSucklerCows** and **FG3_OrgBerriesFruitsVegetables** keep rare breed and cultivate rare crops also contributed to the higher SMART score in the theme of Biodiversity.

The use of chemical-synthetic herbicides on the conventional farms (**FG1_ConvMonoDairy**) contributed to the lower SMART rating with regard to biodiversity. Some herbicides used

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are toxic to aquatic organisms. In line with the results of subtheme Greenhouse Gas emissions, also here higher N- fertiliser inputs led to the lower rating of conventional farms.

Generally, most of the farms across all groups contributed to the interconnection of habitats by participation in regional interconnection projects and therefore to the promotion of beneficial organisms which is part of such projects. According to the farmers at the workshop, there is a difference between organic and conventional farms with regard to the participation in interconnection projects since larger, conventional farms normally do not participate in these projects.

Farms which abstained from the use of GMO feed and crops impacted the rating of the SMART theme Biodiversity positively.

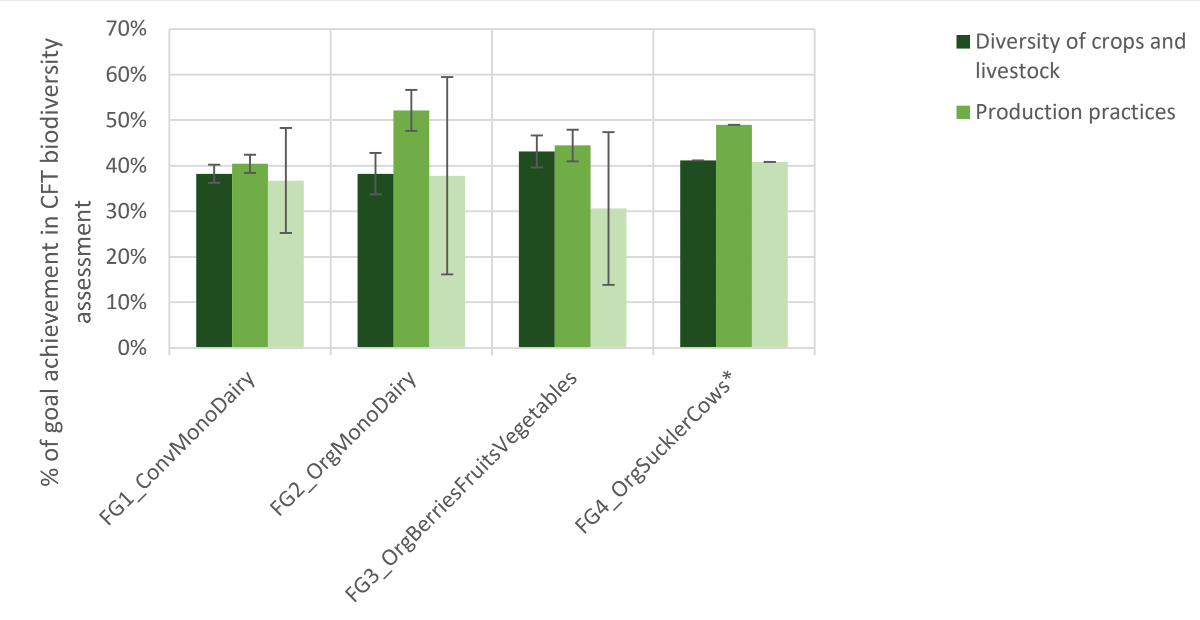

Figure 5. Goal achievement rating (0-100%) for the biodiversity module of CFT for different impact categories. Ranges of uncertainty expressed as standard deviation. * Only one farm in the farm group.

The biodiversity rating of CFT reveals the lack of larger nature protection areas across all farms assessed. However, CFT confirms the higher rating of **organic farming** with regard to production practices. In line with the SMART results for the promotion of beneficial organisms, the ratings for small natural habitats in CFT do not reveal any larger differences between the averages of the groups. However, it exhibits a higher variation also within the farm groups.

In addition, no patterns could be detected between the farm groups with regard to the number of elements in the crop rotation. However, during the workshop farmers argued that there are differences in realty in the case study region: Farms with less animals tend to have more elements in the crop rotation and organic farms normally have more elements because there are more price incentives to grow other arable crops than just fodder crops.

SOIL QUALITY (SOIL AS A MEAN OF PRODUCTION)

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All farm groups scored "good" in the SMART subtheme of *Soil Quality*. The rating score of the group **FG1_ConvMonoDairy** was again slightly lower (66%) than the score of the organic groups **FG2_OrgMonoDairy** (78%), **FG3_OrgBerriesFruitsVegetables** (78%) and **FG4_OrgSucklerCows** (72%). Good erosion management on farms and the fact, that most of the slopes above 15% steepness are covered with grassland lead were reasons for the generally good ratings**.** What contributed to higher score in the organic group was the presence of undersown crops, which can be generalized for a typical organic farm in the region. Signs of soil compaction, another sign of physical soil degradation, was insignificant on all the assessed farms.

Apart from the physical degradation, all farms scored relatively well in the subtheme *Soil Quality* also because on none of the farms, soils were contaminated by the use of fungicides, insecticides and growth-regulators. However, farmers stressed at the workshop that this result depends heavily on what crop is grown in the year of the assessment and the location of the plot the crop is grown on. In addition, there seem to be a substantial share of conventional farmers in the region which are producing cereals with other pesticides apart from herbicides. Rape (increase market demand as a substitute for palm oil) and sugar beet are also crops prone to high pesticide use. The latter two crops are also prone to erosion.

None of the farms used compost to increase the soil fertility. This affected the subtheme score for *Soil Quality* negatively. The farmers confirmed this results to be applicable for the typical farm of the region. They mentioned two reasons for not using compost: The high density of animals causing the promotion of slurry systems and stricter water protection laws, which may require the construction of a concrete floor for composting.

In addition, none of the farms calculated the humus balance of their soils. This also affected the subtheme *Soil Quality* negatively.

WATER QUALITY

In contrast to the case study's dilemma which includes severe water quality problems in the region, the SMART subtheme scores for *Water Quality* were at least "good" (**FG1_ConvMonoDairy**, 74%) and for the organic farms in the groups **FG2_OrgMonoDairy** (89%), **FG3_OrgBerriesFruitsVegetables** (83%) and **FG4_OrgSucklerCows** (82%) even "best". This seeming contradiction comes from the fact that phosphorous loads, which cause the water quality problems in the case study, are only one of many indicators, which contribute to the SMART subtheme score for *Water Quality*. While the high P-fertiliser application affected the subtheme score negatively across all farms, some other indicators contributed to the positive rating of the farms. The absence of significant erosions processes was one of the reasons for the positive rating (see above under *Soil Quality* for more details). As already mentioned above, farms did not use fungicides, insecticides or growth regulators which also contributed to the high rating- but at least for conventional farms, this result is not valid for a typical farm of the region (see above under *Soil Quality* for more details).

What caused the score of **FG1_ConvMonoDairy** to be slightly lower than the scores of the organic groups was the high rate of N-fertiliser application and the application of herbicides. Among the latter are substances with an aquatic half-life time of more than 60 days.

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PRODUCTIVITY

The average labour productivity of the farm groups in the case study are all at least above the Swiss average for labour productivity in agriculture which amounted to 53’000 CHF in 2018 for one fulltime equivalent (2800 hours / year; Swiss Federal Statistical Office, 2019). The Swiss average converts to around 42’400 CHF for a fulltime equivalent of 2200 hours / year. The lowest labour productivity (basis 2200 hours / year) in the case study exhibits the group **FG4_OrgSucklerCows** with roughly 50’000 CHF. This is because the respective farm manager has a job beside agriculture. Then the average labour productivity is higher in the other organic groups in group **FG3_OrgBerriesFruitsVegetable** (around 60’000 CHF) and **FG2_OrgMonoDairy** (85’000 CHF). From the organic to the conventional farms, there is a large difference: the labour productivity of group **FG1_ConvMonoDairy** amounts to roughly 180’000 CHF, which is more than double of the highest average productivity of the organic farm groups. In summary, moving along the agro-ecological transition pathway would mean a decrease in labour productivity.

This large difference between conventional and organic farm groups is because both assessed conventional farms operate highly efficient: one farm has specialized workflows on the farm by means of share farming and the other farm exhibits a high degree of mechanisation. Additionally, the output of both farms is very high and is able to compensate for other aspects such as the rather low milk price. While both farms likely do not to represent typical conventional livestock farm in the region, the general difference between organic and conventional farms with regard to labour productivity seems plausible.

In general, the labour productivity for all farms does not exactly mirror the conditions on the farms because it neglects the fact that farmers often work long hours (see below, under *Quality of Life*).

FARM INCOME

In SMART, all of the investigated farms scored well in the subtheme of *Profitability* (70% - 76%). In SMART, the fact that all farms could cover their cost with their revenues contributed to these “good” ratings.

This is confirmed by the COMPAS indicator *Net farm income* was clearly positive for all farms. The farm revenues and the yields are either constant or rising for some farms the last year. This is expressed in the fact that none of assessed farms had problems with loan providers. The positive net income was generally deemed reasonable for a generalization by farmers a the workshop but some questioned the relevance of such figures since the corresponding workload needs to be considered too.

The SMART scores for *Profitability* were negatively affected by the fact that engagement in activities with high added value (e.g. on-farm processing, agri-tourism etc.) was not common. The farms did not engage in collective marketing which also affected the SMART scores negatively. As reason not to engage in such activities, the spatial planning legislation in Switzerland was mentioned during the workshop.

QUALITY OF LIFE

With regard to the SMART subtheme *Quality of Life*, a slightly different pattern emerged from the ratings than for other topics: The conventional group (**FG1_ConvMonoDairy**)

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performed with a subtheme rating of 85% slightly better than the groups with organic farms (79% – 81%)

The overall “good” results are not surprising since SMART is applied on a global scale and Swiss citizens comparably enjoy a high quality of life. In addition to the country specific factors, farm generally performed well because there was a low fluctuation of staff on farms and most of the farms could pay the union demanded living wage in Switzerland (4’000 CHF). However, this result should not be generalized for a typical farm in the region because the salaries, recommended by the farmer’s association are with 3'270 CHF for unqualified labour lower than 4’000 CHF (Swiss Farm Association, 2019). Bio Suisse, the Swiss organic farmer’s association (Bio Suisse, 2019), also supports these recommendations. With regard to the problematic working conditions in some of the countries of origin of farm inputs, it turned out that farmers commonly did not consider social certificates for their farm inputs.

