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Multicriteria assessment of co-designed future farming systems report based on pilots' data.

WP4 – Task 4.1 Multicriteria assessment of mixed farming and agroforestry sustainability and resilience at farm level

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Index

Index *3*

1 Context and method *5*

1.1 Introduction **5**

1.2 Conception of decision trees and choice of indicators for resilience and sustainability assessment **5**

1.3 Diversity of pilot sites **7**

1.4 Calculation and adaptation of indicators for the multi-criteria assessment per pilot site **8**

2 Summary of results of the multicriteria assessment of sustainability and resilience in the 12 pilot sites *10*

2.1 Sustainability and resilience evolution between the current system and the co-designed one on pilot sites assessed **10**

2.2 Tools and method feedback **11**

3 Multicriteria assessment of pilot sites *12*

3.1 Blue Pig Farm – French pilot (ITAB) **12**

3.1.1 Pilot site description 12
3.1.2 Sustainability and resilience assessment 16
3.1.3 Tools and methods: feedbacks 27
3.1.4 Take-away messages 28

3.2 La Barrossa Farm – Spanish pilot (UNEX) **30**

3.2.1 Pilot site description 30
3.2.2 Sustainability and resilience assessment 34
3.2.3 Tools and methods: feedbacks 41
3.2.4 Take-away messages 42

3.3 Stadtbauernhof Saarbrücken – Germany pilot (IfaS) **43**

3.3.1 Pilot site description 43
3.3.2 Sustainability and resilience assessment 45
3.3.3 Tools and methods: feedbacks 52
3.3.4 Take-away messages 53

3.4 OIKOS Farm – Polish pilot (OSA) **54**

3.4.1 Pilot site description 54
3.4.2 Sustainability and resilience assessment 57
3.4.3 Tools and methods: feedbacks 63
3.4.4 Take-away messages 63

3.5 PHAE – Belgian pilot (ILVO) **64**

3.5.1 Pilot site description 64

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.5.2 Sustainability and resilience assessment ... 66
3.5.3 Tools and methods: feedbacks ... 72
3.5.4 Take-away messages ... 72

3.6 Al Confin Organic Farm – Italian pilot (Venagro) ... 73
3.6.1 Pilot site description ... 73
3.6.2 Sustainability and resilience assessment ... 78
3.6.3 Tools and methods: feedbacks ... 85
3.6.4 Take-away messages ... 86

3.7 Marstan Vale – UK pilot (CRAN) ... 87
3.7.1 Pilot site description ... 87
3.7.2 Sustainability and resilience assessment ... 90
3.7.3 Tools and methods: feedbacks ... 97
3.7.4 Take-away messages ... 97
3.7.5 Appendix ... 98

3.8 Cheese Valley – Italian pilot (SSSA) ... 99
3.8.1 Pilot site description ... 99
3.8.2 Sustainability and resilience assessment ... 102
3.8.3 Tools and methods: feedback ... 114
3.8.4 Take-away messages ... 114

3.9 Swiss Agroforestry Network – Swiss pilot (ZHAW) ... 116
3.9.1 Pilot site description ... 116
3.9.2 Sustainability and resilience assessment ... 120
3.9.3 Tools and methods: feedbacks ... 126
3.9.4 Take-away messages ... 126

3.10 Rudno Farm – Serbian pilot (NRDS) ... 127
3.10.1 Pilot site description ... 127
3.10.2 Sustainability and resilience assessment ... 131
3.10.3 Tools and methods: feedbacks ... 141
3.10.4 Take-away messages ... 142

3.11 Curralões – Portuguese pilot (MVARC) ... 143
3.11.1 Pilot site description ... 143
3.11.3 Sustainability and resilience assessment ... 147
3.11.4 Tools and methods: feedbacks ... 154
3.11.5 Take-away messages ... 155

3.12 Winthagen – Dutch pilot ... 156
3.12.1 Pilot site description ... 156
3.12.2 Sustainability and resilience assessment ... 161
3.12.3 Tools and methods: feedbacks ... 167
3.12.4 Take-away messages ... 168

4 References ... 169

5 Annexes ... 170

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

1 Context and method

1.1 Introduction

AGROMIX project aims to drive the transition towards resilient farming, efficient land use management, and more sustainable agricultural value chains in Europe. To study viable mixed farming and agroforestry (MF/AF) systems, the AGROMIX project permitted us to follow 12 co-design pilot sites in Europe where the transition of farming practices is on the way. The aim of WP2 was to develop a participative co-design approach to design innovative systems including practices of MF and AF on specific contexts. Different scenarios were co-designed on pilots. The activities of WP4 aim to collaborate with other WPs, particularly WP2, to support the participatory approach by implementing tools such as multi-criteria assessment, participatory mapping, and the AGROMIX app. This collaboration seeks to facilitate the transition toward more sustainable mixed-farming and agroforestry systems.

The aim of the Task 4.1 of the AGROMIX project is to evaluate and compare, at pilot site level, the environmental and socio-economic impacts of transition to MF and AF systems through a multi-criteria assessment of sustainability and resilience. In fact, the multi-criteria assessment is based firstly on pilots' data for the ex-ante evaluation and, on subsequently, on the projection of the co-designed systems by pilot actors. At each pilot site, one or two co-designed scenarios have been developed. Comparing the sustainability and resilience of different farm system scenarios within each pilot site to the current system allows for an enhanced understanding of the strengths, weaknesses, and areas for improvement in these mixed farming and agroforestry systems. As the philosophy of AGROMIX is that the pilots are representative / inspirational for a large share of farmers around Europe, resilience and sustainability performances, farming practices and shared strategies will be shared and lead to more generic insights outside of the project.

1.2 Conception of decision trees and choice of indicators for resilience and sustainability assessment

Sustainability and resilience, these two concepts share overlapping goals and application areas while consensus on definitions is often lacking (Marchese et al., 2018). Both encompass environmental (ecological), economic and social dimensions. The concepts are similarly used to describe state of a system over time, resilience as a response of a system to disturbances or stress and sustainability focussing on the persisting quality of life (Marchese et al. 2018). Farming systems are resilient when their productivity and organisation sustains challenges by disturbances due to adverse variability of climate (Altieri et al. 2015, FAO 2018). According to the FAO, to be sustainable, agriculture must meet the needs of present and future generations, while ensuring profitability, environmental health, social and economic equity and contributing to food security.

A group composed by pilots' representatives and AGROMIX partners have built a generic framework of a common decision tree where pillars of the sustainability (Figure 1) and resilience (Figure 2) assessment are included. This first level of the decision tree is shaped according to three dimensions: social, economic, and environmental. After various meeting to co-design the methodology to follow for the assessment, two

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decisions trees regrouping "leaves" of indicators for the resilience assessment and the sustainability assessment have been finalised:

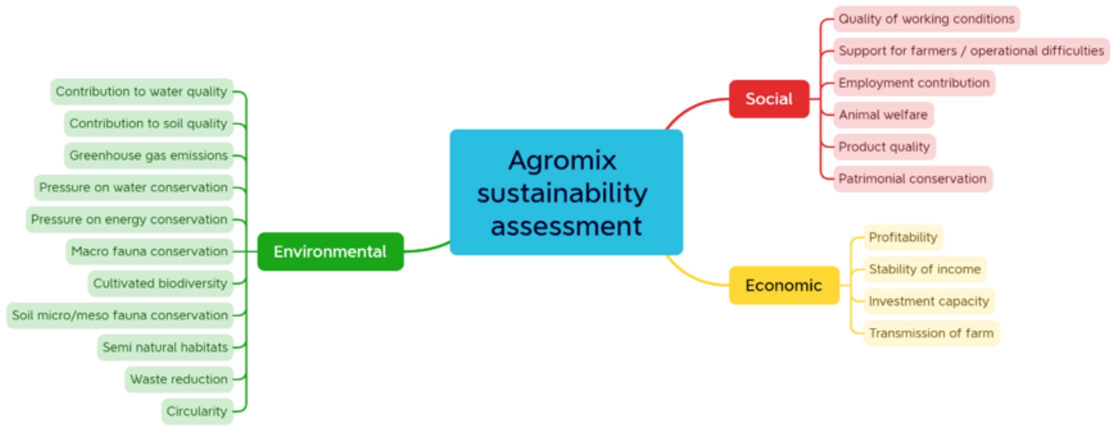

Figure 1 : Decision tree for the sustainability assessment of pilot sites

Figure 2 : Decision tree for the resilience assessment of pilot sites

The "leaves" (criteria per dimensions) have been defined regarding the diversity of pilot sites needed to be evaluated. Interviews with stakeholders of each pilot sites helped to consolidate them.

To perform the multi-criteria sustainability assessment, the common decision tree has been refined based on the indicators from the PG Tool (Organic Research Centre : **OCIS Public Goods Tool - The Organic Research Centre**), which has been used by other European projects (i.e. FABulous Farmers – Interreg NEW) "as a tool for raising farmers' awareness about sustainability and support their learning process".

To perform the resilience assessment, a proposition of indicators per resilience "leaves" have been proposed by WP1 partners. In the task 1.3, they created a resilience self-assessment tool available online (**https://agromixproject.eu/tools/resilience-self-assessment**). Details of the indicators and data required for the assessments are listed in Annexes 1 and 2.

According to the Grant Agreement, we planned initially to use the DEXI tool for the multi-criteria assessment of pilot sites. The DEXI tool is self-assessment tool for valuating farms sustainability, following a decision-tree structure. We kept the thinking of the tool, using a decision tree but used indicators from PG Tool and from the work of our colleagues from AGROMIX. The shift was prompted by a collective realisation that the DEXI

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tool, having seen fewer developments in recent times, may not offer the depth and breadth required for a nuanced assessment in the evolving landscape of sustainability and resilience. The PG Tool, on the other hand, stands out as a more robust and adaptable solution.

1.3 Diversity of pilot sites

The 12 co-design pilots are located in different biogeographical regions, with different land uses, management and socio-economic contexts and vary in size or type of production system, and are representative of a wide range of farming systems in Europe.

6 co-design pilots are based on real farms.
In Germany, Stadtbauernhof Saarbrücken is a small-scale farm (2 hectares) practicing soil conservation techniques and running a community-supported agriculture scheme. It currently cultivates a wide range of crops (almost 100 different vegetables, herbs, and flowers vegetables), and raises free-range chickens, and bees.
In Belgium, PHAE, is a larger arable farm without direct sales to consumers. It grows innovative and ancient cereals, with clover in the rotation, and develops "reduced-tillage" practices to restore the quality of the soil. Farmers are working on improving biodiversity on the farm implementing ponds, trees, hedges, and grass strips.
In France the Blue Pig Farm is a livestock farm combining organic pig farming (almost 500 pigs sold each year) and feed production. The famer is working on improving the autonomy of the farm (feed, litter) and the welfare of pigs. He is also concerned to improve diversity of productions and biodiversity on his farm.
Among farms pilot sites, we find two traditional and extensive farms producing meat. In Spain, La Barrosa farm is a typical traditional Spanish farming system, raising in free range 100 cattle and 150 Iberian pigs on 205 hectares of "dehesa" (extensive pasture with oaks). They sell pigs and cattle to intermediaries that send livestock to regional/national slaughters and the meat is sold in every kind of markets. In Poland, the OIKOS farm is a 300-hectares farm located in a hilly and protected area and covered by grassland grazed by cattle (cows and sheep). Pastures are mixed with individual trees and forest area.
The pilot site of Serbia is an example of a familial farm developed in the Nature Park "Golija" (South of Serbia). Farmers are cultivating 10 hectares harvesting cereals and potatoes. They raise animals (sheep, dairy cows, and pigs) for their own consumption of meat and dairy products and for the production of manure used for crops.
Inside the AGROMIX project, we also studied a non-productive farm looking for diversification of incomes. In the southwest of Portugal, the Curralões farm, extends for 240 hectares with 160 hectares covered by 130,000 *Pinus pinea* trees planted in the 1990s under an afforestation measure in the CAP Pillar 2. The farm is located in a territory dominated by game management and extensive livestock or arable production on low fertility soil. The farm itself with the pine trees, is not a productive farm, incomes came from CAP payments, but to develop independency form subsidies, farmers are exploring the option of opening the land up for innovative mixed farming.

The other pilots are based on regional or value chains networks and face therefore other challenges. The Swiss Agroforestry Network is a community of 140 landowners who are interested to share advice and knowledge. The network has created a community of farmers committed to implement agroforestry

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systems. The network spreads experiences and problematics regarding agroforestry systems and considers dynamics of similar and parallel initiatives to lead a national network to promote agroforestry.
In Tuscany (Italy), the Cheese Valley is about making the value chain of Pecorino Toscano PDO more sustainable through mixed farming and agroforestry. The cooperative's members face several environmental challenges, including soil erosion, important rainfall, and drought. To tackle these challenges, some members are testing climate-smart techniques (reduction of soil tillage, intercropping of grass and legumes, planting trees). In the Veneto region (Northeast Italy), the pilot groups seven farms of varying sizes and disciplines which are engaging with agroforestry and mixed agriculture techniques in a bid to boost the sustainability of their productions, soil fertility and biodiversity. The farms share common aims and some of their challenges, which include extending agroforestry techniques and use of hedgerows, expanding or beginning animal husbandry in rotation with main crops, introducing livestock into already existing woods and designing new agroforestry areas in combination with horticulture and arable crops.
In the Netherland, Winthagen is a region in the south of the Netherlands where changing weather conditions and years of intensive agriculture have led to problems with flooding and erosion. On this pilot site, the aim is to redesign the region together with the various stakeholders to reach different goals such as improving water management, landscape aesthetics, biodiversity, and economic viability.
In England, the pilot sites regroup 5 farmers from the Marston Vale, an area of fertile land for diversified crops such as wheat, barley, oats, oilseed rape and beans and plots of forest. Farmers also raise livestock such as sheep, pigs, and cattle. In response of the objective of the National Farmers Union (NFU) to achieve net zero greenhouse gases (GHG) emissions *"across the whole of agriculture in England and Wales by 2040"* (NFU, 2019), the group of five farmers decided to work on the reduction of GHG emissions on their farms.
For this work of multi-criteria assessment some pilots decided to focus the assessment on one or two specific farms: it is the case of pilots from Switzerland, England, Veneto and Tuscany region in Italy.

1.4 Calculation and adaptation of indicators for the multi-criteria assessment per pilot site

The diversity among pilot sites, contexts and productions requires an adaptation of the multi-criteria assessment, choosing the most appropriate indicators to appreciate evolution of resilience and sustainability between the current system (ex-ante) and the co-designed one (ex-post). These multi-criteria assessments do not have the ambition to provide a "real" score of sustainability and resilience on pilot sites. The aim of this work is to compare evolution in systems implementing mixed and agroforestry practices, with a defined set of criteria in a co-determined perimeter based on actors' perception and awareness (see part 1.2).

Assessments calculations are based on a set of indicators. Indicators permit to calculate a score for each basic criteria (the "leaves") that compose the final output on each dimension. Each indicator is assessed by several questions relative to the indicator.

As the selection of indicators needs to be tailored to the specific conditions of each pilot, a diverse range of indicators is provided for various pilot sites. Pilots' ambassadors have the flexibility to choose whether to

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include certain indicators in the assessment based on their relevance to the local context. Furthermore, for a more precise adaptation, it is necessary to assign a weight to each question.

Thus, to calculate the score of one "leaf", the score of each question include in it is weighted (total 100% per indicator). Like this, assessments can be more adapted, but each choice of weight must be explained. In this way local specificities are considered, and assessments result to be more relevant. For each question, a score between 1 and 5 must be set. This is why, thresholds are defined as the range of values within which we can identify the indicator as 'high', 'medium', 'low' regarding the question considered. Thresholds lay within a range of realistic values/options, for example, given crop rotation as an indicator for soil fertility, the proper thresholds has been defined together with the stakeholders involved, (e.g. below).

Indicator	Measure	High resilient	Resilient	Low resilient
Crop rotation	Unit (years)	>4	3-2	<2

Initial values of weights to create those assessments are pre-set on the base of both work of WP1 and PG Tool. So, to do this step, each component of indicators has been checked: is the question adapted or possible in the context of the pilot site? If yes, the question is kept and allow to calculate score for the indicator with a weight (>0%). If no, the question is rejected, and the weight is 0%. If there is other question relevant to calculate the indicator, the total sum to calculate the indicator should be always 100%.
Also, weight of each indicator is pre-set to calculate the basic criteria/"leaf". The modification of the weight of indicators is possible with proper explanations (Annexes 1 and 2).

Calculation structure:

$$Basic\ Criteria\ (final\ output) = Score\ i_n \times Weight\ i_n$$

Where:

$$Score\ i_n = Score\ iQ_n \times Weight\ iQ_n$$

Where:
i = Indicator
iQ = indicator question "to be addressed"
n = number of indicators and questions

Example from sustainability assessment to calculate the basic criteria "contribution to soil quality" of the environmental dimension:

asic criteria / "leaf"	current Score	future Score
Contribution to soil quality	2,2	3,3

Sustainability Indicators	Weight	current Score	future Score
Soil analysis	25%	1,8	3,8
Herbaceous soil cover	25%	2,0	3,0
Winter grazing	25%	3,0	3,0
Measures taken to reduce the risk of Erosion	25%	2,0	3,5

Data/ Information to ' be addressed' measure the indicators / Questions	Weight	current Score	future Score
How often do you undertake soil analysis?	20%	0,2	0,6
Are you increasing, decreasing or maintaining Soil Organic Matter levels?	80%	1,6	3,2
What is the average yearly %of soil cover ? (visual observation or NDVI value)	100%	2,0	3,0
Do you out winter cattle?	50%	0,5	0,5
How would you describe area used of cattle during winter ?	50%	2,5	2,5
On what percentage of your land are you either implementing cultivation that reduces risk of erosion on arable land (eg minimum tillage and contour ploughing) or permanent pasture ?	50%	1,5	2,0
What is the edge linear in meter per hectare of tree and shrubs ? (Including Agroforestry)	50%	0,5	1,5

Figure 3 : Extract from the tool to the assessment of the sustainability of the basic criteria "contribution to soil quality"

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2 Summary of results of the multicriteria assessment of sustainability and resilience in the 12 pilot sites

2.1 Sustainability and resilience evolution between the current system and the co-designed one on pilot sites assessed

As mentioned in part 1.3, pilot sites are particularly diversified among them in terms of production systems, techniques, management, agro-climatic conditions, and socio-economic contexts. This diversity is also found in the assessment. For this reason, few common criteria are employed in the multicriteria assessment of each pilot site, and the results will be presented on a pilot-by-pilot basis.

Globally, the assessments show an improvement in the sustainability and resilience of pilot sites between the current system and co-designed future system, and the improvement of the value of indicators is more pronounced for the sustainability than resilience. Even if all co-designed systems are different, they have in common to improve diversity of farming systems, agronomic practices or/and developed agroforestry, planting or maintaining trees, hedges, copse. These practices have a positive impact on the environmental aspect of assessments, enhancing both sustainability and resilience.
In most of pilot sites, it is observed an improvement of the conservation and the quality of soil and its biodiversity, an improvement of diversity (livestock diversity, crop rotation) and biodiversity (conservation of macro-fauna), and a positive impact on the balance of greenhouse gases emissions (calculation of this leaf take linear meters of trees and conversion of arable land to woodland or grassland). A few pilot sites report a decrease in specific indicators of the sustainability assessment such as the pressure on abiotic resources (water, energy), and circularity. Report and analysis specific of each pilot sites will help to understand in depth the results.
The multicriteria assessment does not highlight an important improvement of the social dimension in sustainability and resilience assessment on pilot sites. Most of pilot sites present a current system with already good scores for the indicators of the social dimension. This limits major improvements. This phenomenon could be due to the nature of the farmers involved in pilot activities. The farmers engaged are pioneers, typically individuals who demonstrate a higher level of attention and awareness regarding social aspects.
With respect to the economic dimension, notable improvements in economic outcomes are not commonplace. As a pilot site ambassador, rightly highlight it in his report: *"as ecological improvements can only be implemented in practice if they are also economically feasible, the economic performance of co-designed scenario has to be further optimised"*, underlighting the importance of economics measures to help development of MF and AF practices. Some pilot sites have in common an improvement in the assessment of the stability of incomes, which depends, in our calculation, on the diversity of incomes (and the number of sale channels in the sustainability assessment). The development of agroforestry or mixed farming can contribute to this diversity of incomes. One pilot site report in the assessment a reduction in the profitability and transmission of the farm. The farmer of this pilot highlights a *"high uncertain times that the farming industry is currently facing"* threatening the sustainability of the farm.

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2.2 Tools and method feedback

The tool captured the interest of stakeholders and ambassadors from pilot sites due to its capability to assess the future co-designed system in relation to an ex-ante analysis of the system. It contributes to have a critical regard on the co-design decisions to see if they contribute to the overarching goals of pilots. Meeting with farmers and stakeholders to complete the assessment was perceived as challenging and the tool was helping to enhance common understanding of sustainability and resilience of farms. The use of graphics in presenting results facilitated the representation and analysis of the findings.

However, there is a consensus among partners that some indicators were difficult to understand or far too specific for the assessment because they needed a great level of detailed knowledge or measurement. Indicators specific quotes by pilot ambassadors were indicators from the resilience assessment: *greenhouse gas emissions per unit of product, percentage of soil organic matter in 0-30cm, soil permeability (cm/h).*
On the other hand, some indicators that would have been interesting from certain pilot sites are missing.

The subjectivity of the method was also highlighted by partners. The possibility to set the weight of the indicators was relevant, however, it does make it more subjective. In addition, in this method we try to give a report on the evolution of the farm developing new practices. Some elements take a long time to set up (typically when trees are planted), some practices will be abandoned, and economical context will change, so predictions are difficult to be accurate. It is important to emphasise that the assessment only portrays a hypothetical final result; thus, we must exercise caution and maintain a critical perspective regarding the outcomes of this assessment. The actual value of the method therefore does not lie in the assessment itself, but rather in the process and the farm management's "awareness" of the various levers and their effects when planning future scenarios for the further development of agricultural operations. By examining the categories and indicators, reflecting on the initial situation (and the strategic direction), and weighting these factors *("What is important to me in terms of sustainability and resilience?")*, farm managers are able to better evaluate their own plans and decisions.

To transform this method into a farmer-friendly self-assessment tool or stakeholders outside the scientific community, it needs to be clarified and simplified. It could pass through a simplification of some indicators (modifying in particular indicators mentioned in the precedent paragraph), and an improvement of the interface used (with more visual aids, such as graphs or charts). Farmers might require a more straightforward interpretation of the results, with actionable insights and recommendations. The tool could also offer streamlined data entry options and prioritise the most critical indicators for a basic assessment, with the option to delve deeper for a comprehensive evaluation. The self-assessment tool should also consider the long-term sustainability of the farm. Regular monitoring is essential to track progress and adapt strategies as needed. However, it can be difficult for farmers to maintain consistent, ongoing assessments. To address this issue, the tool should include features that facilitate periodic check-ins and reminders to encourage continued monitoring. So, developing a self-assessment tool to help transition will require further activities. Nevertheless, in the presence of an advisor, the current tool would be functional for the assessment of farms.

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3 Multicriteria assessment of pilot sites

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3.1 Blue Pig Farm – French pilot (ITAB)

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3.1.1 Pilot site description

3.1.1.1 Pilot site environment

The French pilot site named "Blue pig farm" is located in the northwest of France, in the department of Maine et Loire. The farm is quite isolated, outside of the village of Noyant la Gravoyère, crossed by a road with little traffic, and a hiking path. A tourist site (old slate mine) and a leisure centre on the edge of a small lake are located near the farm. The farm fits into a specific landscape: the valley of Misengrain, designated as a natural zone of ecological, faunal, and floral value. In fact, this zone is distinguished by its soil of blue schist (exploiting for a long time by mines of slates), a specific topography characterised by the alternation of moist valleys and ridges, and the runoff of the river of Misengrain with a diversified faunal and floral composition, and the presence of protected species.

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The furthest south plots of the farm border the river of Misengrain and the high-value ecological zone. Some fauna censuses on the farm revealed the presence of endangered birds' species (Northern wheatear (*Oenanthe Oenanthe),* Yellowhammer (*Emberiza citronella*)*,* Madow pipit (*Anthus pratensis*)*,* Winchat (*Saxicola rubetra*)).

Moreover, in the west of France, the landscape is characterised by an important network of hedges named "bocage" which segment and organise farms, plots and lands (Figure 4). On Blue pig farm, Carl, the farmer, conserved the old network of bocage surrounding the farm and decided to plant more lines of hedges to densify the network and enhance biodiversity on his lands. The farm is also surrounding by copses where we can find common species like chestnut (*Castanea sativa*), wild cherry (*Prunus avium*), hazel tree (*Corylus avellana*), black elder (*Sambucus nigra*), oaks (*Quercus petraea, Quercus robur*), birch (*Betula pendula*), willow tree (*Salix alba*).

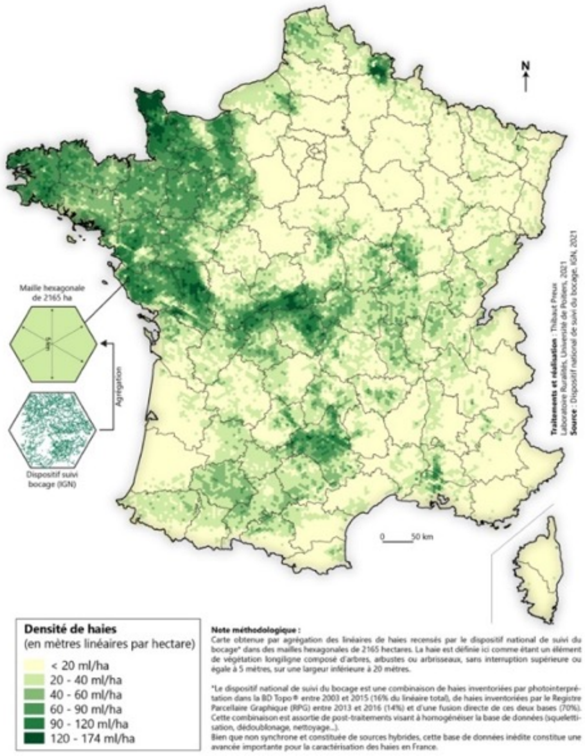

Figure 4 : French hedgerows density ((Preux, 2021)

On the farm, the shallow soil is acidic, moderately fresh, and mainly dry in summer. The texture is fine silt which involve that the soil is quite exposed to risks of compaction. The farmer pays attention to enrich the soil with organic matter and to limits mineral deficiencies, the last analysis was satisfying.

3.1.1.2 Current system

The farmer, Carl, cultivates on Blue Pig Farm 42 hectares of land and raises 500 pigs per year. Carl is the only worker on the farm. Pigs are sold to a cooperative which supplies supermarkets and organic food shops.

Regarding the rearing part, Carl has implemented a free-range breeder-fattener system. Sows which are gestating or in the lactation period are rearing outdoor, such as post-weaning piglets. Sows and piglets use 9 hectares of outdoor area, in a fully fenced plot, sown with a grassland mix designed to resist trampling (not for food purposes). During growth and finishing phase, pigs are transferred in barns and fed with purchased commercial concentrates. Since 2020, the farmer has decided to gradually include forages in the pigs' diet. Inside the French project Valorage[3], the farm was involved in a study aiming to test the changes in the feeding system, and the incorporation of silage in the ration (20%). Furthermore, 35 growing pigs are fed on pasture (rotational grazing) as a supplement to their concentrate ration.

[3] CASDAR Valorage : Valorisation de parcours et de fourrages riches en protéines par les monogastriques biologiques (Valorised protein-rich rangeland and forage for organic monogastric animals) **Alimentation 100% BIO : Alimentation 100% BIO : ProjValorage (itab-lab.fr)**

A fenced plot of 6.5 hectares, divided into 7 strips of 24 meters separated by lines of trees (agroforestry), is dedicated to grazing of this growing pigs. On this plot, pigs use each year for pasture only 1.6 hectares of lands (2 strips) cultivated with diversified forage crops (plantain, ray-grass, clover, forage chicory).
Regarding the cropping system, crop rotation is based on cereals (white oats, common wheat, barley or triticale), legumes (field bean or lucerne), mixture for pasture and beetroot. Beetroot, lucerne and mixture are used to feed pigs as fodder. Cereals are available in the organic market. It is important to notice that the farmer does not have his own equipment, and farm requires contractor for husbandry. The strategy results in minimal investments in equipment, which might be challenging to absorb. However, it also creates a dependency on the external company's reactivity, potentially affecting both the quantity and quality of harvested products. After the crop harvest, pigs' manure is spread. Quantity of manure applied is managed according to requirement of the main crop. Then to bury the manure a ploughing is always made before the sowing. The sowing is carried out using a combined seed drill equipped with a rotary harrow. To ensure that the soil is never left bare over the winter, N-fixing cover crops are systematically sown in autumn before a warm-season crop. None of the plots are irrigated. Carl report difficulties and decreases of yields these last years due to the drought during summer 2022.
Attracted by the potential benefits of agroforestry, Carl decided in 2017 to plant 650 trees on 14 hectares. Trees species were chosen regarding species naturally present around the farm, and soil characteristics. We find on the plot trees for timber production (different *Quercus*, *Acer campestre*, *Prunus avium*, *Sorbus torminalis, Tilia cordata, Carpinus betulus*) and for forage resources (*Gleditsia triacanthos*). The plantation was designed to reduce the competition between crops and trees, and to allow the passage of machines between the trees rows. The trees were planted with a layout of 24 meters between trees and 8 meters between trees. The northwest part of the plantation has been destroyed since 2017 by roes which are numerous around the farm. In 2023, only 60% of trees had survived in this area. The fenced plot is preserved and most of the trees are still present.

Figure 5 : Blue Pig Farm - Mix for pasture between rows of trees

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.1.1.3 New co-designed system

During the co-designed process, the group of stakeholders involved created two evolution scenarios of the farm by 10 years. This first scenario synthesises various proposals for the evolution of the Blue Pig farm, designed to optimise its current system, without fundamentally calling into question the objectives of the farm. For a constant number of workers (1 unit), the main objectives are (1) to improve the production of fodder on the farm, (2) to strengthen the presence of trees, and (3) to optimise the use of areas not dedicated to pigs.

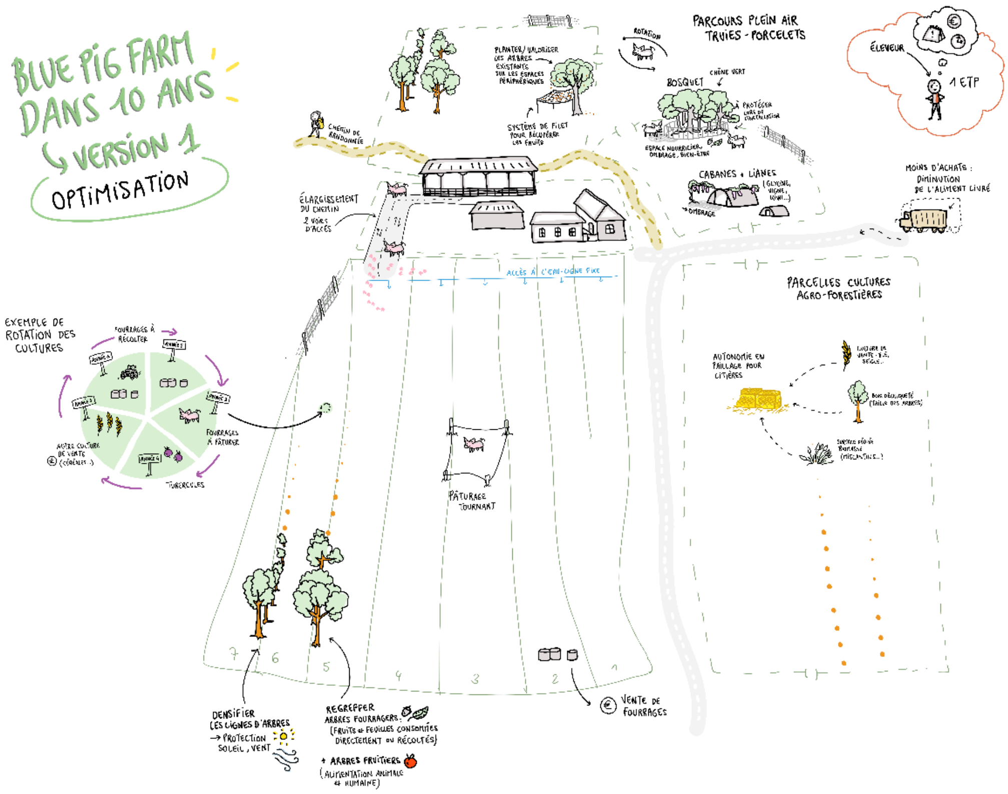

Figure 6 : Artist's impression of the co-designed system optimised of the Blue Pig Farm

1) The improvement of fodder production for pigs is based on:

- An optimisation of the pasture for pigs by developing a rotational grazing system for pigs. Pigs stay in a paddock for 7 days. The paddocks are separated by electrified fences and sized according to the size of pig groups, with 15 to 20 m² per pig. They graze a meadow with a varied perennial flora composed by legumes, chicory plantains and grasses. A path serves all the paddocks, in order to keep the unproductive area as small as possible. To enable more animals to have access to the pasture, this co-designed system proposes the installation of a double access path to the pasture. To achieve this, the access path has been widened and separated into 2 lanes by an electrified fence.
- Producing a nutritive fodder in quantity. It is not possible to graze more than 2 groups of pigs at the same time. Moreover, some seasons are not suitable for grazing. Producing silage is therefore necessary. To promote the longevity of grasslands and make the cost of plantation profitable, grasslands with varied flora are harvested as a priority in the first 2 years. This enables fodder to be produced without damaging the soil.