The SMART auditor did not discover signs of discrimination on the farms visited (e.g. with regard to salary etc.). In addition, the high degree of mechanisation on all farms led to a reduction of physical workload which also had a positive impact on the subtheme results. According to the farmers at the workshop, the high degree of mechanisation is common in the region. In turn, the results from the assessed farms showed that not all farm mangers were aware of the security risks on the farm.

The workload in the conventional group (**FG1_ConvMonoDairy**) was on average lower than on organic farms. However, the spread in the data was quite substantial ranging from 48h / week to 75 h / week (considering the worker with the worst condition of averaged workload over the year). The reduced workload in the conventional group was rather counterintuitive because of its dairy enterprise but could be explained by the presence of a milking robot and implementation of highly specialized share farming. This does not seem to be an exception: Farmers at the workshop argued that those dairy farms remaining during the course of the structural change in the dairy sector are bigger and technically better equipped.

With regard to days of absence due to occupational injuries, the farm group **FG3_OrgBerriesFruitsVegetables** exhibited the highest number. However, this was not confirmed to be a typical pattern during the workshop for vegetables, fruit or berry farms in the region.

Finally, the participants of the workshops added that one of the most important indicators for quality of life was whether the farmer was satisfied with the general farm activities. Among the farms investigated, that was for almost all farms the case (case study specific indicator also assessed on the field visits). One farmer was not satisfied with the dairy enterprise, which most likely mirrors the high economic pressure on the milk market, even with the innovations described above.

THE CASE STUDY DILEMMA AND HOW TO OVERCOME IT: FIRST IMPRESSIONS GATHERED ON FARM VISITS

The perception of the case study dilemma across actors is different and in some cases converse. During the workshop with farmers, also opinions of the farmers differed with regard to the severity of the problem of lake pollution due to high phosphorous loads.

A recent study of the research institute Agroscope (Stoll, von Arb, Jörg, Kopp und Prasuhn, 2019) acknowledged that the high phosphorous loads to lake Baldegg, one of the three

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lakes in the region, are still too high. This corresponds with the results from the farm assessments where all the farms with the exception of one farm had soils classified in category D (excess P) or even category E (high excess P). All those farms take part in a programme in which they receive subsidies for reducing phosphorous emissions by various measures. This programme defines thresholds for P emissions for the different soil classes. The average of the farm groups is close to the lower threshold for soils with an excess of P (Figure 5).

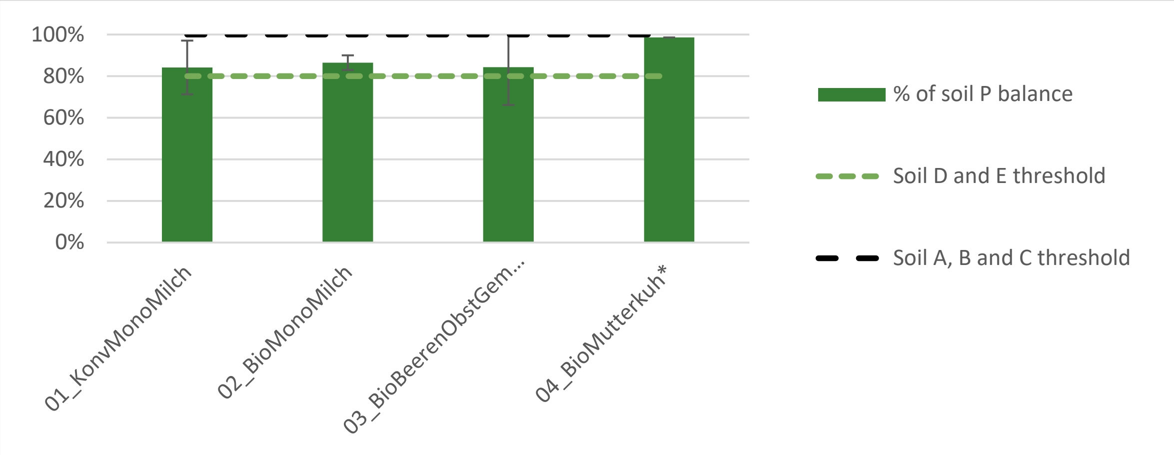

Figure 6. % of phosphorous soil balance (values below 100% mean that there is more P export from soils than inputs). Ranges of uncertainties expressed as standard deviation. Lines represent thresholds for the P balance defined in the regional programme to reduce P emissions. *Only represented by one farm.

Considering the uncertainty in the data set, there is **no clear difference between conventional and organic farm groups**. Among other reasons, this is likely because conventional farmers are better able to decouple P-input from N-input whereas organic farmers try to maximise the already rather low N-input on their fields by going close to the thresholds of the P balance with the application of slurry and manure.

In line with the case study dilemma, the above-mentioned study of Stoll et al. (2019) recommends reducing the intensity of animal farming in the region. This involves to some extent the re-use of stables for other farm enterprises, because of the high investments into stables. This is subject to spatial planning law, which also affects structures for other agricultural enterprises such as direct marketing. Farmers raised these potential spatial planning conflicts several times during the workshop. Consequently, this will be a topic, which will be more investigate in in the next steps of the project.

15.4. Farm Comparisons

GENERAL DIFFERENCES BETWEEN FARM GROUPS

One obvious difference between the average SMART subtheme ratings of the farm groups was that farm mangers in the group **FG3_OrgBerriesFruitsVegetables** seemed more concerned about the societal issues than other farms (subtheme *Civic Responsibility*). The group scored 59% percent where the other farm groups ranged from 25 – 37%. This result manifests itself in cooperation with ethical financial institutions was well as the voluntary social, environmental and political engagement outside the farm.

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The same group (**FG3_OrgBerriesFruitsVegetables**) stood out with regard to **the SMART subtheme** local procurement. The farm group scored 65% whereas the other ranged from 97% to 100%. One explanation for the difference is that some farm enterprises in this group are new to the region and the corresponding inputs are not available locally.

For the subthemes *Public Health*, *Product Information* and *Food Safety*, the farm group **FG1_ConvMonoDairy** scored on average lower than the other farm groups. Amongst other reasons, this pattern explains itself by the difference in production system. Use of chemical synthetic pesticides impact both, public health and food safety negatively. Product information is impacted negatively because the production is not organically labelled and hence it is less clear to the consumer what product he or she is buying.

GENERAL SIMILARITIES BETWEEN FARM GROUPS

In many SMART subthemes, the farms scored in a similar range. This is e.g. true for animal welfare. Additional data collected on the field confirmed that all the farms were certified with the same animal welfare labels. One explanation for this is the rather high share of organic farms in the sample (75%) which are normally already compliant with these labels.

For the governance subthemes *Full-Cost Accounting*, *Holistic Audits* and *Mission Statement* all farms scored rather low, which expresses the fact that management processes on the farms are in their majority not explicitly formal.

15.5. Trade-offs / Synergies Between Focus Topics

The main trade-off in the case study seems to be the increased labour productivity of conventional farms (economic dimension) versus the performance of the agro-ecological farms with regard to provision of public goods. However, across all farms in the case study region, this trade-off is expected to be weaker because the conventional farmers in the farm sample were very innovative.

15.6. Synthesis of Task 3.2 Results in the Case Study

The results did not mirror the agro-ecological transition pathway in all cases. This was especially the case for the farm income / profitability as well as for the topic quality of life. Also for the other topics, the difference between conventional baseline (**FG1_ConvMonoDairy**) and the organic farm groups **FG2_OrgMonoDairy**, **FG3_OrgBerriesFruitsVegetables** and **FG4_OrgSucklerCows** were not as high as expected. One possible explanation, also confirmed at the workshop with the farmers, is that the sample of farms was composed of rather innovative and diversified farms compared to the regional typical farm.

Some of the important patterns that emerged from the data:

- The high N-fertiliser input and the use of herbicides in the group **FG1_ConvMonoDairy** has led to a negative impact on the performance of this farm group with regard to Biodiversity and Water Quality.
- With regard to biodiversity, soil quality and water quality, no clear differences between the organic groups **FG2_OrgMonoDairy**, **FG3_OrgBerriesFruitsVegetables** and **FG4_OrgSucklerCows** could be observed.

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- The organic production practices of those three groups led to a higher performance with regard to Biodiversity. Two of them **FG4_OrgSucklerCows** and **FG3_OrgBerriesFruitsVegetables,** also make use of rare races and breeds and therefore increase the agro-biodiversity.
- The change to no-till practices for organic farms in the region has positive impacts with regard to greenhouse gas emissions as well as soil and water quality.
- With regard to farm income, all farms assessed to have a positive net income and either constant or growing revenues and yields. The conventional farms exhibited a substantially higher productivity.
- Although the sample was composed of rather innovative farms, engagement in activities with potentially high added value, such as on- farm processing or agri-tourism, was not common.

With regard to the core dilemma of the case study region (high density of animals), innovations in the group **FG3_OrgBerriesFruitsVegetables** (e.g. production of sprouts in old pig stable, production of sweet potatoes) show that the transition towards a more agro-ecological system is possible. Innovations also happen on farms being part of the conventional baseline (such as milking robot and share farming) that lead to an increased quality of life and economic performances but do not directly help in overcoming the core dilemma of the case study region. There is the need to further investigate on the innovations that could be helpful for the future transition of agriculture.

15.7. References

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16. UNITED KINGDOM (GRAMPIAN AND TAYSIDE IN NORTH-EAST SCOTLAND – MIXED FARMS)

By Inge Aalders (HUT), Fabrizio Albanito (UNIABN), Katherine N Irvine (HUT), Carol Kyle (HUT), David Miller (HUT), Pete Smith (UNIABN)

16.1. Description of Case Study Dilemma

The dilemma being addressed in the United Kingdom (UK) case study is the production of public goods whilst maintaining viable production of private goods, and securing economic and social sustainability at a farm level.

Geographic location

The geographic area of the UK case study includes Grampian and Tayside in north-east Scotland (Figure 1). This area has a focus on the primary production of agriculture, forestry and fishing, which are characteristics of its landscapes and cultural identity. The farming production systems represented by this case study are relevant across the European Union (i.e. Mixed farming with livestock, and General cropping). Examples of the agro-ecological farming practices used to address issues of sustainability are biodiversity support practices, nutrient budgeting, organic farming, permaculture and agroforestry.