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Then they are opened to grazing, which will inevitably degrade them despite optimised grazing. Some lands of the farm are also sowed with a mix for forage and harvested to produce silage. This production contributes to improve feed autonomy on farm.

- Increasing other fodder productions. In the co-designed system, the plots allocated to beetroot production is increased by including this crop in the initial crop rotation following 3 years of grassland. The Jerusalem artichoke is a newly planted crop on a specific plot: it is intended to be taken directly from the field by the animals, and to remain in place for several years. The trees are harvested from time to time and the fruit distributed.

2) To strengthen the presence of trees on the farm, the co-designed system planned to:

- Densify the lines of trees on the grazed plot by interspersing new species between trees initially spaced 8 m apart. Several effects are expected from this planting:
    - Improved windbreaks and shading for the welfare of the pigs.
    - Feed production, through the planting of new species for fodder (ash, mulberry, etc.) and fruit (for animals and/or humans). Some of the trees initially present can be grafted to improve their fruit production (e.g. chestnut trees).
- Plant shrubs planted to increase the density of the lower layers and accentuate the windbreak effect. Trees are planted on free-range run for sows and post weaning piglets to create feeding and shading areas, which are totally lacking in the initial system. The species are chosen to be heat-resistant, and feed-producing species such as holm oaks.
- Plant creepers (wisteria, vines, kiwifruit) around the huts, on pergolas designed to provide shade for the animals.

3) To optimise the use of lands not dedicated to pigs the co-designed system few proposition have been made :

- Inside the plot dedicated to grazing, the area allocated to fodder production is greater than necessary. High value-added sales crops can be sown occasionally behind grassland or beetroot, providing an additional source of income.
- The 11 hectares of lands with agroforestry and unfenced is not needed for fodder production. It can therefore be used for sales and/or energy crops. Growing cereals improves the farm's self-sufficiency in straw for barns.
- The plot behind the farm could be densified with lines of trees and devoted to sales crops. Depending on the density of sows and post weaning piglets, part of this plot could potentially be rotated with the current free range run for sows in order to reduce nitrogen pressure on the environment. However, this option would require substantial investment in new biosecurity fencing.

3.1.2 Sustainability and resilience assessment

3.1.2.1 Selection of indicators for local assessment

No changes have been made to the weights of the sustainability and resilience assessment indicators.

3.1.2.2 Impact of co-designed changes on sustainability

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.1.2.2.1 Major changes at global scales

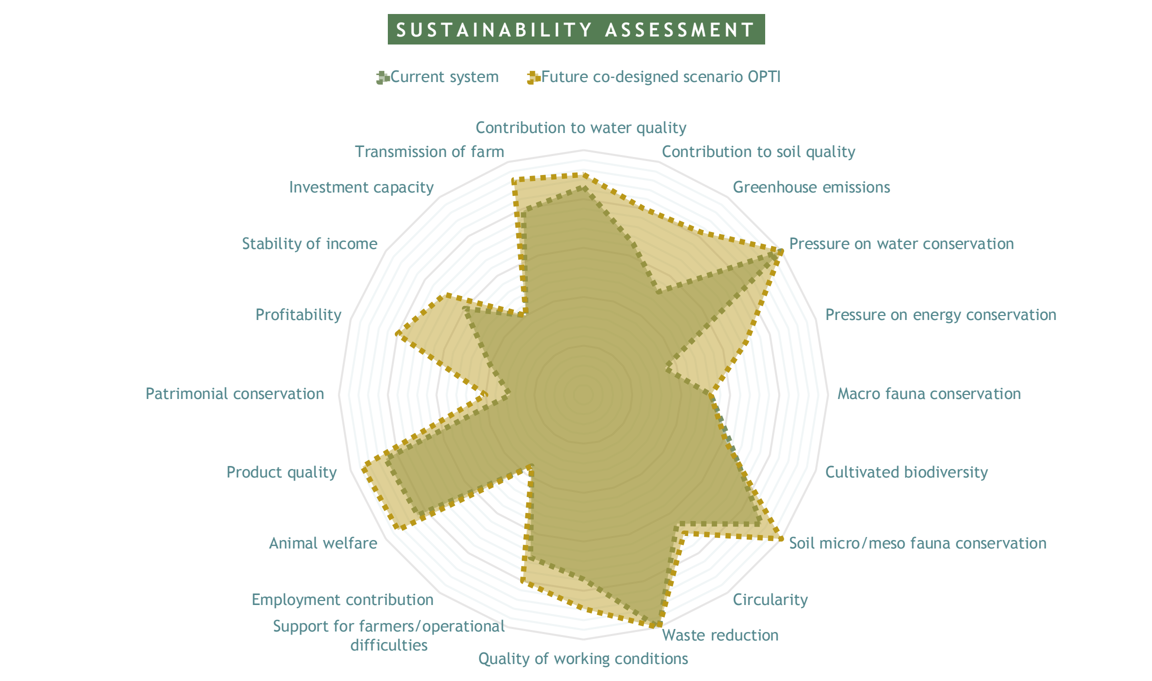

Figure 7 : Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario

Globally, this multicriteria analysis shows that the co-designed scenario improves the sustainability of the farm. Some indicators stay stable between the current system and the future co-designed system but there is no reduction of social, economic or environmental impacts of the farm.

Major improvements concern the economical dimension with an improvement of the profitability and the stability of income on the farm. This is a very positive evolution, as economic sustainability was the main weakness of the initial system.

Overall, changes are more moderate in the environmental and social dimensions, as sustainability was generally quite good in the initial system. But some important improvements are also seen on the environmental aspect with an improvement of greenhouse gas storage. We will enter more specifically in the analysis of this assessment for the rest of the report.

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3.1.2.2.2 Environmental impacts

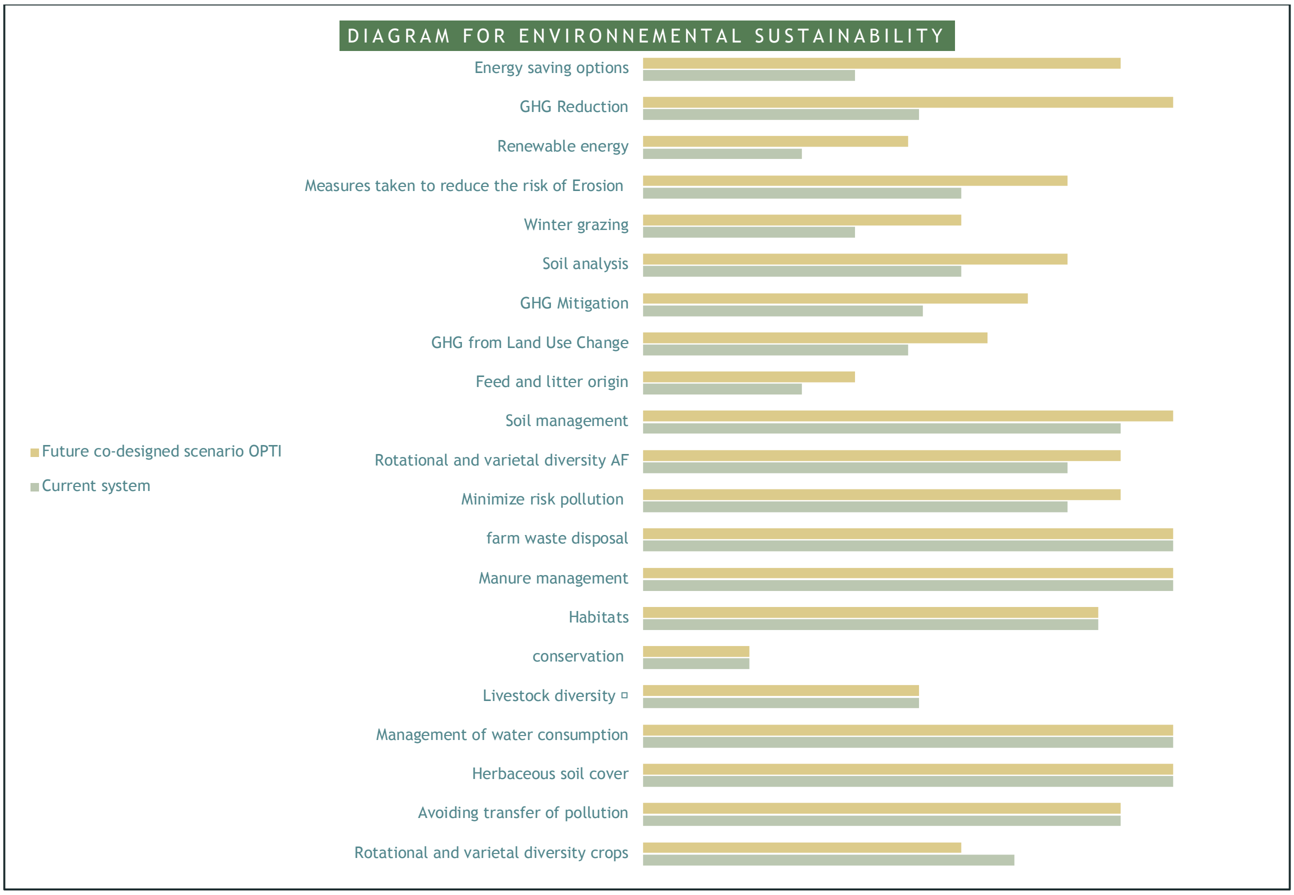

Figure 8 : Scores of the environmental sustainability indicators, showing the current system and the future co-designed system

If we focus on the environmental assessment of the current system, we can notice that some indicators have already an important score on the management of wastes, manure, water, or pollution. As the farm is certified organic, it makes sense to have a system that is already virtuous in terms of sustainability. There is therefore little or no possibilities for improvement in the co-designed system. This highlights that Carl, the farmer, is already in an approach that maintains the environmental sustainability of his farm.

Major improvements concern the reduction and mitigation of greenhouse gasses and improvement on the use of energy. As part of a continuous improvement process, an evaluation of GHG emissions and an energy audit will be conducted on the farm to explore efficiency. Then, a plan for improvement will be elaborated. On the Blue Pig Farm, new plantations of trees are planned to densify current lines of agroforestry and to add copses in grazing land for pigs and sows. In addition, optimising the use of pasture for pigs and piglets means increasing the area devoted to permanent meadow. Reducing the amount of imported feed concentrate by increasing forage distribution reduces dependence on protein or soybean on the farm.
Increasing area dedicated to meadow and density of trees contributes also to improve soil quality by improving inputs of organic matter and reducing risks of erosion.

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Also, soil degradation and erosion are important points focus with pig grazing. Management of it during bad weather condition is crucial: pig density, choice of plot regarding soil conditions and longer of stay in the same plot has to be guided.

3.1.2.2.3 Socials impacts

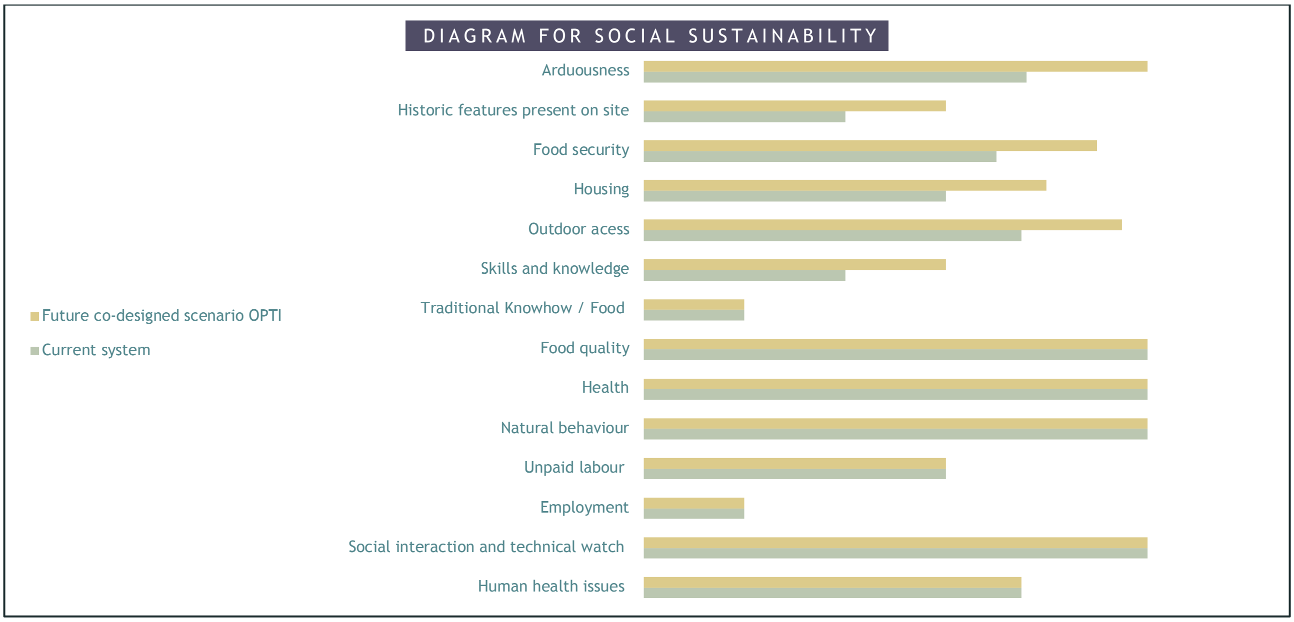

Figure 9 : Scores of the social sustainability indicators, showing the current system and the future co-designed system

In terms of social sustainability, most indicators do not present any improvement or reduction. For a half of them (food quality linked to the organic label, health and natural behaviour of pigs…), scores of indicators are already at the maximum, so they cannot be improved. Other indicator scores are low, it is the case for example of the indicator of employment. Indeed, on the current farm, Carl is the only worker. He only employs one person to replace him during holidays. In our prevision, the optimisation's scenario does not allow to appoint more casual staff.

We can see an improvement in housing quality and outdoor access. Indeed, increasing the number of animals with access to pasture reduces the density of animals in the barns, thereby promoting good housing conditions and limiting, for example, the rapid deterioration of litter. Also, managing pasture with rotational grazing improves quality of outdoor area with a preservation of a good vegetation.

Cleaning barns, getting out manure and disinfecting are among the most difficult activities for the farmer. So, have more pigs outdoor contributes to reduce the arduousness of the farmer work. By comparison, maintain pastures and paddocks, move fences and pigs is quicker and easier.