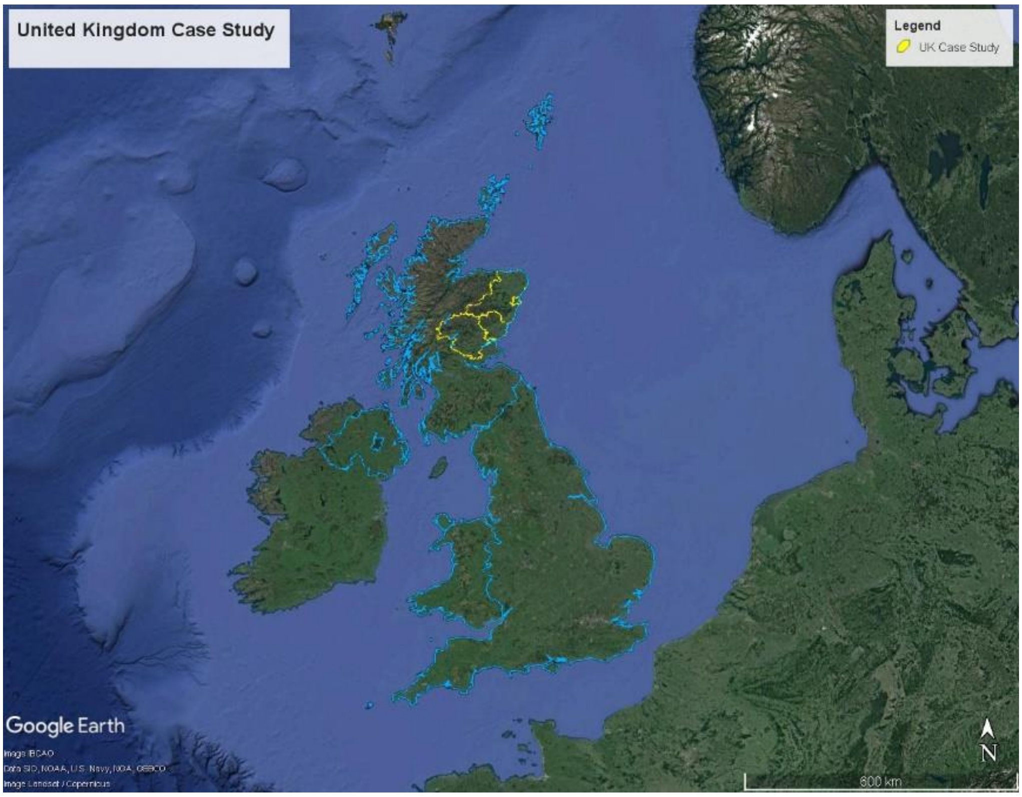

Figure 7. The United Kingdom Case Study Area.

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Policy context

The Scottish Government places a high policy priority on tackling climate change. The CLIMATE CHANGE (SCOTLAND) ACT 2009[20] sets targets to reduce Scotland's emissions of greenhouse gases by at least 42% by 2020, and 80% by 2050. The new SCOTTISH CLIMATE CHANGE BILL (2018)[21], amended in 2019, sets a revised target date of 2045 for reaching net-zero emissions, and raises those for reducing greenhouse gases by 70% by 2030 and 90% by 2040.

In its ECONOMIC STRATEGY[22], the Scottish Government states that 'Protecting and enhancing this stock of natural capital, which includes our air, land, water, soil and biodiversity and geological resources is fundamental to a healthy and resilient economy' (page 45). This statement is reflected in the central dilemma for the case study.

In its BIODIVERSITY ROUTEMAP 2020[23], the Scottish Government (2015) identifies the role of Government policy and actions in relation to biodiversity, highlighting agri-environment measures supported in the Scottish Rural Development Programme (SRDP), and the targeting of priority species. In the Green Deal in the PROGRAMME FOR GOVERNMENT 2019/20[24], the Scottish Government positions human well-being at the core of government policy, components of which are the protection of the environment and a just transition to net zero emissions.

These policies are also reflected in the context for the analysis of the social network of the case study, with respect to achieving the dilemma, reported in UNISECO Deliverable D5.2 (Vanni *et al*., 2019).

16.2. Description of Investigated Farm Groups

The case study focuses on farm systems of Mixed crops and livestock (FADN Farm type codes 83 and 84) and General cropping (FADN Farm type code 16). The geographical area of the case study comprises 12,360 farm holdings, equivalent to 24.2% of holdings in Scotland,

[20] Scottish Parliament (2009) Climate Change (Scotland) Act 2009, HTTP://WWW.LEGISLATION.GOV.UK/ASP/2009/12/CONTENTS

[21] Scottish Government (2018) Climate Change Bill (2018), Scottish Government HTTPS://WWW.GOV.SCOT/POLICIES/CLIMATE-CHANGE/CLIMATE-CHANGE-BILL/

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[23] Scottish Government (2019) Scotland's biodiversity: a route map to 2020, Scottish Government, pp40. HTTPS://WWW.GOV.SCOT/PUBLICATIONS/SCOTLANDS-BIODIVERSITY-ROUTE-MAP-2020/

[24] Scottish Government (2019) Protecting Scotland's Future: The Government's Programme for Government 2019-20, Scottish Government, pp162. https://www.gov.scot/publications/protecting-scotlands-future-governments-programme-scotland-2019-20/

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of which 1,574 are mixed holdings (36.2% of those in Scotland) and 1,022 are general cropping (59.3% of those in Scotland). In 2017, 67,000 people were employed in farming (including owners) across Scotland; 19,500 (29.1%) were in Grampian and Tayside.

Farmers in six farms were interviewed between May and July 2019 using the COOL FARM TOOL (CFT)[25], COMPAS, and SMART-FARM TOOL[26], and a further three farms surveyed in August and September using SMART-Farm Tool. In combination, these surveys enabled the production of a holistic sustainability assessment. The detailed scores calculated for each farm are provided in an accompanying MS Excel spreadsheet, using each tool with the data available as of October 2019. These scores are pseudo-anonymised to respect confidentiality of the respondents in line with the requirements and processes of the UNISECO project as set out in Deliverables D9.1 to D9.4. A summary of those farms is provided in Table 1.

Of the nine farms surveyed in the UK case study, eight farms (Farms 1, 3, 4, 6, 8, 10 and 14) are located in the Grampian area, and two farms (Farms 2 and 5) in the Tayside area of the north-east of Scotland. Farm 3 has the largest Utilisable Agricultural Area (709 ha of arable land and 112 ha of grassland), and Farm 10 the smallest Utilisable Agricultural Area (16 ha arable land and 8.6 ha of grassland and 10 hectares of woodland) (Table 1). The main crops on the farms are barley, oats, wheat, potato, and grass for silage. Beef and sheep are the dominant types of livestock farming. Of the farms interviewed for Cool Farm Tool and COMPAS, two farms included both breeding and finishing beef farming. Farm 3 reported the highest annual number of animals in the farm (100 breeding beef cattle, 1,100 sheep, and 150 red deer managed for meat), and Farm 8 includes additional revenue from a herd of 15 horses for leisure (Table 1).

[25] Cool Farm Tool, https://coolfarmtool.org/

[26] SMART-Farm Tool, https://www.sustainable-food-systems.com/en/

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Table 1. Overview of the farms surveyed in the UK case study. The farm numbers relate to the pseudo-anonymised coding for each farm; the farming system relates to that identified for the UK Case Study; the farming practices relate to the classification used in describing the Case Study comprising conventional, transition, and organic practices.

	Farm 1	**Farm 2**	**Farm 3**	**Farm 4**	**Farm 5**	**Farm 6**	**Farm 8**	**Farm 10**	**Farm 14**
Farming System	Mixed farming with livestock	General cropping	Mixed farming with livestock	Mixed farming with livestock	General cropping	Mixed farming with livestock	Mixed farming with livestock	General cropping	General cropping
Farming Practices	Organic	Convention al	Convention al	Transitio n	Conventional	Transition	Organic	Organic	Organic
Arable (ha)	25	142	709	122	82	38.8	165	16	9.6
Grassland (ha)	48		112	251	6	95.2	149	8.6	54.3
Forest (ha)	3.4	10	66	63		2.9	120	10	0
Number of livestock types	2		3	1		2	3	2	1
Number of crop types	3	7	2	3	2	3	3	3	2
Labour working units	2	2	4	4	2	1	1	1	1

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16.3. Analysis of Results

The results from the interviews of farmers using the SMART-Farm tool have been used to derive a set of data that represent a 'Hypothetical Farm' for the case study. These are presented in a spider diagram (Figure 2), with sub-sectors shown in Figures App. 1 to 4.

The results for the Hypothetical Farm for the case study show that all categories of Good Governance, Environmental Integrity, Economic Resilience and Social Well-being have components with scores above 40%, ranging from accountability at 40% and animal welfare at 86%. The high score for animal welfare reflects high scores for both animal health (88%) and freedom from stress (85%) (Figure App. 1). These scores reflect the high standards and tight regulations that were put in place in the United Kingdom in response to outbreaks of animal disease (e.g. Foot and Mouth; Creutzfeldt-Jakob disease, vCJD). These standards were developed from the Defra Farm Animal Welfare Committee as the 'Five Freedoms' in 1979. These Five Freedoms are the basis of the majority of animal welfare assessment tools across the world, on which other United Kingdom legislation was built (e.g. Welfare Act 2006; Animal Health and Welfare (Scotland) Act 2006).

The next highest set of scores are those for materials and energy, ranging between 70% (energy use) and 79% (waste reduction and disposal) (Figure 2 and Figure App. 2). The values for atmosphere, water and land are broadly within the same range of 61% to 69%, and those for biodiversity in a separate, grouping with lower values (46%, genetic diversity, to 57%, species diversity).

These figures suggest relatively high levels of delivery to public goods relating to land, water, atmosphere and animal health and welfare, and slightly lower for biodiversity. These are supportive of one part of the overarching dilemma to be tackled in the case study area.

Compared to the dimension of environmental integrity, the sub-sectors of Economic Resilience (Figure 2 and Figure App. 1) have assessment scores which are heterogeneous. An example of that heterogeneity is the assessment of the sector of local economy which has a range of values for sub-sectors of between 69% (local procurement) and 35% (value creation). Studying the scores for individual farms, the range for local procurement is from 61% and 63% for conventional and transition Farms 4 and 2, reflecting the requirement for purchasing specialist materials (e.g. wind turbine infrastructure), up to 93% and 97% for Farms 14 and 10 both of which use organic farming practices. In comparison, the range of scores for value creation is considerably lower, from 24% to 45% across all farms.

The greatest range in characteristics assessed are in the dimension of Good Governance (Figure 2 and Figure App. 3). The range is from 25% for civic responsibility to 78% for legitimacy. The preponderance of small, primarily family, businesses explains the absence of formal documents such as a mission statement (38%), and the low score for civic responsibility, which reflects the lack of an obligation to consult with neighbours or the local community in relation to most business activities. It is also reflective that in many instances a small family farm has little capacity for effort beyond the management of the farm. Exceptions are those farms on which wind turbines have been constructed, or engaged in developments requiring formal planning permission.