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3.1.2.2.4 Economic impacts

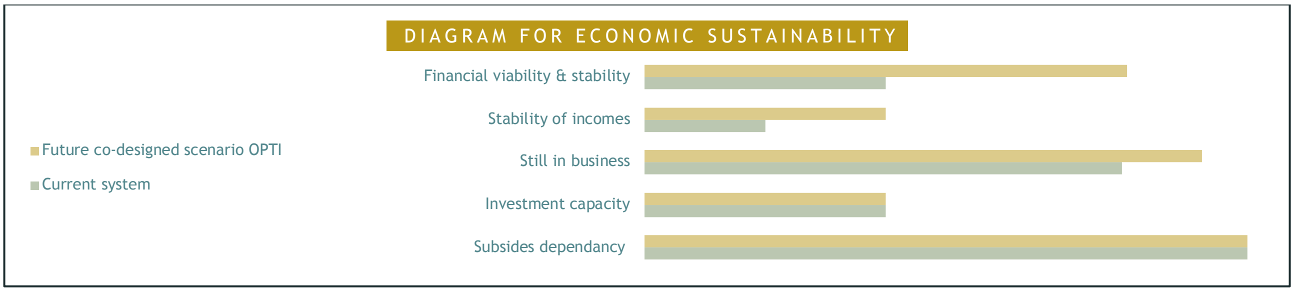

Figure 10 : Scores of the economic sustainability indicators, showing the current system and the future co-designed system

Regarding the economic assessment, we notice that 2 indicators present a significant improvement. They concern the stability of incomes and the financial viability and stability of the farm.

This result come from the supposition that the co-designed system will help to increase the stability of incomes and increase net assets thanks to 2 factors:

- the diversification of selling markets,
- an increase in treasury and a reduction in depts, due to:
  - o an increase of the selling price of meat through new marketing channels,
  - o and a reduction in rearing costs (in a lesser extent).

In fact, the co-designed system plans to diversify the market channels increasing sells in direct to consumers and to organic stores. This diversification of markets proposed, which involves a direct link with customers, seems interesting because the farmer has strong arguments to communicate (animal welfare, meat quality, environmental and landscape impacts of agroforestry, etc.). The interest of increasing direct selling is especially important since these last years because we observed in France difficulties in selling organic pork to distribution companies. This market is flooded due to a fast increase of the production, while the demand is negatively impacted by the inflation crisis. Moreover, on the Blue Pig Farm, the farmer is experimenting breeding rustic species of pigs, which product fatter carcasses penalised by criteria of the cooperative which buy the meat. That is why, diversify selling markets suppose for us an improvement of the financial valorisation of pigs and meat. However, finding and developing new marketing channels supposed to spend more time for the sale, making contacts and developing communication tools to present the philosophy and the approach of the farmer. An idea developed during co-design meeting was to create a new label to valorised quality of "fodder pigs" in terms of animal welfare and quality of the meat. This represents a huge and important work, that the farmer cannot lead alone, and which need years.

Moreover, these last years the price of the concentrate feed distributed to pigs significantly increased, impacting the amount of breeding costs and reducing profit of the farmer. Improving feeding autonomy with pasture, fodders, tubers, must help to better control these costs and (lightly) decreased them.
Finally, by selling new products (fodder or fruits) in addition to crops, the source of incomes on the farm will also be a little more important.

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3.1.2.3 Impact of co-designed changes on resilience

3.1.2.3.1 Major changes at global scales and comparison with sustainability assessment

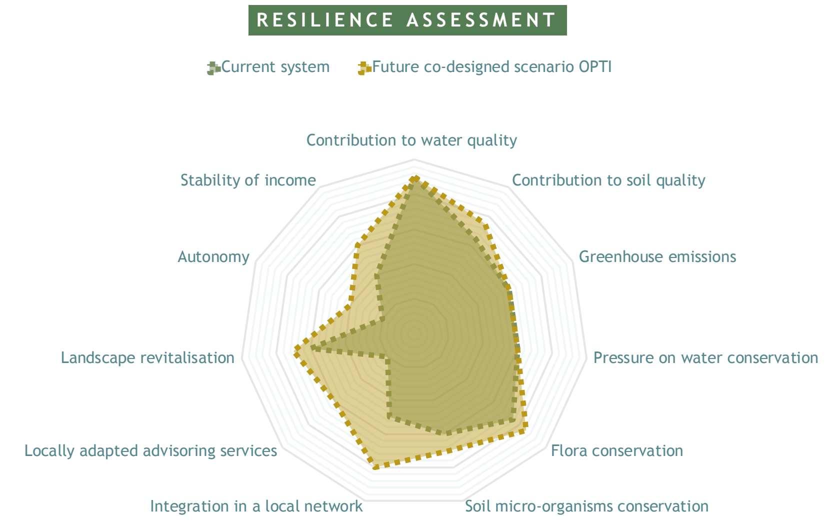

Figure 11 : Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario

Just like the sustainability assessment, the multicriteria analysis globally shows that the co-designed scenario improves the resilience of the farm: 8 out of 11 indicators are improved. Some indicators stay stable between the two systems but there is no reduction of social, economic, or environmental impacts of the farm. The main improvements concern the social dimension, with an increase in indicators relating to the use of locally adapted advisory services and integration into a local network. Improvements on economic impacts stay visible, the co-designed system improving autonomy on farm and stability of incomes. There is very little improvement in the environmental dimension. Specifically, in contrast to the sustainability assessment, in resilience we do not notice any improvement on greenhouse emissions.

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3.1.2.3.2 Environmental impacts

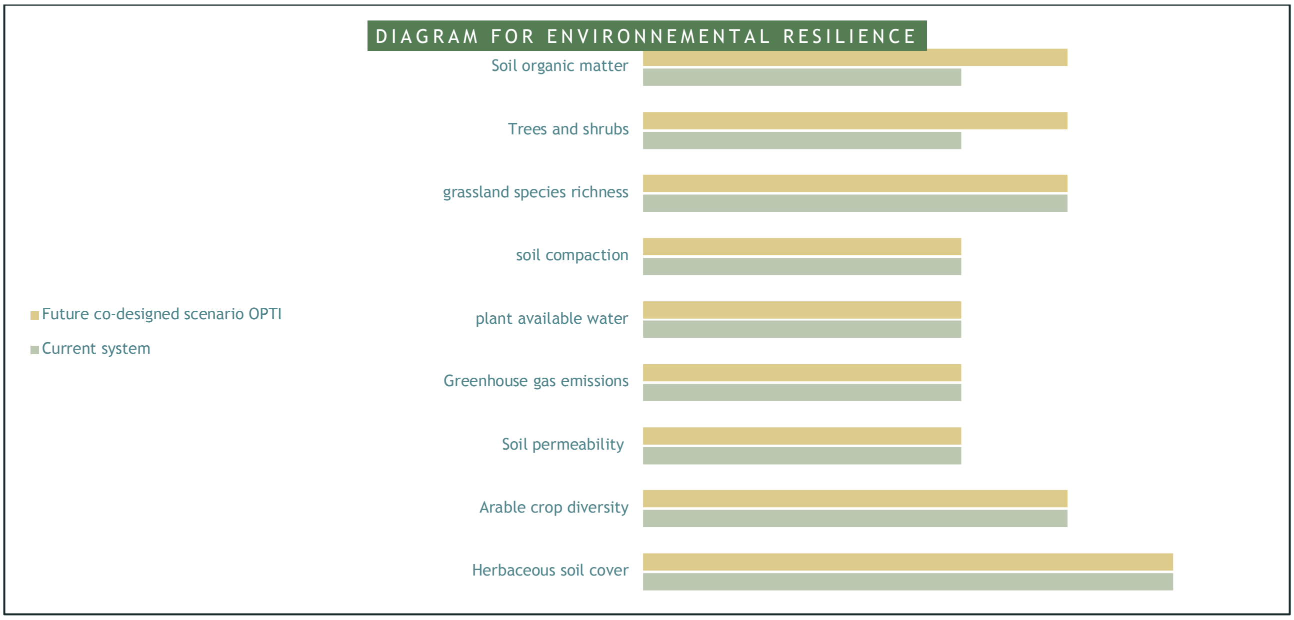

Figure 12 : Scores of the environmental resilience indicators, showing the current system and the future co-designed system

Regarding the environmental impacts on the pilot resilience, we notice that only two indicators show an improvement between the current system and the co-designed one. They concern the percentage of soil organic matter in 0-30cm and the edge linear of trees and shrubs.

With the current practices of the farmer, the percentage of organic matter in the soil is 2.2%. In the co-designed system, the reduction of ploughing and the lengthening of crops rotation, introducing more meadow, will help to improve the soil organic matter, improving at the same time the global quality of soil.

The densification of hedges and the planting of copses explain the improvement in the indicator "trees and shrubs".

On this resilience assessment the method to calculate the indicator relating to greenhouse emission bring us back to CO_2 equivalents emission produced per ton of product. At the moment, we do not have information on the carbon impact of the production of organic pork.

3.1.2.3.3 Socials impacts

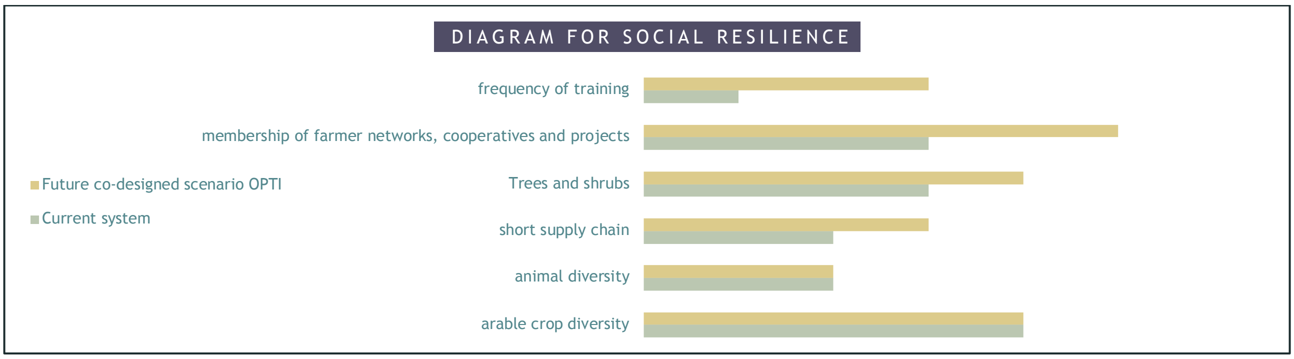

Figure 13 : Scores of the social resilience indicators, showing the current system and the future co-designed system

In term of social resilience, the assessment highlights an improvement on advising services to the farmer and a better integration on the local network. The farmer was already involved in professional networks, but his desire to develop his system led him to contact new networks. The co-designed system plans to optimise the current system, also optimising the working time of the farmer. Reducing the working time with pigs will help the farmer to free up time outside the farm. He will be enabled to increase training time in the subjects he knows least about, improving by this way his knowledges and practices on crops, trees, or meadows. With this free time, these trainings, and the multiplication of channel markets, the local network of the farmer will be more and more important. The feeding system on the Blue Pig Farm is very innovative in France, so the farm will stay in the future, a pilot farm.

3.1.2.3.4 Economic impacts

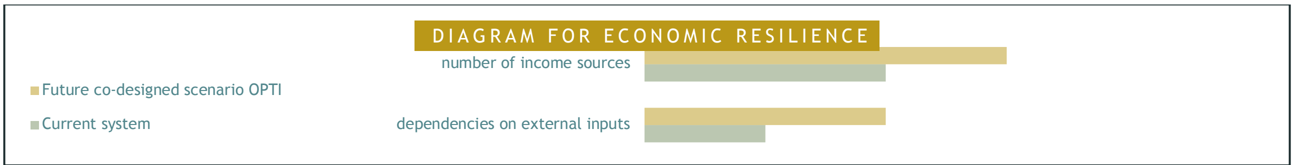

Figure 14 : Scores of the economic resilience indicators, showing the current system and the future co-designed system

The economic assessments of co-designed and current systems are based upon two indicators relating to the diversity of incomes and inputs. As in the sustainability assessment, the economic analysis of the co-designed system shows an improvement in the stability of incomes thanks to the diversification of the market channels and products sold (crops, fruits, fodders). The co-designed system plans to enhance the autonomy of feed and straw on the farm, increasing the area dedicated to straw cereals and forage. These productions contribute to decrease dependencies on external inputs. The score for this last indicator remains fairly low, as most pig feed is still purchased on the organic market, and the farmer do not want to invest in on-farm feed manufacturing.

3.1.2.4 Perspectives on this assessment

With the aim of increasing diversity on the farm and creating jobs, a second system was considered and co-designed during the workshop. This system is named the diversified scenario. This scenario plans modifications on the pigs production, the creation of new farm productions and the development of direct selling. The changes regarding pigs' production developed in the "optimisation" scenario are all compatible with this "diversification" scenario but are not necessarily all implemented. On this second co-designed scenario, new proposals are made for this production:

- Setting up a feed manufacture on the farm. This enables cereal and legume crops to be used directly on the farm, thereby increasing the feed autonomy of the farm. This installation requires economical investments and the improvement of crops production and yields to reach an interesting feed autonomy. However, it is unlikely that the farm will be entirely self-sufficient, hence the need to maintain, in particular, purchases of protein sources.

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- Setting up a cutting and processing plant for the pigs' meat. This installation requires substantial investment and the use of specialist labour. It will help to improve the promotion of meat form free-range and foraging pigs and the economic valorisation of the production.

New activities are considered with the diversified scenario, linked with the environment of the farm and the project to increase direct selling:

- The farm is crossed by a footpath, so there is real potential for opening it up to walkers. Putting up an information board about the farm's special features could encourage walkers to stop off and/or buy the products made on site. Consideration could also be given to opening a small shop, a bed and breakfast and/or a gîte (a French holiday house).

- The presence of trees could be accentuated and enhanced economically through fruit production. The planting of fruit trees such as apple, pear and walnut trees is therefore a priority as part of the densification of the agroforestry lines. In addition, a space dedicated to an orchard can easily be made available in the block behind the farm. Finally, planting small fruits (raspberries, bilberries, blackcurrants, etc.) between trees spaced 8 m apart could be considered. It should be noted that it takes several years for the trees to bear fruit.

- Development of high added-value crops for human consumption. The agroforestry plot dedicated to crops is reserved for technical crops that also generate income. This means bringing new skills onto the farm, and/or training, and investing in high-performance growing equipment. Possible crops include milling wheat, breakfast cereals, legumes, vegetables.

- Other possibilities could arise with the installation of a second farmer such as setting up a small mobile poultry workshop, a bee-keeping activity, an aromatics and medicinal plants production.

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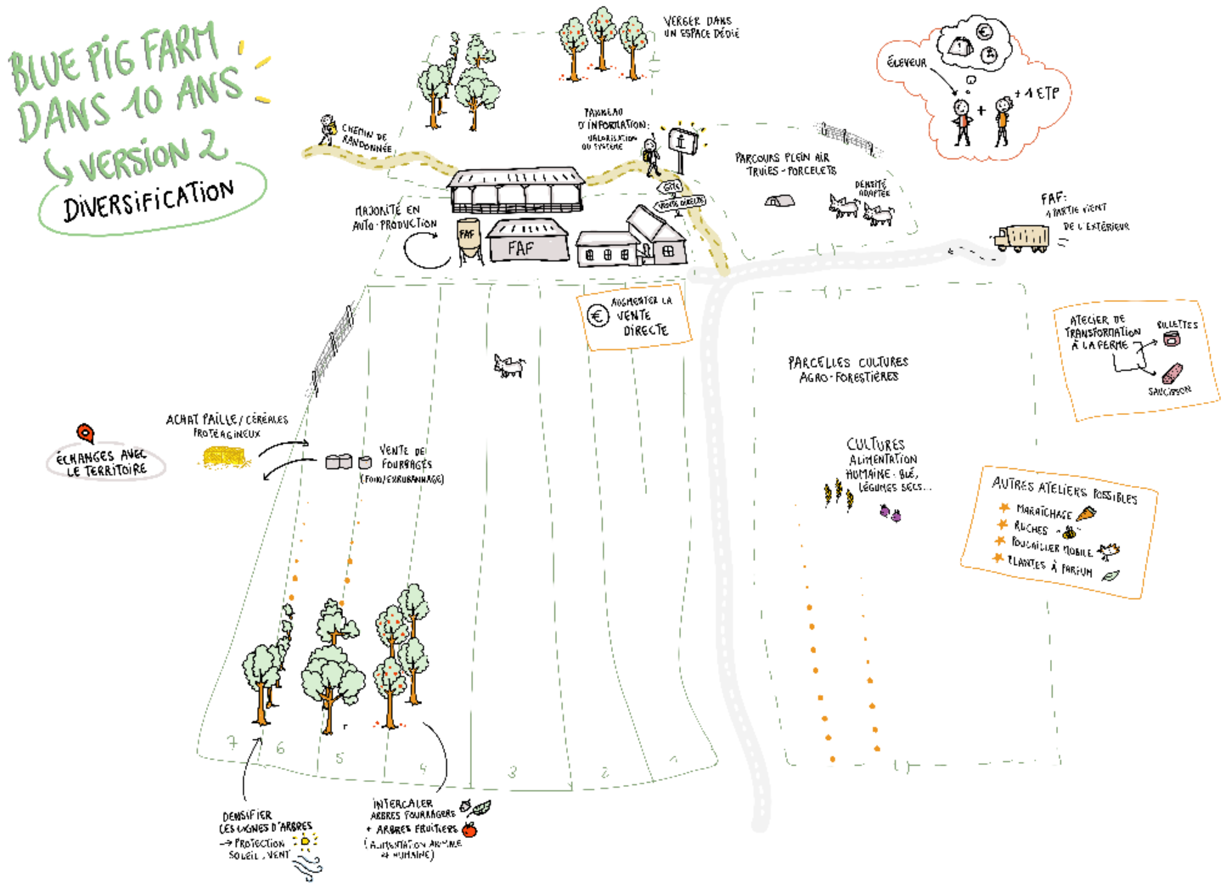

Figure 15 : Artist's impression of the co-designed system diversified of the Blue Pig Farm

The assessment of the sustainability and the resilience of this second "diversified" system in comparison to the "optimisation" scenario and the current system give interesting results.

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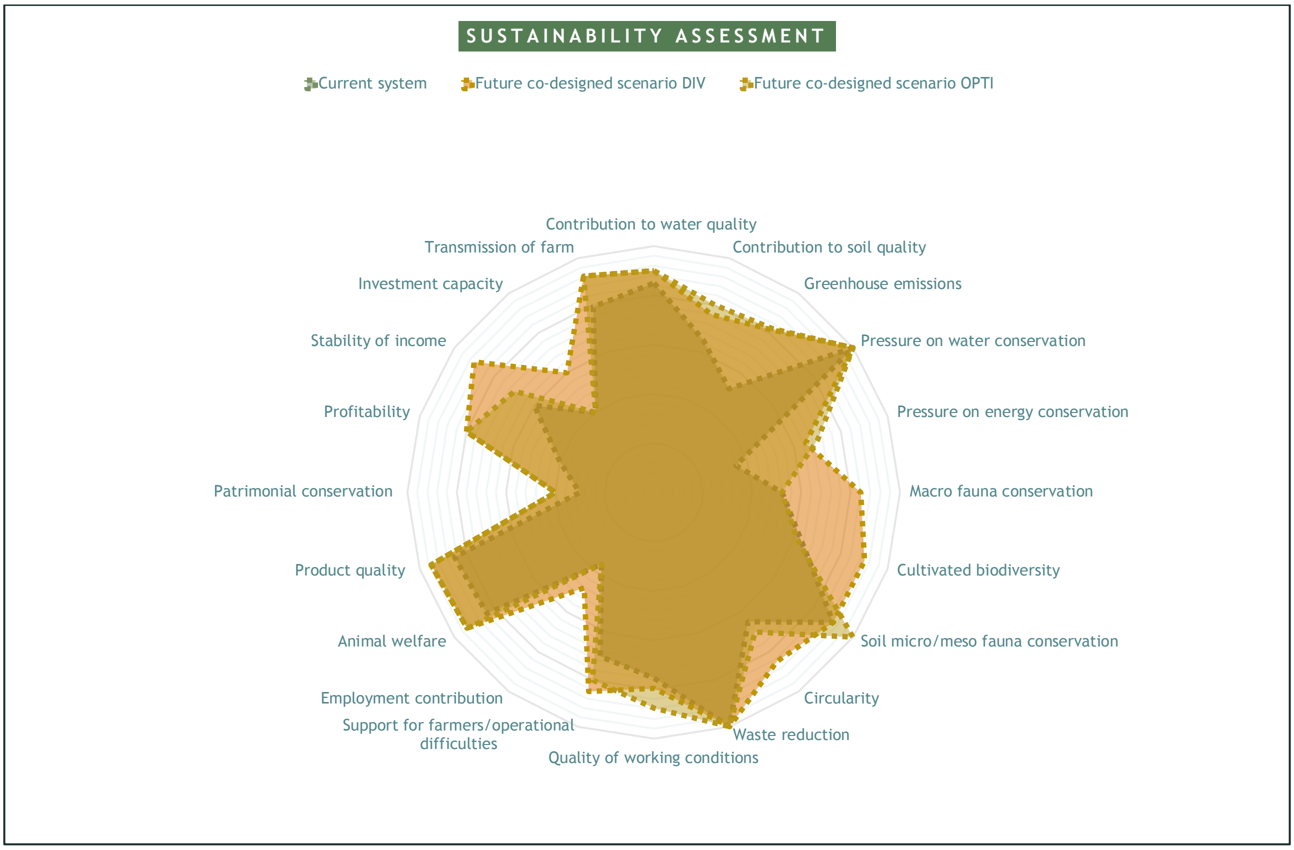

Figure 16 : Radar diagram of the results of the sustainability assessment, showing the current system, the future co-designed scenario "optimisation" and the future co-designed scenario "diversification"

This co-designed diversified system present better global results on the sustainability assessment in comparison with the co-designed optimised system and the current system, regarding environmental and economic indicators. In fact, in this second co-designed system the diversification is important with:

- animal productions with the idea of raising bees and poultry.
- plant productions with the cultivation of plants and fruits for human food (legumes, cereals, maybe some field vegetables) in supplement of culture for pigs (fodder, cereals).

This improves the assessment regarding macro-fauna conservation and cultivated biodiversity.

The scenario plans to install a feed manufacture for pig to improve feed autonomy on the farm and to reduce the amount of feeding cost. The scenario plans also to create a processing and cutting plant to transform the pork meat and bring surplus value on the production. Doing that, the circularity, and the profitability of the farm are improved.

With the direct selling and the diversity of new productions on the farm, the assessment calculates an improvement of the stability of income on the farm. The diversification of the productions on farm allows and requires at least one new full-time worker to help the farmer which improve the contribution of the farm to create employment. However, if the production does not permit to create enough value to employ more than one person the workload will be heavy and impact the quality of work conditions.

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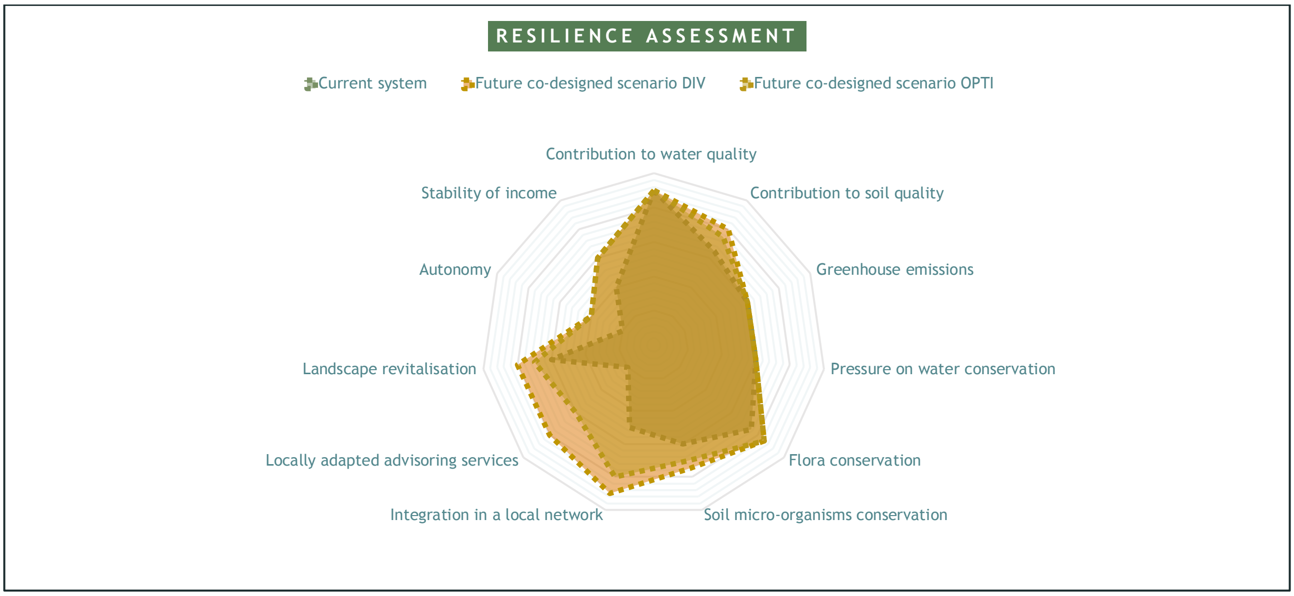

Figure 17 : Radar diagram of the results of the resilience assessment, showing the current system, the future co-designed scenario "optimisation" and the future co-designed scenario "diversification"

On the resilience assessment the main improvements of the diversification scenario in comparison with the optimisation scenario concern exclusively the social dimension. This diversification scenario improves the animal and arable crop diversity which contribute to the landscape revitalisation.

Regarding the indicator of integration in a local network, the development of direct selling implicates the introduction of the farmer in new local networks and the diversity of the farm's productions will probably be interesting to develop new projects. To improve performance of the different farming activities, training will be necessary and important for the farmer. The number of training sessions contributes to calculate the indicator "Locally adapted advisor services" that is why we can notice an improvement of this criteria.

3.1.3 Tools and methods: feedbacks

This multicriterial assessment is an interesting method that contribute to evaluate and simply represent the evolutions of a farm system. With the project AGROMIX, in each country, we co-designed in groups, agroforestry systems that we considered more resilient or sustainable. This assessment allows us to concretely evaluate the sustainability and the resilience of our co-designed system in the future and consider positives or negatives consequences of changes in farming practices.

When we begin to work on the conception of the assessment method, we were confronted with the difficulty to have appropriate indicators for the diversity of AGROMIX' pilot sites. In fact, we needed indicators which were enough general to be applied to the diversity of contexts from each country, and, specific to respond to the objective of the assessment. Most of indicators may be the same for all of pilot site, to permit us to compile results and draw conclusions. We decided to allow each partner to adapt indicators, scores, and weighting to better represent their co-designed system. For the sustainability assessment we were inspired

by the PG tool method and added new indicators, and for the resilience assessment we based on the result of the work done in the Work Package 1 of the project AGROMIX.
We discussed about the interest of doing two assessments, one for the sustainability and one for the resilience. Now that we have done the work, it seems that these two assessments are not quite complementary and sometimes there are in contradiction. The indicators chosen for the resilience were specific and often hard to evaluate or estimate. That is why, the sustainability assessment is for us the most interesting method to evaluate evolutions of co-designed systems.

In fact, the farm pilot is constantly in evolution, so it is important to define what is the initial system. We decided to define our current system as the farm from 5-7 years ago, when trees were not planted, and pigs were fattened only with concentrate feed. The system we evaluate as the co-designed one is the farm in, maybe, 15 years. We chose to project ourselves in a mid-term future. That is why, in this agroforestry system, the main difficulty we encountered was to give a report on the evolution by the assessment method. Some elements take a long time to set up (typically when trees are planted) and the assessment only reflects a hypothetical final result and not the path which has to be taken to reach it. In 15 years, some practices will be adapted or abandoned by the farmer for the purpose of simplicity, and we cannot evaluate this. On the contrary in changes we estimated, some are minor and do not seem to influence the result of the assessment. Scores of indicators are also difficult to estimate because of the lack of measures we could make. Some scores are selected thanks to expert estimates. For the future co-designed system, this scoring is even more difficult because we are assessing a hypothetic system, so we may lack objectivity and realism. However, if we had to calculate everything, so that all the indicators were totally objective and sourced, it would take an important amount of time, and the added value would probably be modest. That is why, we had to stay cautious and critical about the results of this assessment.

3.1.4 Take-away messages

Our analysis shows an overall improvement in the sustainability and resilience of the optimised co-designed system compared with the current system. However, the improvement remains limited for many factors/indicators, because the system is already advanced on several points.

The major improvements concern the economic aspect, with the hypothesis of a better financial stability and greater diversity of income. However, this improvement is based on assumptions and is conditional on the possibility of developing new selling markets (whether for direct pork sales or for new products), and on the farmer's ability to achieve sufficient technical performances.

Concerning the environmental impact of the farm, the assessment shows that the plantation of new trees and the lengthening of crop rotations, provided in the co-designed system contribute to limit greenhouse gases emissions and to improve soil quality and stability. In social terms, they also contribute to the welfare of the pigs on pasture. However, these benefits are only expected to be effective in several years - once the trees have grown - which raise the question of how to manage the transition period.

The social sustainability and resilience assessment highlights clear improvements in the arduousness of the work, the welfare of the animals and the isolation of the farmer. Training farmer in subject he is less proficient, will help him to achieve his objectives.

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Although autonomy on the farm has improved, it is still not optimal and there is still room for improvement. In this optimised co-designed system, livestock farming does not contribute to job creation and remains highly specialised. The introduction of new animal or plant productions remains limited.

Analysing the second scenario of a diversified co-designed system, and according to this method, we noticed that improving the diversity on farm contributes to improve global sustainability and resilience of the system in comparison with the optimised co-designed system. It helps to improve the biodiversity on the farm and the financial stability, to reinforce the network of the farmer, and to create jobs.

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3.2 La Barrossa Farm – Spanish pilot (UNEX)

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Reviewer	Ulrich Schmutz

3.2.1 Pilot site description

3.2.1.1 Pilot site environment

La Barrosa farm is the AGROMIX Spanish pilot site representing the traditional Spanish farming system *dehesa*, called *montado* in Portuguese, aimed at extensive livestock husbandry. It is located in the municipality of Alburquerque, province of Badajoz, Autonomous Region of Extremadura, in the southwest of Spain (Figure 18). More specifically, the farm is in the right side of the road BA-007 to the Portuguese border crossing the streams Arroyo de Valdeborracho and Arroyo de los Abejeros.

The farm is a good example of a traditional land system that still covers a land surface of 3.5 million hectares in Spain and Portugal (Figure 18 and 19) and it has served as inspiration for many other land systems such as American ranches, Brazilian *faxinal* and Chilean *espinal*. This system is considered by the European Union as a high natural value (HNV) farming system and also as a habitat of interest by the Directive on habitats due to the presence of endangered species: birds, mammals, etc. *Dehesa* is actually the human conversion of the Mediterranean forest by clearing to obtain scattered trees of the gene Quercus (mostly Q. ilex and Q. suber since they produce acorns and cork, respectively) and annual pastures to feed livestock in local ecosystems. The *dehesa* climate is Mediterranean with warm and dry summers, landscapes are undulated, and soils are shallow, sandy-loam textured, slightly acidic and poor in nutrients and organic matter (not suitable for annual crops and commercial agriculture).