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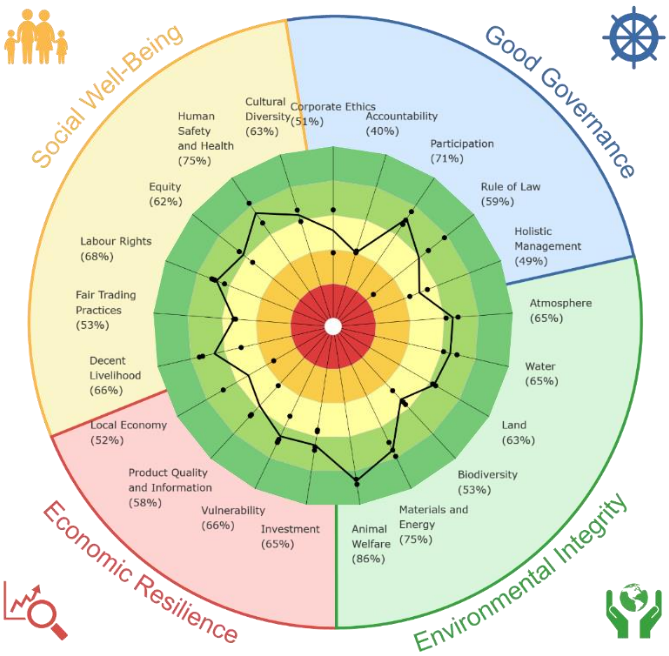
The results for Social Well-being (Figure App. 4) show relatively high scores for topics of workplace safety and health provisions (82%) and quality of life (75%). This reflects regulatory standards applying to all workplaces, overseen by the UK HEALTH AND SAFETY EXECUTIVE[27], and guidelines and advice provided to agricultural business and practices by representative bodies (e.g. Annual Farm Safety Week, and the Farm Safety Partnership, run by the NATIONAL FARMERS UNION SCOTLAND)[28].

Note that the questions which underpin the assessment of labour rights include those relating to the characteristics of suppliers, and those of the countries of the origins of raw materials such as mineral fertiliser (Farms 2, 4 and 5), as discussed in detail under Greenhouse gas emissions and water footprint assessment at farm scale. The scores for these inputs are reflected in the assessment classes in SMART-Farm such as forced labour (63%) and child labour (69%). This means that the assessment reflects the overall system and not the actions on the farm which is an important distinction when considering where there are drivers and barriers to transitions to agro-ecological practices.



27 UK Health and Safety Executive, Agriculture Health and Safety HTTP://WWW.HSE.GOV.UK/AGRICULTURE/INDEX.HTM

28 National Farmers Union Scotland (NFUS), Farm Safety Policy, HTTPS://WWW.NFUS.ORG.UK/POLICY/CAMPAIGNS/FARM-SAFETY.ASPX

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Figure 2. Representation of results from the SMART-FARM TOOL for the Hypothetical Farm in the UK Case Study: all dimensions. Based on SMART-Farm Tool assessment conducted during May to September 2019 with nine farms.

GREENHOUSE GAS EMISSIONS AND WATER FOOTPRINT ASSESSMENT AT FARM SCALE

Depending upon the crop type and management practices, in arable land in the farms surveyed for the Cool Farm Tool, the greenhouse gas intensity ranged from +3.7 t CO_{2eq}/ha for Potatoes, to -1.7 t CO_{2eq}/ha for Spring Barley managed with long-term organic fertilization (Table 2).

Table 2. Crop types cultivated in the six farms surveyed in the UK case study using Cool Farm Tool, and the cumulative annual greenhouse gas emissions from seed production, crop residues, soil fertilization, crop protection, and energy use for field and processing operations.

Crop Type	**Greenhouse Gas Emmission (mean ± sd) (t CO_{2eq}/ha)**
Potatoes	3.7
Wheat	2.5
Oats	1.8 ± 0.5
Barley	1.6 ± 1
Grass Silage	1.2 ± 0.9
Oilseed Rape	1.01
Other forages	0.7 ± 0.3
Sring Beans	0.6
Grass Silage (m)	-1.1 ± 0.4
Barley (m)	-1.7 ± 2.2

Potatoes were the only crop which was irrigated artificially in the case study, providing the opportunity to assess the water footprint in Cool Farm Tool. In particular, over the growing season (from June to September) the potatoes grown on the case study farm which had potatoes received 352 mm of water (60% from precipitation and 40% from irrigation), achieving an overall water footprint of 66.2k litre per kg of potatoes produced (56% from a green and 44% from a blue water footprint). This resulted in 40.3 mm of water run-off from soil, which could contribute to the discharge into waters and rivers adjacent to the farm of any surplus of chemical fertiliser and soil protection products applied across the 3.5 ha of potatoes.

In livestock farming, the greenhouse gas category with the highest emission rate was enteric fermentation from animal digestion (2,106 tCO_{2eq}/year), followed by emissions from animal grazing (465 tCO_{2eq}/year), and on-farm animal manure management (257 tCO_{2eq}/year) (Table 3).

Table 3. Annual greenhouse gas emissions from livestock farming for the six farms surveyed in the case study using Cool Farm Tool.

Category of Greenhouse Gas Emissions	**Greenhouse Gas Emmissions (t CO_{2eq} / year)**

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Grazing of breeding beef	402.4
Grazing of finishing beef	62.6
Grazing of other livestock	na
Enteric fermentation breeding beef	1489.8
Enteric fermentation finishing beef	314.2
Enteric fermentation other livestock	302.8
Manure management in breeding beef	42.9
Manure management in finishing beef	210.7
Manure management in other livestock	3.5

In the UK case study, the overall greenhouse gas emissions from cropland and livestock farming ranged from 166 to 2,531 t CO_{2eq}/year (Table 4). Livestock farming emitted approximately 4,160 t CO_{2eq}/year and resulted in a ranking from highest to lowest of farms: Farm 4 > Farm 3 > Farm 8 > Farm 1. The total emissions from cropland resulted in emissions of 584 t CO_{2eq}/year and farm, ranking the farms (highest to lowest) as Farm 2 > Farm 4 > Farm 5 > Farm 1 > Farm 8. Therefore, the management practices characterizing Farms 1 and 8 (organic farms), produced direct climate benefits in both cropland and livestock enterprises.

Table 4. Annual greenhouse gas emissions for the six farms surveyed with Cool Farm Tool, reported for crops and livestock farming.

Farm	**Crops Emissions (t CO_{2eq}/year)**	**Livestock Emissions (t CO_{2eq}/year)**	**Total Emissions (t CO_{2eq}/year)**
Farm 1	22	420	**441**
Farm 2	178		**178**
Farm 3	41	772	**813**
Farm 4	176	2,355	**2,531**
Farm 5	166		**166**
Farm 8	2.3	613	**615**
Total	**584**	**4,160**	

Results from Farm 4 indicated that it had the highest emissions of greenhouse gases at the farm-level, the source of which was livestock, as well as it being the farm with the lowest intensity of greenhouse gas emission from breeding beef (0.17 kg CO_{2eq}/kg live weight). The latter was due to the annual turnover of more than 100 animals sold in 2018 (i.e. 40.7 tonne of live weight meat).

Conversely, Farm 1 had the lowest emissions at the farm-level, the source of which was beef farming. This low level of emissions was due to the limited number of animals sold in the calendar year 2018 (only 1 beef cattle) but producing the highest intensity of greenhouse gas emissions which was from the breeding beef enterprise (0.31 t CO_{2eq}/kg live weight). These results highlight, in particular, the limitation of surveying the farms over only one calendar year and so not reflecting the turnover of animals on farms between years.

In Farm 8, the organic agricultural practices resulted in the lowest intensity of greenhouse gas emissions from cropland (~24 kg CO_{2eq}/ha). The long-term organic fertilization carried out on Farm 8 (represented in Figure 3 by the yellow category) contributes to an increase in the stock of Carbon in arable soils at a rate of 265 t CO_{2eq}/year. The relatively large beef and

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sheep herd on this farm was the second largest source of greenhouse gases in the case study from enteric fermentation (551 t CO_{2eq}/year, Figure 3).

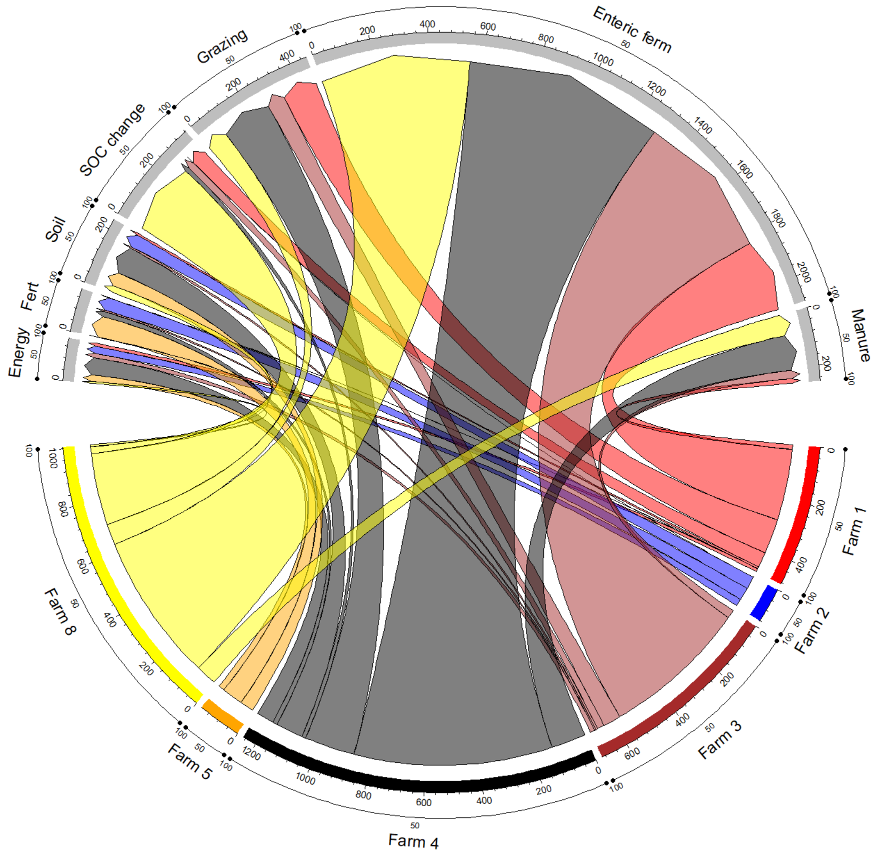

Figure 3. Circular plot presenting the environmental impact of greenhouse gas emissions of the six farms surveyed for distinct emission sources using Cool Farm Tool. From left to right the emissions sources are reported as: energy use in field and processing operations (Energy), fertilisers production (Fert), soil fertilization and plant protection practices (Soil), change is soil Carbon stock (SOC change), animal grazing (Grazing), animal enteric fermentation (Enteric ferm), and manure management (manure). (Legend: Farm 1, red; Farm 2, blue; Farm 3, pink; Farm 4, grey; Farm 5, light green; Farm 8, yellow).