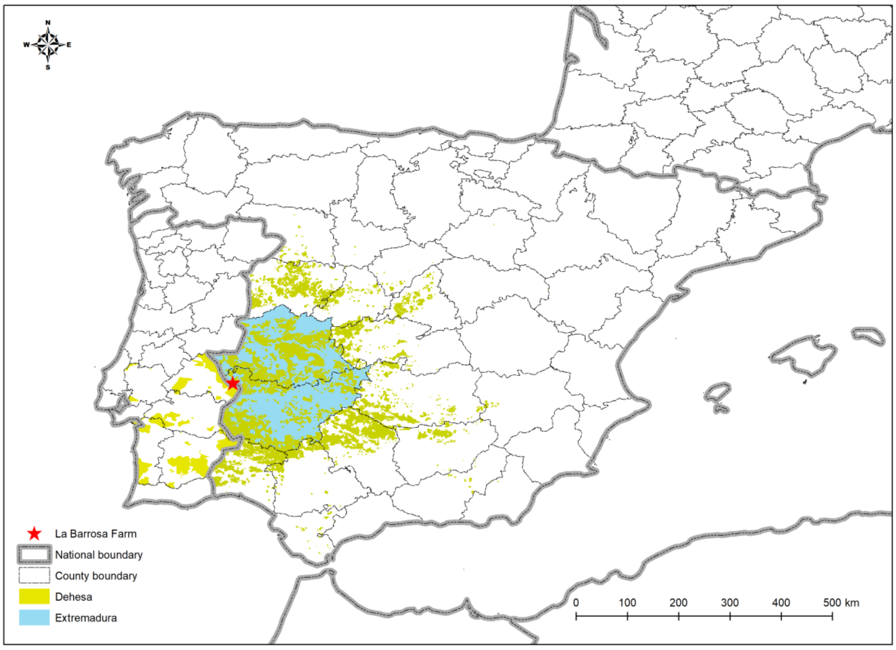

Figure 18. Map of geographical location of La Barrosa farm within the dehesa farming system context.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.2.1.2 Current system

La Barrosa is a family farm legally owned and managed by the brothers Valentín and Felipe Maya Blanco and their mother, third generation of farmers. They keep the essence of this traditional and semi-natural land system in terms of livestock (species, rates, etc.) and land management (trees, pastures, occasional crops, etc.) (Figure 19). Nowadays, its land size is 205 hectares in which usually 100 cattle (Retinta breed) graze the whole year and 150 Iberian pigs graze from October to February (≈4 months per year) during the *montanera* period to feed acorns. The farm is mostly covered by scattered holm oaks (*Quercus ilex*) with an average tree density above 30 trees ha^{-1} and also by cork oaks (Quercus suber) in the north part of the farm (steeper slopes, sierras below quartzite ridges) from which cork is drawn in cycles of 9 years. In addition, cereal and fodder crops were common in the past as well as hunting and other economic activities.

From an economic point of view, Valentín and Felipe are the only labour force of the farm since now it is not easy to find skilled workers to be hired due to ageing and emigration from the rural to the urban areas in Extremadura. Their main output is the sale of pigs and cattle to intermediaries that send livestock to regional/national slaughters (strict legal control in Spain) and after that this meat is sold in every kind of markets. In addition, each 9 years they obtain an extra income from the sale of cork that their cork oaks produce. Finally, they also receive some inputs from the European Union Common Agricultural Policy (CAP) subsidies. Normally, their livestock is fed by annual pastures and acorns but in specific moments they need commercial feed bought in local cooperatives.

Regarding livestock management, livestock is rotationally moved from one plot (fenced area) to another in a system of 11 wired fences in which there is at least one watering pond by plot to water livestock in summer. The strategy is to find a balance between pastures supplied by each fenced area and livestock needs. The main goal is to take profit of natural resources reducing as much as possible risks of land degradation: soil erosion, compaction, tree diseases, loss of seeds, decline in soil nutrients and pasture yields, etc. It is possible thanks to empirical and scientific knowledge provided by the farmers due to own experience in land management inherited by their ancestors. To do that, they usually keep an adequate animal stocking rate but it can be excessive during periods of drought.

Cereal cultivation has been progressively abandoned in the last 20 years, on one hand, because they provoke soil erosion and compaction and serious damages in tree rooting systems. On the other hand, they have decided to bet for cropping systems that can improve pasture quality and, consequently, enhance soil quality and pasture yield at the long-term. They have also considered recreational purposes for their farm based on fishing, beehives, mushrooms, agritourism, hunting, etc. but none of them has been implemented yet. The farm has also machinery and facilities such as tractors, vehicles, paddocks, boreholes, farmers and workers houses, building for storage, etc. as well as scientific knowledge because one of the farmers is an agronomist expert on pastures (he shares land management with a job in a regional research centre) and the other one is a vet that also offers his services to local farms. So, land management for them is a jot at partial time with special efforts during the weekend and in specific campaigns related to livestock safety, sales, etc.

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Figure 19. Overall view of La Barrosa farm including holm oaks and annual pastures. Date: February 2023.

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3.2.1.3 New co-design system

La Barrosa farm has been co-designed twice so far: [1] In the previous decade when Valentín and Felipe took the responsibility of its land management and they decided to make improvements in its annual pasture (Figure 20); [2] During the AGROMIX project when they selected some of the initiatives proposed during the workshop of 26 October 2022 (Figure 21). Figure 20 shows seven campaigns of pasture improvements carried out in the farm so far. They include the incorporation of legumes and annual pasture more adapted to dry conditions.

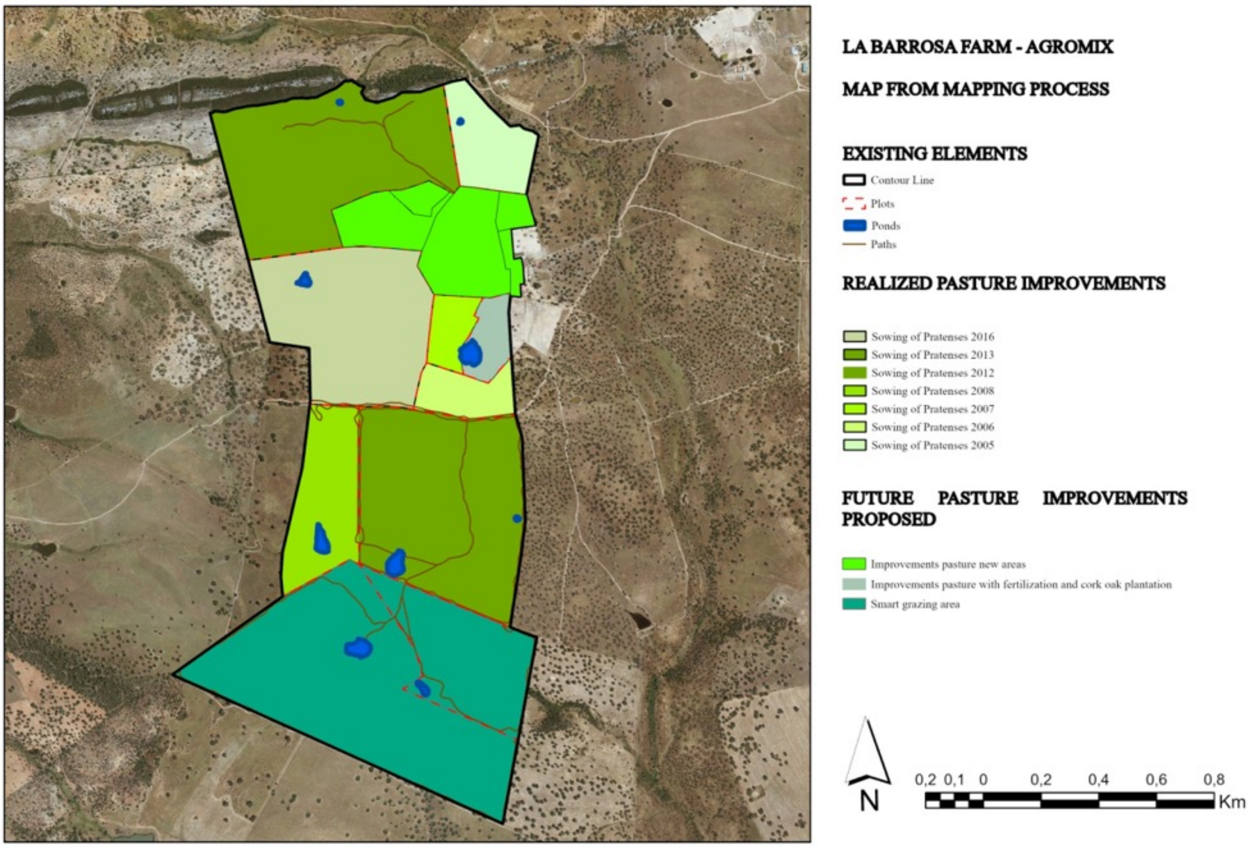

Figure 20. Map of pasture improvements made by owners in La Barrosa farm so far since the decade of 2000.

Figure 21 shows the ten improvements proposed during the AGROMIX workshop. Since the farmers considered it is impossible to carry out all of them at the same time, they decided to install a watering point to reduce animal diseases and to rent their pasture instead of raising Iberian pigs. The rest of measures are being studied and they will probably be conducted before 2030 depending on farm profitability. Both measures implemented (watering point and pasture rental) have been already assessed and results have been quite satisfactory according to the opinions given by the farmers and water samples analysis that they did not return pathogen microorganisms such as *E. coli*.

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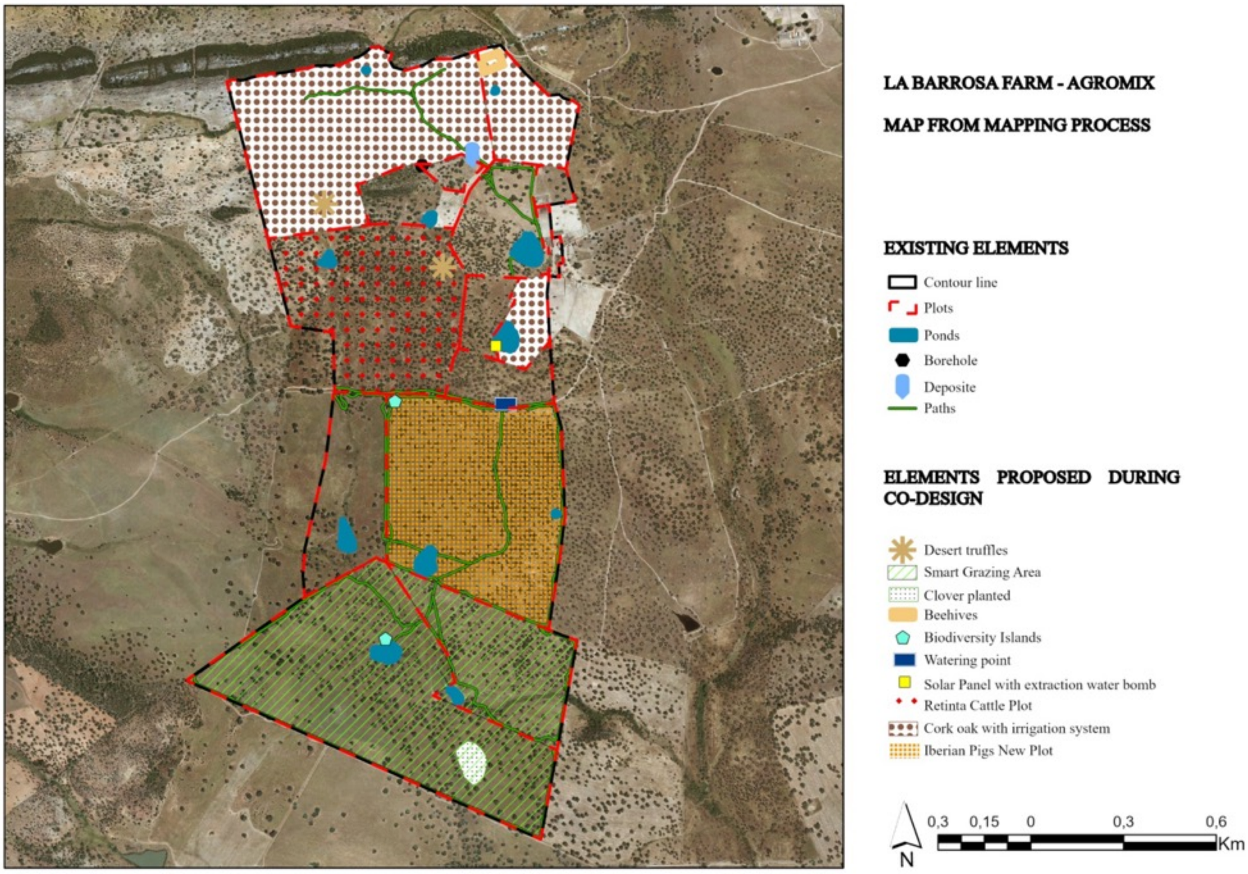

Figure 21. Map of improvements proposed during the AGROMIX workshop carried out on 26 October 2022.

3.2.2 Sustainability and resilience assessment

3.2.2.1 Selection of indicators for local assessment

The global assessment of La Barrosa farm has been made from a set of 29 indicators of sustainability and 22 of resilience that try to give an overall value based on environmental, social and economic aspects. All of them are in consonance with the local context of the farm. Each indicator must be interpreted in a scale range from 1 to 5 that returns three qualitative categories: high resilient/sustainable (>4), resilient/sustainable (2-≤4) and low resilient/sustainable (<2). As an illustrative example, Figure 22 shows a screenshot of sustainability indicators including values both current system and future co-designed scenario.

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	Current system	Future co-designed scenario
Contribution to water quality	3.3	4.5
Contribution to soil quality	3.7	4.3
Greenhouse emissions	2.2	3.9
Pressure on water conservation	4.4	3.2
Pressure on energy conservation	2.3	5.0
Macro fauna conservation	1.5	4.0
Cultivated biodiversity	2.6	2.6
Soil micro/meso fauna conservation	3.0	3.0
Circularity	3.0	3.0
Waste reduction	2.0	5.0

	Current system	Future co-designed scenario
Human health issues	4.3	4.3
Arduousness	3.0	5.0
Skills and knowledge	2.5	4.5
Social interaction and technical watch	3.0	5.0
Employment	1.0	3.5
Unpaid labour	1.0	5.0
Outdoor acess	3.3	3.5
Natural behaviour	5.0	5.0
Health	5.0	5.0
Housing	3.5	5.0
Food security	4.5	5.0
Food quality	3.0	5.0
Traditional Knowhow / Food	1.0	5.0
Historic features present on site	3.0	3.0

	Current system	Future co-designed scenario
Financial viability & stability	3.0	5.0
Subsides dependancy	4.5	5.0
Stability of incomes	1.0	5.0
Investment capacity	1.0	4.0
Still in business	3.3	5.0

Figure 22. List of sustainability indicators including current and future values for La Barrosa farm.

3.2.2.2 Impact of co-design changes on sustainability

3.2.2.2.1 Major changes at global scales

According to our predictions, La Barrosa farm will improve an average of 21%, 30% and 45% in environmental, social and economic issues, respectively. This forecast is logically since *dehesa* system is a semi-natural farming system (almost organic) that influences positively on welfare of local society, but it needs some efforts to improve its farm profitability (e.g., marketing, fair prices, etc.).

From an environmental point of view, the co-design will improve the farm from 11 to 60% in aspects such as soil and water quality, reduction of GHG emissions, energy conservation, fauna conservation and waste reduction. Although no improvements are expected in aspects such as biodiversity, soil fauna and circularity. In addition, an increase of 24% is expected to pressure on water conservation due to climate change effects. These predictions are quite logical since soil from *dehesa* system is mostly shallow and poor in nutrients.

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From a social point of view, La Barrosa farm will improve between 5 to 80% in aspects such as arduousness, skills and knowledge, social interaction, technical watch, employment, unpaid labour, outdoor access, housing, food security, food quality, and traditional knowhow. It is due to the progressive implementation of new technologies, and smart sensors in this kind of farms, as well as social reputation are also increasing in the current society. Nonetheless, aspects related to human health, natural behaviour and historical features are not foreseen their improvement since its land management is little aggressive in terms of pollution and degradation. This latter has to do with the fact that regional society does not have the perception yet of dehesa system is part of its cultural heritage as well as it must be considered as an endangered land system since its land abandonment could suppose wildfires and proliferation of animal diseases. Hopefully, any indicator will show lower values in the future co-designed scenario. Anyway, some efforts by regional/national authorities to design training plans for skilled labour (e.g., shepherding, animal welfare) are still needed.

From an economic point of view, only five indicators were considered: financial viability and stability, subsides dependency, stability of incomes, investment capacity and still in business. All of them are foreseen to be improved since their current state is still low. EU subsidies dependency will only improve 10% since they are necessary to keep ecosystem services provided by this farming system. Aspects related to business are foreseen to increase until 40% since farm profitability is still a weakness of the system. Finally, the economic stability and investment capacity will increase between 60 and 80% because prices of products and by-products will presumably increase.

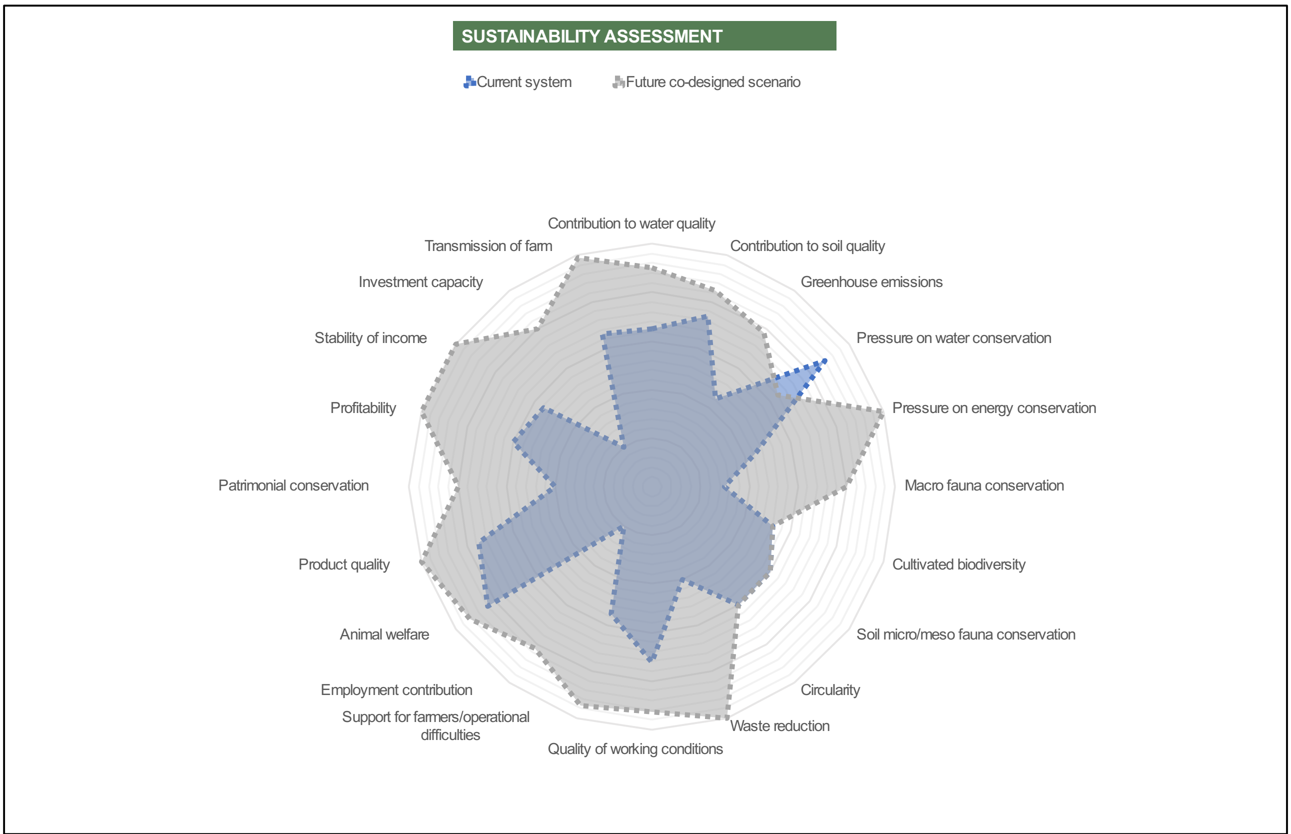

Figure 23. Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario

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3.2.2.2.2 Environmental impacts

The two indicators with highest impact on environmental issues are waste reduction and pressure on energy conservation (Figure 24). It is due to the inspirational effect of dehesa can have on the overall society since it is a good strategy both to enhance animal welfare and avoid large number of manures (e.g., landless production) and small parts of the farm can be used to produce solar energy through the installation of solar panels for self-production.

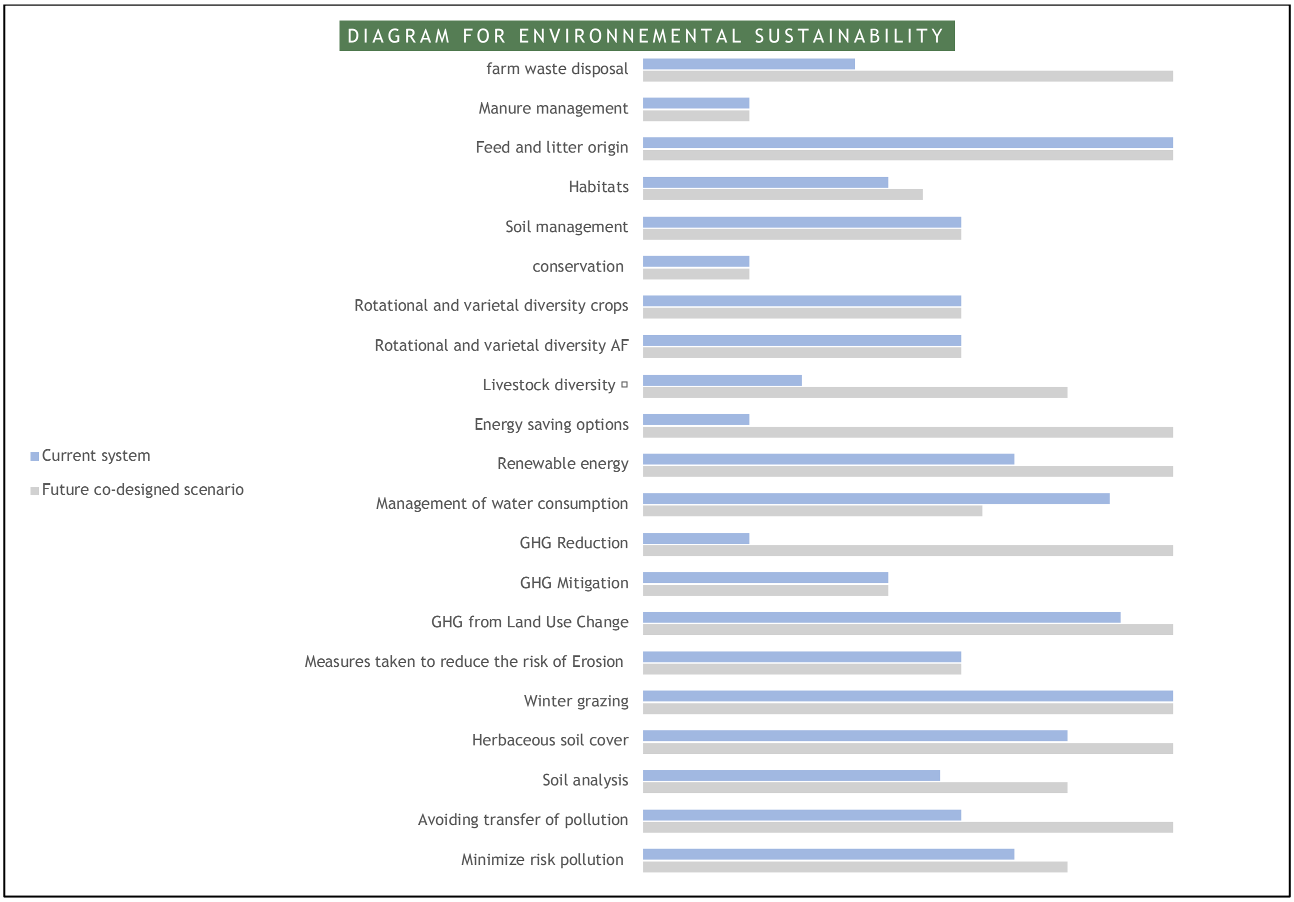

Figure 24. Scores of the environmental sustainability indicators, showing the current system and the future co-designed system

3.2.2.2.3 Social impacts

The highest social impacts were found in the indicators unpaid labour and traditional knowhow (Figure 25). It is due to a threat already expressed by farmers and stakeholders in the AGROMIX workshop (carried out on 26 October 2022): there is not skilled labour. It means farmers must work a lot in their free time to keep farm profitability and more efforts must be done to design training plans to encourage young people to work in extensive livestock husbandry sector.

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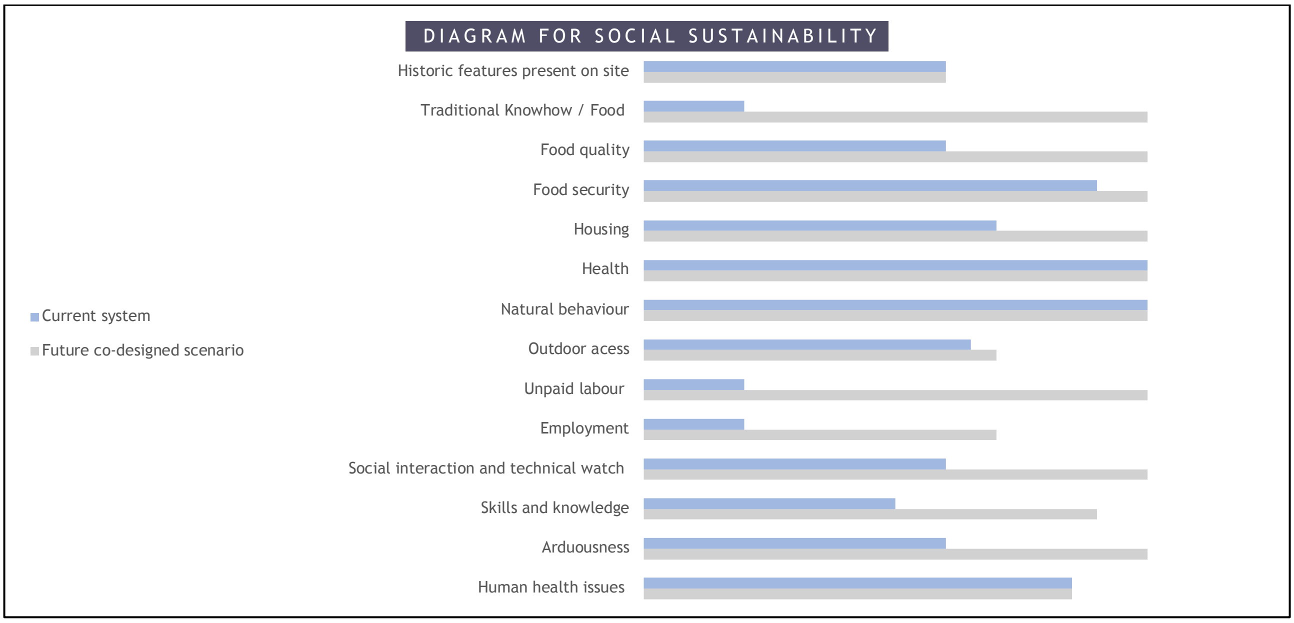

Figure 25. Scores of the social sustainability indicators, showing the current system and the future co-designed system

3.2.2.2.4 Economic impacts

The most important economic impacts were found in the indicators: "stability of incomes" and "investment capacity" (Figure 2). It is since many farmers express meat price is variable and production yield is biased by climate factors such as drought that reduce pasture production and increase needs in buying external support. The fact of farm profitability is not guaranteed every year (subsidies dependency) reduces considerably the investment capacity of this farm and many others.

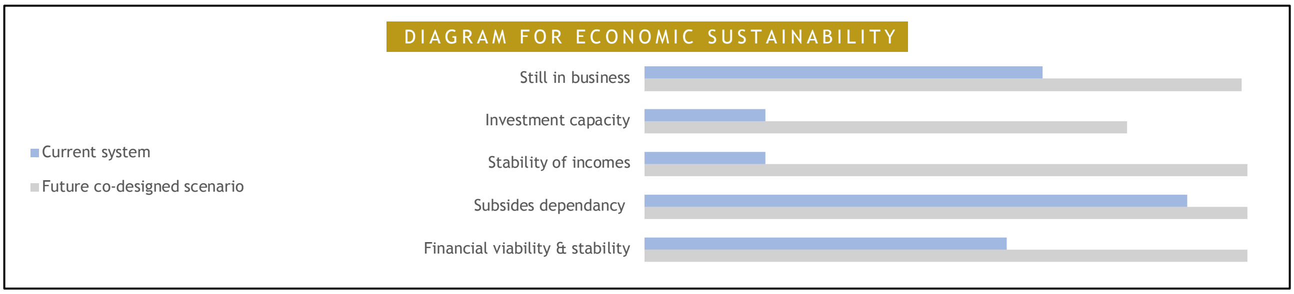

Figure 26. Scores of the economic sustainability indicators, showing the current system and the future co-designed system

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3.2.2.3 Impact of co-design changes on resilience

3.2.2.3.1 Major changes at global scales and comparison with sustainability assessment

On average, the pilot site will be 20% more resilient thanks to the co-design process. This percentage of improvement is quite balanced if we compare the dimensions of every indicator. Resilience will increase from 0 to 60% depending on each specific indicator but resilience will not be lower in none of them. Trees and arable crop diversity will not increase because *dehesa* system is a semi-natural system composed by holm and cork oaks and tillage is an agricultural practice not suggested by experts and farmers. The highest advance in resilience will be effective regarding memberships of farmers since they are not still well-coordinated in the sale of their products. La Barrosa farm is not an exception. Grassland species and short-chain supply seem to be two indicators in which resilience will increase until 40%.

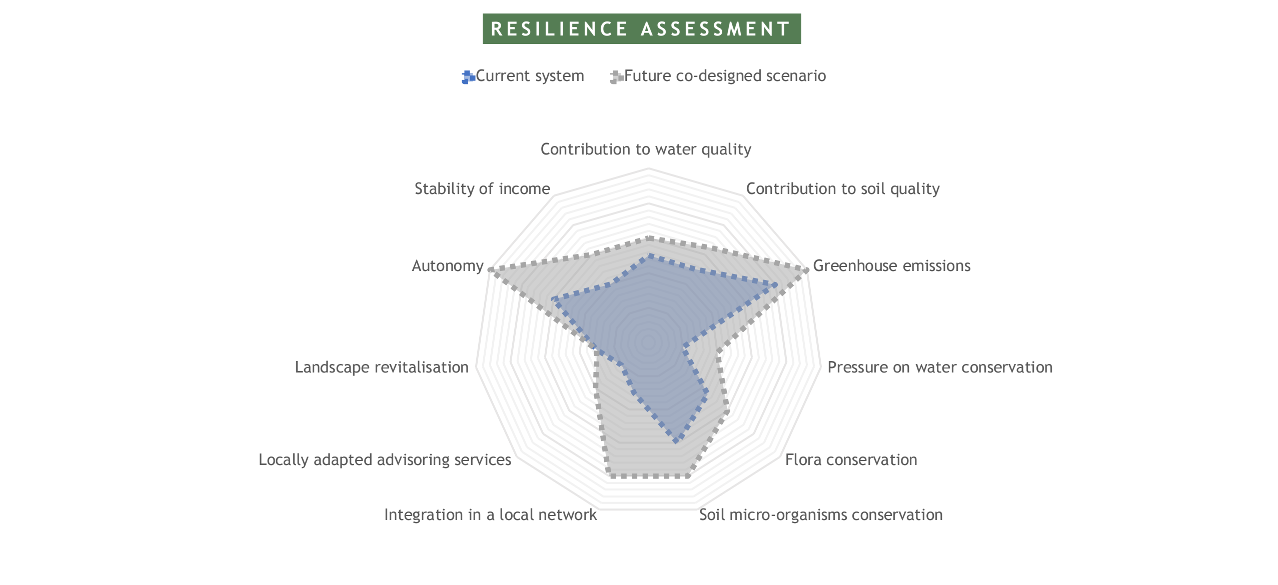

Figure 27. Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario

3.2.2.3.2 Environmental impacts

The indicator with highest impact on environmental resilience was grassland species (Figure 28). It is due to the fact that trees species are always the same in dehesa farms and shrubs are not presumably desirable for farmers, so, only grass species can be modified. In fact, La Barrosa farmers have improved often its annual pastures trying to find optimum species that can both feed livestock and improve soil and water quality.