The conventional and transitional Farms 2, 4 and 5 use mineral fertilisers and crop protection products. Their use on these three farms resulted in the cumulative greenhouse gas emissions from soils representing approximately 83% of the overall soil greenhouse gas emissions (i.e. 198 t co2eq/year), and 96% (i.e. 144 t co2eq/year) of the overall emissions deriving from the industrial production of the fertilisers used in the Utilised Agricultural Area of the UK case study.

IMPACT OF FARMING ON BIODIVERSITY AT FARM SCALE

The farming practices that benefit biodiversity on the six farms evaluated using Cool Farm Tool were based upon their effectiveness across the area of the farm, and on the benefits from the actions on biodiversity. Two types of general actions are provided by Cool Farm

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Tool which are based upon: (i) the use of products and the application of practices providing general biodiversity benefits (Figure 4a); and (ii) the extent of farmland upon where the actions could potentially provide some benefits to biodiversity (small and large areas) (Figure 4b). In the organic farms (Farms 1 and 8) the management practices and organic products used across the farmland resulted in the highest values for biodiversity in the case study. While, on the conventional and transition farms (Farm 2, 3, 4, and 5) the use of chemical fertilisers and crop protection products limited their general biodiversity scores. These observations are consistent with those obtained from SMART-Farm Tool (Figures 5 and 7).

In the organic Farm 1, however, the beneficial actions on biodiversity were applied primarily in the small units of the farm. Due to application of wildlife-friendly management practices in the marginal, non-productive small areas, higher scores were produced by the conventional and transition Farms 2 and 3 than those by the organic Farm 1 (Figure 4b). However, in SMART-Farm Tool the assessment for these three farms indicates that Farm 1 has higher scores for ecosystem diversity (67%) and species diversity (74%) than Farms 2 and 3.

Using Cool Farm Tool, additional biodiversity scores were evaluated for the identification of positive actions towards specific flora and fauna group species. In this case, organic Farm 8 showed a consistently high score for grassland, woodland and wetland habitats for both flora and fauna from Cool Farm Tool. Farm 1, also organic, does not have specific practices which lead to encouraging the presence of any particular species of flora and fauna on the farm (Table 5) but, as noted above, from analysis in SMART-Farm Tool it scores relatively high for ecosystem diversity (67%) and species diversity (74%), although lower for genetic diversity (55%).

Table 5. Summary of the scores for six farms (surveyed using Cool Farm Tool) for the actions carried out to benefit the flora and fauna species in specific habitats.

	Habitat Type	**Farm 1**	**Farm 2**	**Farm 3**	**Farm 4**	**Farm 5**	**Farm 8**
Flora	Arable	50%	50%	17%	33%	17%	39%
	Wetland and Aquatic	5%	32%	18%	32%	14%	95%
	Woodland	57%	100%	43%	71%	14%	86%
	Grassland	37%	53%	40%	50%	17%	73%
Fauna	Arable	42%	58%	13%	45%	21%	58%
	Woodland	40%	69%	20%	60%	14%	57%
	Grassland	32%	47%	38%	53%	15%	74%
	Aquatic	25%	57%	29%	48%	25%	80%
	Soil	64%	42%	47%	42%	11%	53%
	Invertebrates	33%	57%	24%	44%	17%	57%
	Total	**385%**	**565%**	**289%**	**478%**	**165%**	**672%**

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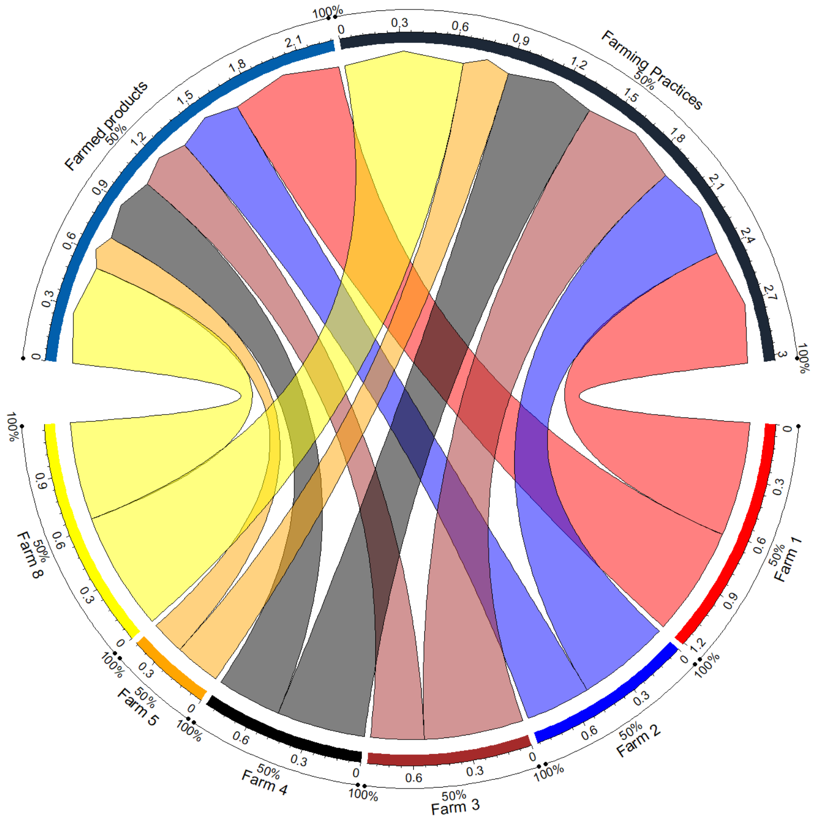

Figure 4(a). Circular plot presenting the score of products and practices providing general biodiversity benefits on the six farms surveyed with Cool Farm Tool. (Legend: Farm 1, red; Farm 2, blue; Farm 3, pink; Farm 4, grey; Farm 5, light green; Farm 8, yellow).

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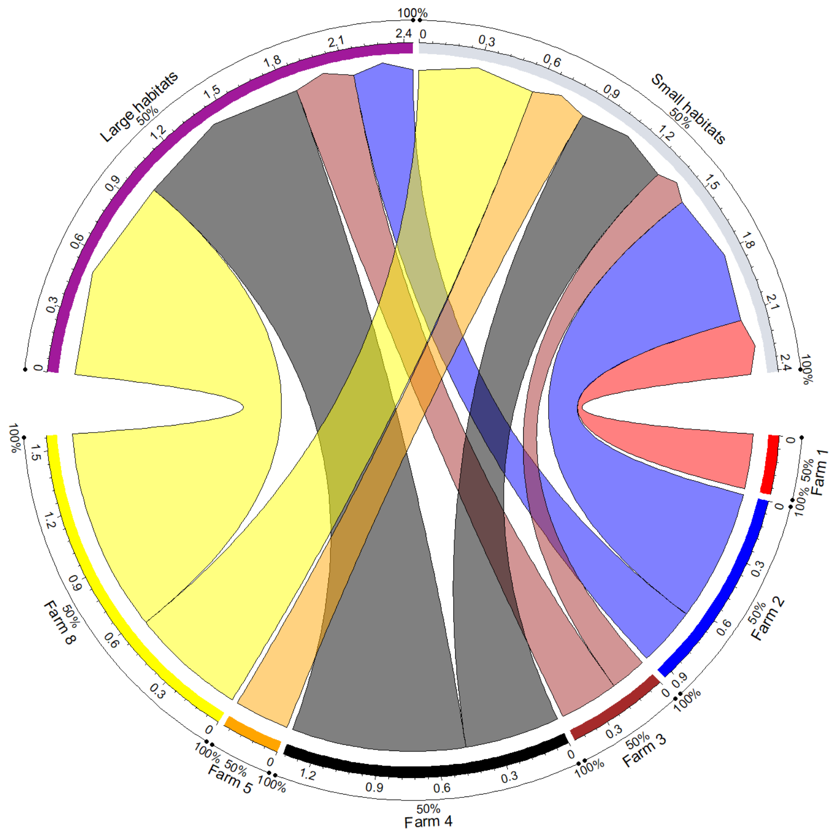

Figure 4(b). Circular plot reporting the score of the extent of farmland upon where actions could potentially provide benefits for biodiversity. (Legend: Farm 1, red; Farm 2, blue; Farm 3, pink; Farm 4, grey; Farm 5, light green; Farm 8, yellow).

SOIL QUALITY

The overall assessment score for Land in the 'Hypothetical Farm' is 65%, based upon scores for Soil Quality of 62% and land degradation of 64%.

There are no significant differences between different farm practices or farming systems. The assessment scores for land degradation overlap for the different types of farm practices and farming systems. The assessment scores from SMART-Farm Tool range from 47% (conventional, general cropping, Farm 5) to 70% (organic, general cropping, Farm 14). However, another farm with conventional general cropping has a score of 60% and organic general cropping of 65%. Farms with Mixed farming with livestock have scores of between 61% and 69%.

With only the observation for 2018/19 no further interpretation is appropriate.

WATER QUALITY

The overall assessment score for Water in the 'Hypothetical Farm' is 63%, based upon scores for Water Withdrawl of 61% and Water Quality of 69%.

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The assessment scores from SMART-Farm Tool for Water Quality range from 47% to 87%. The highest and lowest scores are for the same two farms as those for Soil Quality (Farm 65 and Farm 14 respectively). The other scores overlap for the different farm practices and farming systems. As was the case for soil quality, with only the observation for 2018/19 no further interpretation is appropriate.

PRODUCTIVITY

Data are available from COMPAS for five farms (2, 3, 4, 5 and 8). On these farms, the labour force (Annual Work Unit) ranges from 2.0 (Farm 2) to 4.0 (Farm 3) (Figure 5a). Of these, there are no family Work Units on Farms 2 and 3 (which are owned by an organisation), compared to between 33% and 100% of work units being from the family for Farms 3, 5 and 8. Labour Productivity ranges from -£7,346, the only farm with a negative value for productivity, to £58,773 (Figure 5b). In that respect, the negative value of labour productivity of Farm 2 resulted from the relatively low Net Value Added of the farm, which excluded the remuneration of the permanent stuff.

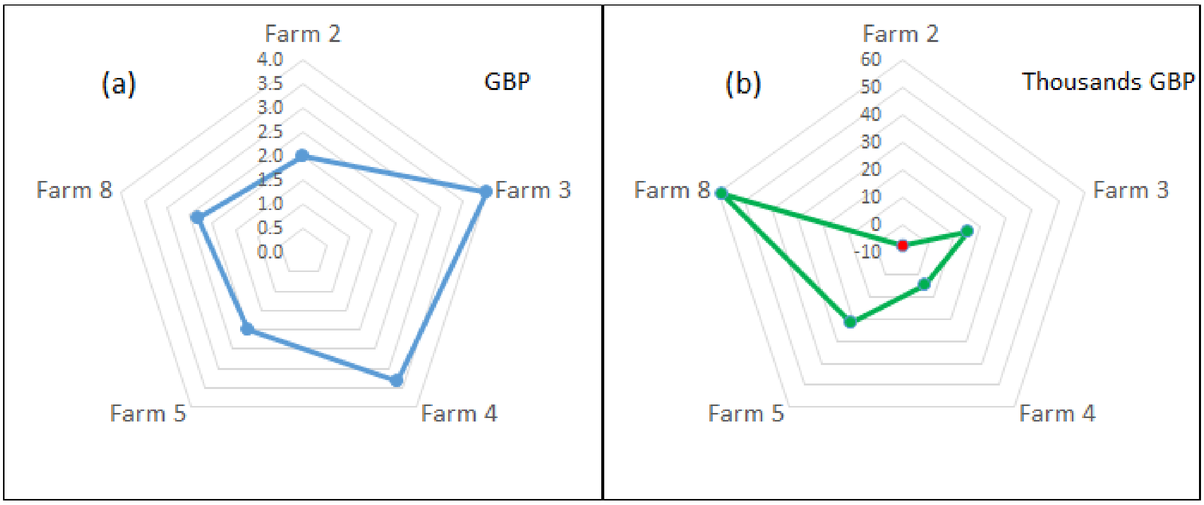

Figure 5. Data for five farms for which data are available from COMPAS (2, 3, 4, 5 and 8): (a) Annual Work Unit; (b) Annual Labour Productivity. The red point corresponds to a negative value.

FARM INCOME

Across these five farms, the Net Value Added (all farm incomes and subsidies minus all farm costs and depreciations) ranged from -£14,692 to £135,179 (Figure 6a). The negative Net Value Added for one farm was due to the relatively low subsidies declared (£57,698) and high annual depreciation values (£64,428). The farm with the highest Net Value Added was due to its relatively high annual subsidies (£96,304 from several agri-environmental direct payments).

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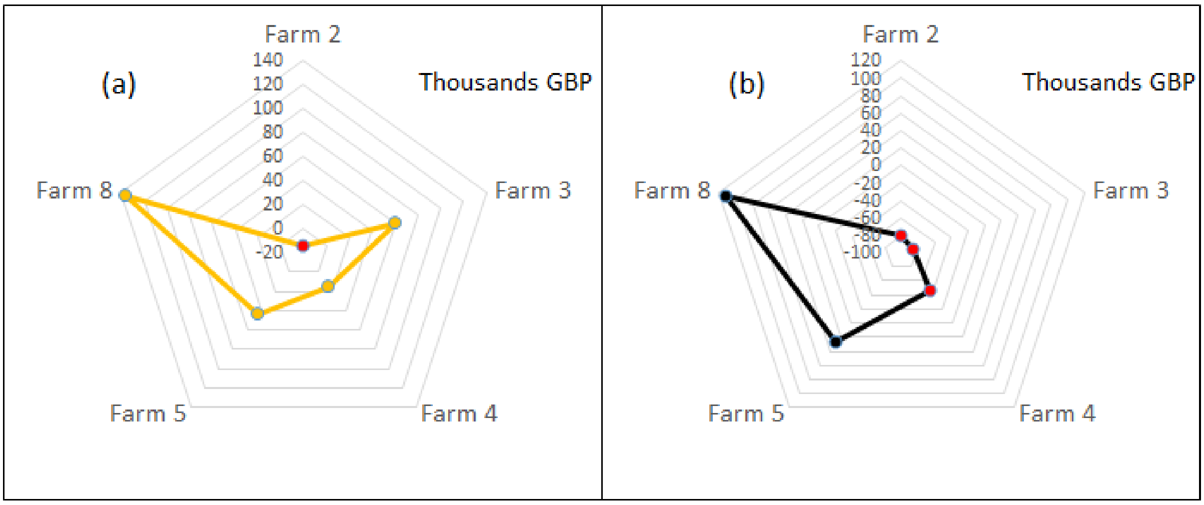

Figure 6. Data for five farms for which data are available from COMPAS (2, 3, 4, 5 and 8): (a) Net Value Added (a); (b) Net Farm Income. The red points correspond to negative values in the plots.

The sources of income for the five farms shows significant contrasts, reflecting the types of farm. Farm 2 has the greatest diversity in the number of crops (7), compared to 3 crops for Farm 5. However, the income from crops for Farm 2 is predominantly from one crop, Spring barley (72%). Farm 8 has the greatest diversity in sources of income, deriving from livestock (sheep, cattle), horses, and a small amount from crops (Spring barley).

As noted above, Farms 5 and 8 are different types of farming systems and types. Farms 2 and 3 are owned by the same organisation, but are run independently and as businesses. Farm 4 is an independent business. In that respect, Net Farm Income (Net Value Added - Total External Factors) is negative for three farms (Farms 2, 3 and 4) and positive for two (Farms 5 and 8), ranging from -£85,974 to £113,179 (Figure 6b). For Farm 2 the Net Farm Income reflects its annual Net Value Added (see above). While for Farm 3 the negative income is due to the relatively high value of Total External Factors Costs (£154,500 from annual wages for the four permanent workers). Finally, for Farm 4 the negative income can be explained by its relatively high annual depreciation value of machinery and farm buildings (£100,000) which affected the overall annual Net Value Added.

The overall assessment score for Investment in the 'Hypothetical Farm' is 65%, under which Profitability is 68%. The range in levels of profitability are from 53% (for an organic general cropping farm) to 77% (associated with a conventional general cropping farm). The ranges in values overlap for each of the types of farming system and farm types. As observations were only for 2018/19 no further interpretation is appropriate.

QUALITY OF LIFE

The overall assessment score for Decent Livelihood in the 'Hypothetical Farm' is 66%, based upon scores for which Quality of Life is 75%, Capacity Development is 50% and Fair Access to Means of Production is 73%.

All of the assessment scores from SMART-Farm Tool for Quality of Life range from 68% to 87%, which are relatively high. The highest three scores are for Farms 6 (87%), 2 (85%) and 3 (83%) in which the farmer is at least a second generation farmer, which is also true of all

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farms except Farms 1 and 14 which are believed to be first generation farmers. The evidence is weak, but it is possible that the high rating of quality of life is a reflection of a belief in farming as a vocation and associated positive motivation.

There is no distinction apparent due to farming systems or types.

16.4. General Differences and Similarities Between Farm Groups

Farms which are operating convention farming practices have different patterns of assessment scores for their characteristics as recorded with the SMART-Farm Tool (Figure 7). They reflect differences between the farming systems of Mixed farming with livestock (Farm 3) and those which are General cropping (Farms 2 and 5).

Broadly, the levels of Environmental Integrity are similar, reflecting regulatory requirements for crop management (e.g. timing of straw burning), restrictions on outflows of inputs into water courses and on the types of pesticides and heribicides which can be used. However, as there are few regulatory constraints that relate to biodiversity, each of these farms score lower on that characteristic. Also reflecting regulatory requirements, the standards of animal welfare scores highly for the study farm which has livestock.

Under Good Governance the farms show considerable differences, but within which there are similarities. Notable amongst those similarities are the relatively low level of accountability for two of the three farms (19%, 27%), which reflects the nature of tenure of private ownership or rented land. The relatively high levels of participation across the three farms (58% to 77%) is explained, in part, by high scores for Farms 2 and 3 which are operated as part of an organisation which has formalised processes (e.g. grievence procedures, and training in conflict resolution) and a remit for facilitating public dialogue (e.g. hosting farm engagement events). The nature of Farms 2 and 3 is also reflected in assessments of Social well-being of labour rights, health and safety and decent livelihood.

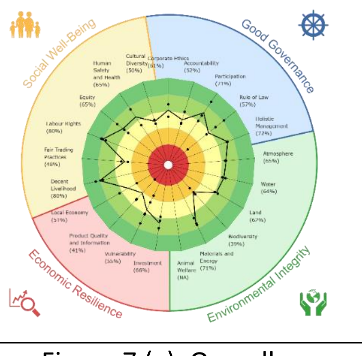	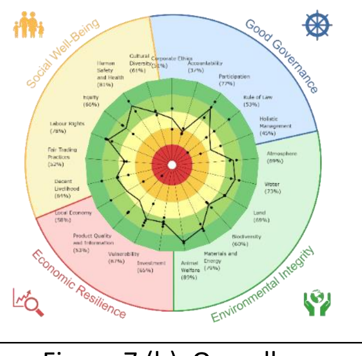	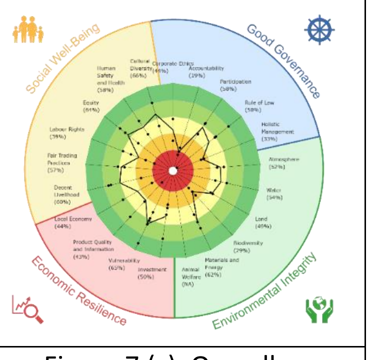
Figure 7 (a). Overall assessment: Farm 2	Figure 7 (b). Overall assessment: Farm 3	Figure 7 (c). Overall assessment: Farm 5

Figure 7. Overall assessments from SMART-Farm Tool, for farms using only conventional farming practices.

Farms which use transitional farming practices have some similarities, and others which are substantively different, as measured by the SMART-Farm Tool (Figure 8). There are relatively high scores for animal welfare, materials and energy (73% and 80%), and similarities in

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Environmental Integrity, notably for atmosphere, water and land. These are explained by the on-farm generation of renewable energy (which also relates to the highest assessment score for internal investment, 76%) and waste reduction and disposal, and adherence to the requirements of regulation and best practice.

Differences are evident in assessment scores for Social Well-being and Good Governance. For example equity (38% and 79%) reflects the composition of the businesses (e.g. gender) and the current employment or uptake of opportunities for gaining experience (e.g. support for vulnerable people). Assessments for participation are both relatively high reflecting the requirement for formal public engagement as part of the process of gaining planning permission for wind turbines (94%), and the knowledge and role of a farmer in engaging in dialogue with other farms through the representative body (67%).

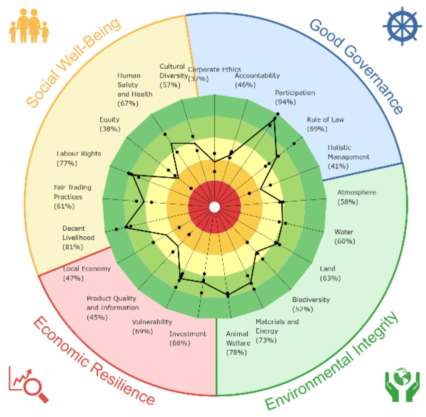

Figure 8 (a). Overall assessment: Farm 4

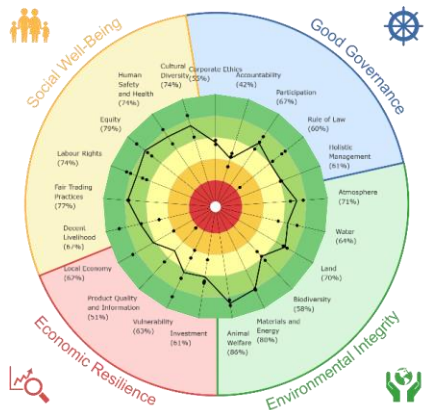

Figure 8 (b). Overall assessment: Farm 6

Figure 8. Overall assessments from SMART-Farm Tool, for farms using transitional farming practices.

Farms which have an organic status for their farming practices (Farms 1, 8, 10 and 14), for both the Mixed farming with livestock and General cropping farming systems, have certain characteristics in common. They have broadly similar scores for characteristics of Environmental Integrity of atmosphere, water and land. The spider diagrams of the overall farm assessment, from SMART-Farm Tool, are shown in Figure 9 (a to d). These farms have relatively high assessment scores for human health and safety (86% to 92%), animal welfare (78% to 94%), and product quality and information (72% to 85%).

The two lowest assessment scores are for holistic management (18% and 27%), which reflect the lack of a system, need and resources for full-cost accounting and a formal sustainability management plan for small farm businesses. The relatively low scores for accountability (32% to 48%) have similar explanations in relation to holistic audits, or the provision of information for public audiences (e.g. by WWW sites).

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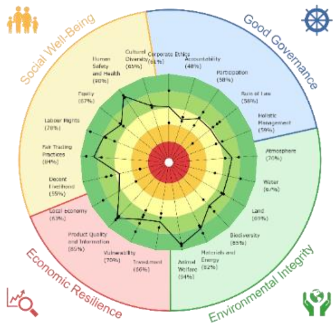

Figure 9 (a). Overall assessment: Farm 1

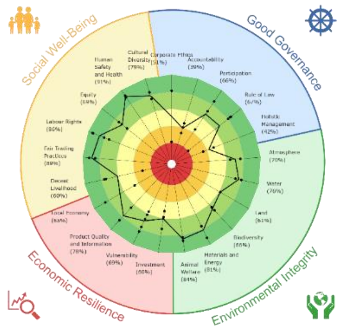

Figure 9 (b). Overall assessment: Farm 8

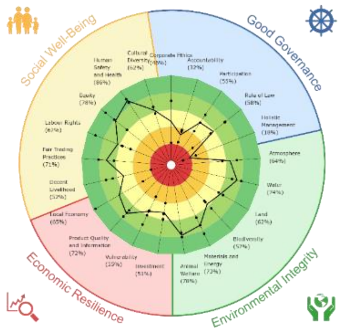

Figure 9 (c). Overall assessment: Farm 10

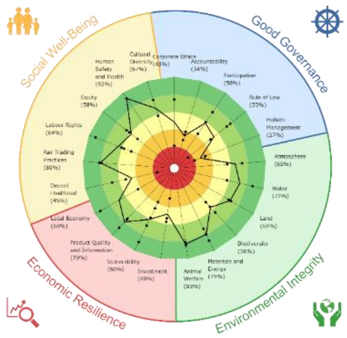

Figure 9 (d). Overall assessment: Farm 14

Figure 9. Overall assessments from SMART-Farm Tool, for farms using organic farming practices.

Further differences between groups, where the range of scores from SMART Farm Tool do not overlap between the farms identified as either operating conventional farm practices or organic practices, are those for Fair trading practices (organic: 71% to 89%; conventional: 48% to 57%), with those in transition being between (61% to 77%).

Selected observations on overall similarities between groups are: (i) the ranges of profitability (based upon SMART-Farm Tool) overlap for all types of farm practices and systems; (ii) the high levels of perceptions of the quality of life from farming; and, (iii) positive profitability (i.e. a score of more than 50%), albeit with a broad range in values as noted under the in-depth topic analysis on farm income.

16.5. Trade-offs and Synergies Between the Focus Topics

The data captured and reported relate to approximately one year across 2018 and 2019. Without a second set of results for a different snapshot in time the assessment of where trade-offs are being made is restricted to interpretation of the interviews with farmers.

No evidence can be interpreted from SMART-Farm Tool of any trade offs made between environmental public goods (land, water and air, and biodiversity). As noted above, the

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ranges in the assessment scores for each type of farm practice and farming system overlap. Regulatory requirements limit variation in water quality, which is confirmed by the assessment.

Synergies are sought from the addition of cattle to the farm for the provision of on-farm manure for consistency with status of organic certification, or in a transition, while focusing on crops as the principal enterprise.

Farms 2 and 3 are while owned by the same organisation, are different farming systems, and operate independently. They share overarching policies (e.g. health and safety, labour rights, mission statement) and some opportunities for civil responsibility and public engagement. They may benefit from sharing and access to information in terms of a progressive transition towards agro-ecological farming systems, but this will be limited in terms of their operational activities.

There is no other evidence of significance of synergies between groups.

16.6. Synthesis of Task 3.2 Results in The Case Study

The dilemma being tackled in the UK case study is the production of public goods whilst maintaining viable production of private goods, and securing economic and social sustainability at a farm level.

Highlights identified from the results of the analysis are:

- All of the farms deliver to regulatory outputs and associated processes, such as financial reporting, agricultural census, applications for farm payments. However, the business contexts, governance and size of the farms influence their needs and organisational infrastructure to create formalised strategies which form part of the assessments of Social Well-being and Good Governance (using the SMART-Farm Tool). The nature of some indicators means that it is unlikely that they will change significantly through time, therefore making it more challenging to track their transition towards agro-ecological farm systems.
- Farms which use, or are in transition towards, organic farming practices are adding livestock for the on-farm production of manure. To do so, arable farms expand their systems accordingly. That means that farms that are solely general cropping with organic status are few in number.
- Processes associated with a transition position between conventional and organic status such as farms with on-farm renewable energy production have adhered to regulatory requirements of public consultations and engagement with neighbours. However, the high scores of engagement also reflect the farmer’s use of such new facilities as a focus for facilitating visits from community groups and schools. So, the content of the transition, which leads to a high score for stakeholder dialogue (100%), is reinforced by a process which leads to high scores for conflict resolution (95%). Therefore, over time that internal investment (76%) will have multiple benefits across energy use (66%).
- All of the farmers in the case study convey a belief of a high quality of life associated with their farm and farming activities. This is irrespective of type of farming system

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and practice. There is suggestive evidence of the highest levels of perceived quality of life being associated with those who are second or third generation farmers.

Overall, the analysis of the farms in the UK case study show a high level of delivery with respect to the overarching dilemma. Public goods are being delivered across the farms of each type of farming practice. In both farming systems, environmental (e.g. land, atmosphere, water), animal health and welfare, outputs of food quality and food safety are contributing to economic sustainability through local procurement and stability of both production and supply (i.e. demand). Additionally, the process of operating the farms is compatible with social well-being (e.g. workplace safety and health) and fair access to means of production, and fair trade practices.

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16.7. Appendix 1 to UK report: Representation of the Hypothetical Farm, as Derived from SMART-FARM TOOL, in the UK Case Study

The Hypothetical Farm for the UK case study has been calculated. Figure Apps. 1 to 4 show the representation of results for the Economic Resilience, Environmental Integrity, Good Governance and Social Well-being.

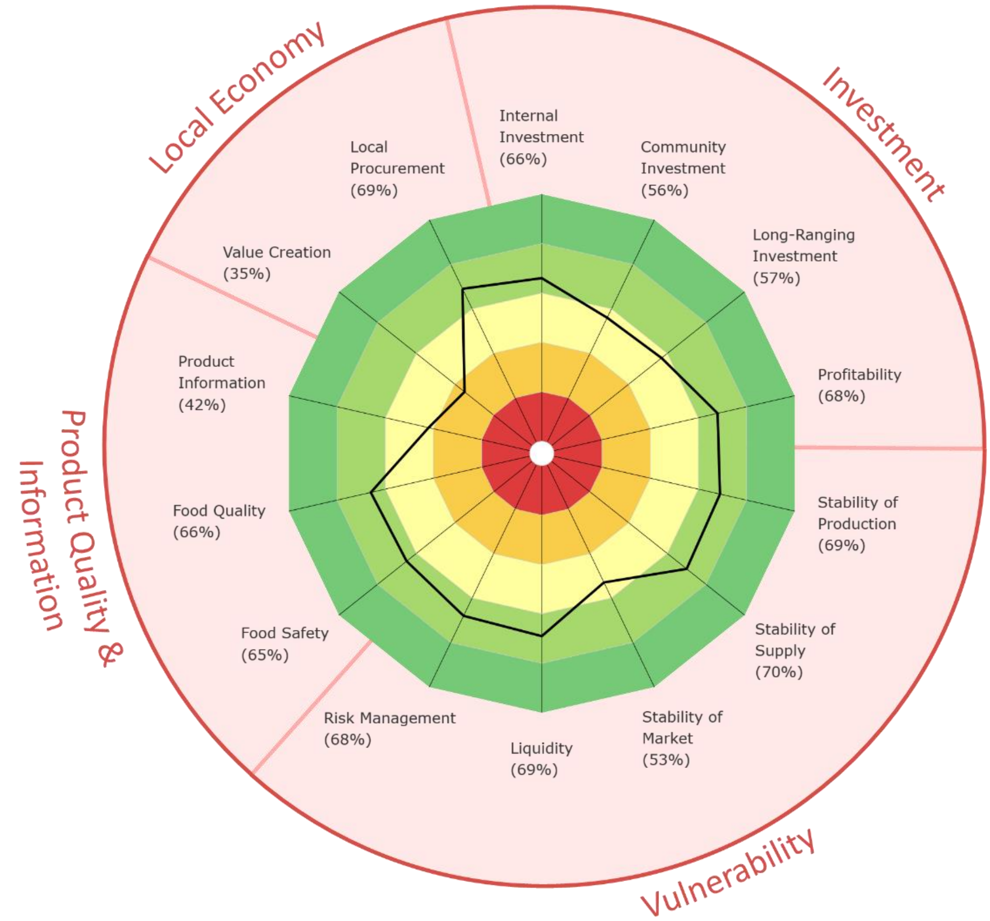

Figure App. 1. Representation of results for the Hypothetical Farm in the UK Case Study: Economic Resilience. Based on SMART-Farm Tool assessment conducted during May to September 2019 with nine farms.

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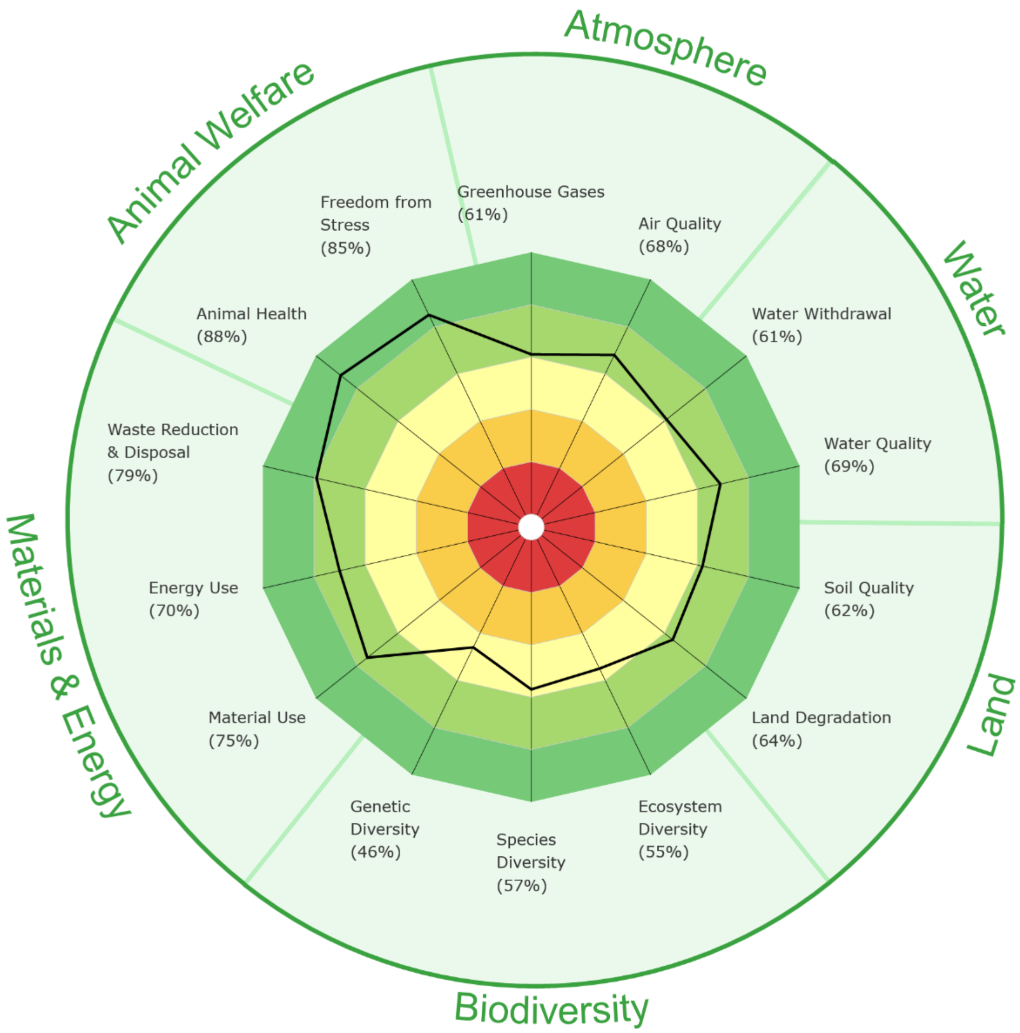

Figure App. 2. Representation of results for the Hypothetical Farm in the UK Case Study: Environmental Integrity. Based on SMART-Farm Tool assessment conducted during May to September 2019 with nine farms.

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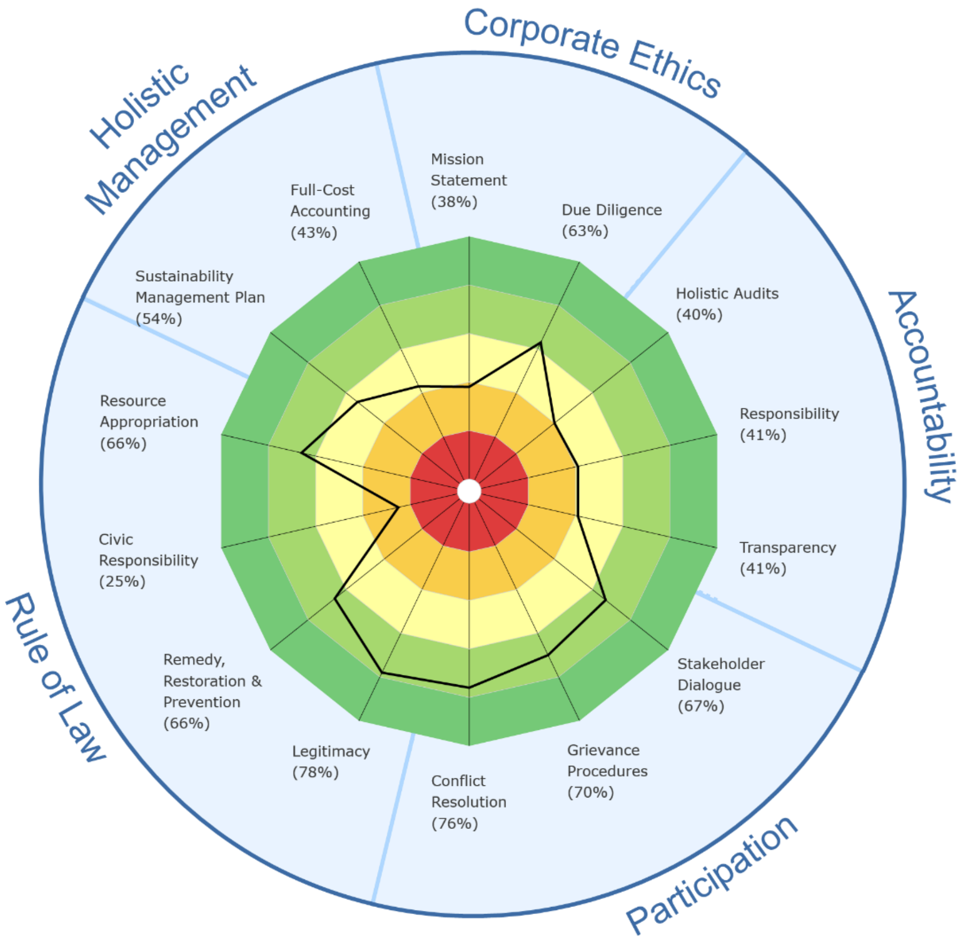

Figure App. 3. Representation of results for the Hypothetical Farm in the UK Case Study: Good Governance. Based on SMART-Farm Tool assessment conducted during May to September 2019 with nine farms.

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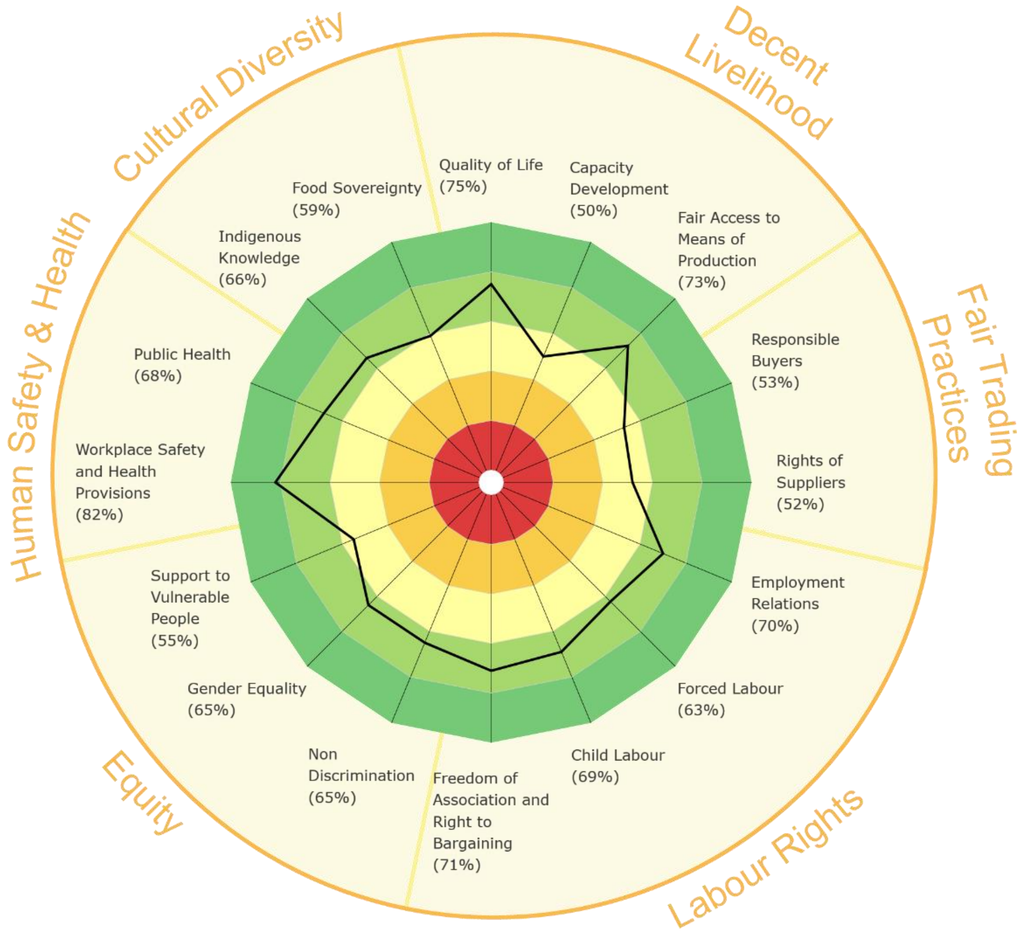

Figure App. 4. Representation of results for the Hypothetical Farm in the UK Case Study: social well-being. Based on SMART-Farm Tool assessment conducted during May to September 2019 with nine farms.

Farm sustainability performance data is contained in deliverable D3.2.

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