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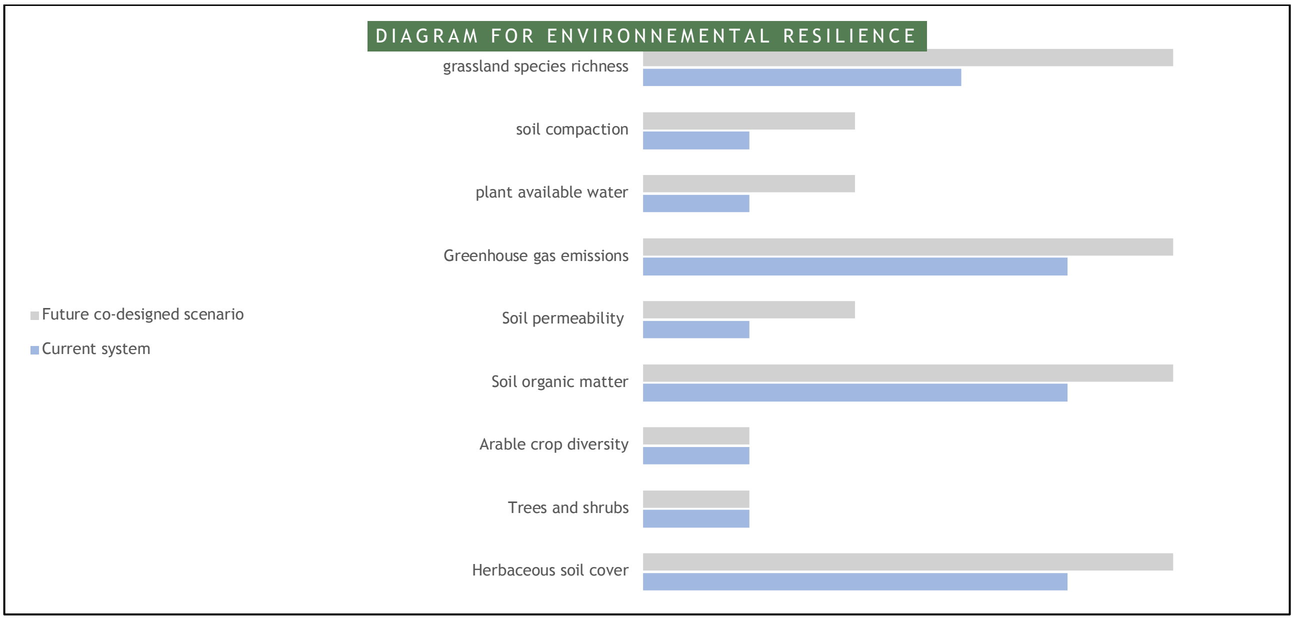

Figure 28. Scores of the environmental resilience indicators, showing the current system and the future co-designed system

3.2.2.3.3 Socials impacts

The highest social impacts were found in the resilience indicators: short supply chains and frequency of training (Figure 29). It is due to, on one hand, the lack of connection between farmers and end-users, i.e., meat consumers. The existing legal restrictions to livestock sacrifice are actually a serious barrier for farmers that they have problems to sell their products directly to consumers. It is starting to change thanks to the activism of some organisations. In addition, a large involvement of authorities to train skilled labour is still needed for dehesa resilience.

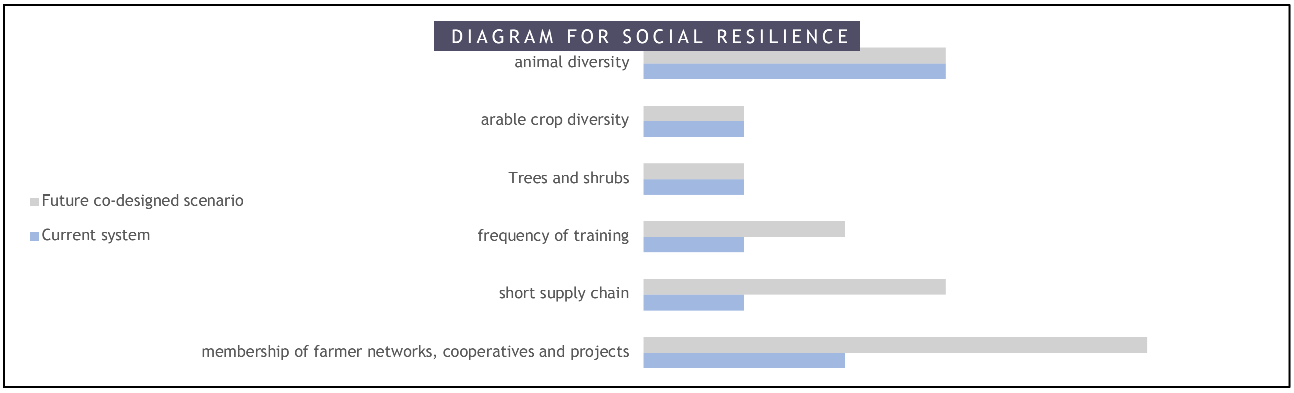

Figure 29. Scores of the social resilience indicators, showing the current system and the future co-designed system

3.2.2.3.4 Economic impacts

Only two indicators were considered in the resilience assessment: number of incomes sources and dependencies on external inputs (Figure 30). Regarding the first one, it is foreseen that La Barrosa farm is going to invest in new ways of incomes: beehives, fishing, agritourism, etc. In addition, its main goal is re-

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design the farm until finding zero dependency of external inputs since prices of feed, fuel, labour force, machinery, etc. is quite high since COVID-19 pandemic and the War in Ukraine (inflation, dependencies of Russian primary matters such as cereal and fodder, etc.).

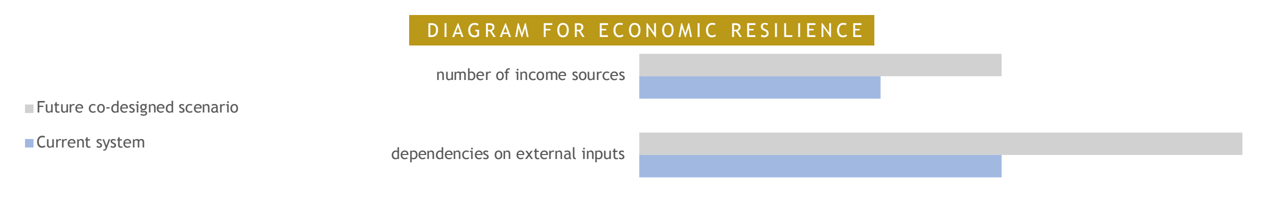

Figure 30. Scores of the social resilience indicators, showing the current system and the future co-designed system

3.2.3 Tools and methods: feedbacks

This multicriteria assessment has proven to be valuable in identifying and informing farmers about the areas where they need to make efforts to achieve a proper balance among environmental, economic, and societal aspects. Considering these indicators, it will be easier re-design La Barrosa farm after AGROMIX project lifetime to become it in a 100% sustainable and resilience farm in the future decades. The willingness and open mind of farmers will be undoubtedly useful in this matter.

The results here obtained make us think about the fact the farm is working properly although it can be improved, particularly in economic matters (e.g., farm profitability, new ways of marketing). Nonetheless, it is still worrying the pressure exerted on water resources since it is located in a Mediterranean climate type area and also water is crucial for the survivorship of its 100 cattle since Iberian pigs are starting to be owned by other farmers that they rent La Barrosa pastures.

La Barrosa pilot team is happy and in agreement with the indicators proposed by the leader of the Task 4.1. In our humble opinion, they have been a good job, and this methodology should be published and replicable for many other environments throughout the world. In addition, we consider more valuable their job because the inherent difficulty to obtain good indicators and their thresholds and the proper understanding of each one of the pilot farms that they are very different among them.

We agree the dominant of sustainability and resilience indicators can be often misunderstood because their similarities. Anyway, it must be interpreted as an excellent first attempt to distinguish between both concepts that they are not equal, but their feedback is important since one farm can be sustainable and not resilient and vice versa. In our particular case, La Barrosa farm seems to be sustainable and also resilient, but we are worried because the recovery of *dehesa* farms can be particularly difficult if some thresholds are exceeded. For instance, if the number of holm oaks decreases significantly since they are well-adapted to average annual temperatures between 13 and 17°C and nowadays climate is becoming warmer and warmer.

During the AGROMIX project, several proposals have been given to the farmers, but they have decided working step by step since *dehesa* system is a fragile environment that changes must be included slowly to assess properly each change is influencing in the whole land system.

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3.2.4 Take-away messages

Our analysis predicts a significant improvement in sustainability and resilience of La Barrosa farm thanks to some ideas co-designed by the AGROMIX project. Nevertheless, we must be prudent in our forecast since many improvements are related to products and by-products commercialisation (value-chains) and it does not depend on La Barrosa farmers. Anyway, they are working in the right direction and the survivorship of the farm at short and mid-term can be guaranteed. The most plausible reason of these satisfactory results lies on the fact that *dehesa* farming system is one of the few semi-natural agricultural systems of the European Union. In other words, it keeps the essence of this methodology in which environmental issues represent one third of the overall assessment.

The most important improvements concern to socio-economic aspects mostly focused on new selling markets thought to obtain fair prices for dehesa meat since they are almost *organic*, but they are not sold like that. In fact, its main competitor is meat intensively obtained from landless production farms. Hopefully, the regional government of Extremadura is working on labels of geographical protection for cattle, lamb, Iberian pig and goat meat that can be a guarantee for the final consumer that they are eating meat of excellent quality, environmentally friendly and though to increase animal welfare.

Regarding environmental impacts, the abandonment of tillage and new ways of promoting good pastures that can be helpful for tree health is being crucial to avoid carbon releases and reduce waste production as well as the buy of fertilisers, external feed, etc. In the long-term it will be quite positive to enhance soil and water quality and consequently biodiversity for birds, reptiles, amphibians, fishes, and mammals apart of soil fauna and many other genetic and pharmaceutical resources such as the bank of seeds.

From a social point of view, the efforts must come from regional and/or national authorities since Extremadura is experiencing a serious problem of depopulation, particularly remarkable in the rural areas. It is being a coin with two sides. The positive one is that is encouraging farmers to obtain a full autonomy of their farm, but the negative side is the generational relay cannot be guaranteed. In the specific case of La Barrosa farm, the owners have children under 5 years old. They are trying to inoculate them the family legacy linked to extensive livestock husbandry, but they are worried that they can decide not working in the farm when they will become adult.

Finally, we can state that La Barrosa farm is an inspirational example of a well-managed *dehesa* farm. However, its dependency of EU subsidies and the fragility of the regional context (e.g., depopulation, scarcity of skilled labour, low prices of meat, soil shallowness) can be serious constrains both for the sustainability and resilience of this centennial land system that was replicated in all the continents.

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3.3 Stadtbauernhof Saarbrücken – Germany pilot (IfaS)

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Reviewer	Erica Tettamanti, Ulrich Schmutz

3.3.1 Pilot site description

3.3.1.1 Pilot site environment

Founded in 2015, Stadtbauernhof Saarbrücken is a two-hectare organic farm in Germany. The farm runs a community-supported agriculture scheme, bringing together members to collect their own produce from the farm weekly, and hosts educational program for groups of all ages, making sustainable food production accessible for all.

Stadtbauernhof is located in the outskirts of Saarbrücken, the capital of the federal state of Saarland, Germany, a city with app. 190.000 inhabitants. The "Almet" valley, a local recreation area is one of the few open land areas in the urban area of Saarbrücken. Composed of allotment gardens, paddocks and a few mown meadows, agriculture in the area is under pressure from construction activities in the neighbouring districts. The site is characterised by a sandy loam to loamy sand on alluvial soils. With its small 0.5 hectares bio-intensive market-garden vegetable production, Stadtbauernhof is the only arable farm in the area. The high diversity of crops (almost 100 different vegetables, herbs and flowers are grown on the farm, see Figure 31) and climate friendly production methods (high share of handwork, minimal tillage and humus preservation) are part of the holistic farming concept at Stadtbauernhof. The farming team is planning to expand these activities further.

Figure 31: Aerial photography of the German pilot site Stadtbauernhof Saarbrücken. (source: Mike Kelly)

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3.3.1.2 Current system

Based on the existing vegetable farm, the idea was to offer other, additional products to the members who come to the farm every week to collect their produce. A survey conducted a few years ago identified eggs, fruit and honey as obvious products. For this reason, the farm has been keeping bees and a small group of chickens for several years. Various fruit trees have also been planted since the farm was founded in 2015. However, it has become apparent that these "experiments" have been far too small and too little integrated into the working economy of the farm. However, regardless of economic purposes, keeping bees and chickens and planting trees also served aesthetic and educational purposes (see Figure 32).

Figure 32: Impressions from the educational work at Stadtbauernhof: kids with chicken, kids with beekeeper clothing, volunteers planting trees.

So far, 5-7 bee colonies and 15-20 chickens were managed by two volunteer teams. Tree plantations have only had limited success because not all trees received the necessary attention alongside vegetable cultivation.

A new approach for an integrated use of existing ancillary areas (meadows, paths and peripheral areas) on the farm for agroforestry for the integrated production of fruit, eggs and possibly meat seemed necessary in order to turn these challenges into opportunities.

3.3.1.3 New co-design system

Based on the Co-Design process in WP2 of AGROMIX, the idea for a new system was developed, integrating results from the initial consumer survey, stakeholder interviews and a co-design workshop with the employees of the farm (see Figure 33).

The following goals for integrated fruit and chicken farming on the farm were identified:

- Professional, outsourced beekeeping on the farm enables an improvement in pollination performance for vegetables and fruit.
- Honey from the farm for the harvesting community can be offered for sale.
- Chicken farming should be expanded to 80-100 chickens, which can use the orchards as a run. Eggs can be offered as an additional product on the farm. The chickens also bring manure as fertiliser.
- Fruit growing can expand the range of products (fruit and juice) for the farm members.
- The agroforestry system with fruit growing and chicken farming offers further synergies:
    - Protection of fruit stocks from insect pests through grazing with chickens.
    - Protection of chickens from excessive sunlight and heat due to tree population, better utilisation of the free-range areas.
    - Reduction of competing vegetation in orchards through scratching by chickens under the trees.

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Figure 33: Co-Design workshop with the farm team.

A second co-design workshop integrating technical-economic knowledge from external experts is still being planned. This workshop has not yet been held because the initial plan was to find a person responsible for the future management of chicken farming and fruit growing beforehand. This has not yet been successful due to the small scale of the activity (not a full-time job). Thus, as the AGROMIX schedule is proceeding, the second workshop will be held in early 2024. The workshop is intended to shed more light on the technical details and the economic levers for the concept and to concretise them.

Although the planning process has not yet been finished, some elements of the future concept have already been implemented:

1. Beekeeping was outsourced, a professional beekeeper now manages 10 colonies on the farm.
2. The stable building for keeping chickens was partially renovated (roof was renewed), fences for the chicken run were improved.
3. Fruit trees in the areas for the chicken run were planted already some years ago and tended – apples, plums, and soft fruit.

Building on the first steps already taken and the results of the upcoming second co-design workshop, the next steps towards agroforestry at Stadtbauernhof are to be implemented in 2024/25.

3.3.2 Sustainability and resilience assessment

3.3.2.1 Selection of indicators for local assessment

The general method for evaluating and weighting individual indicators and evaluation criteria is described in detail in the report on the French pilot site "blue pig farm". Based on this general method, the criteria for sustainability and resilience assessment have been selected and adapted to the individual case study of Stadtbauernhof.

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3.3.2.1.1 Sustainability assessment

For the sustainability assessment in the environmental dimension, only a limited number of indicators have been selected, these are (indicators listed with regard to the respective corresponding categories):

- Soil analysis and herbaceous soil cover with regard to resource protection
- GHG mitigation with regard to greenhouse gas emissions
- Livestock diversity and varietal diversity with regard to biodiversity restauration/improvement
- Feed & litter origin and manure management with regard to circularity.

All other criteria or indicators (e.g. winter grazing of cattle) were irrelevant for a comparison of the status quo with the future scenario.

Also within the social dimension of the sustainability assessment, only part of the indicators given were relevant:

- Employment and unpaid labour with regard to employment contribution
- Outdoor access, natural behaviour, health and housing with regard to animal welfare
- Food security with regard to product quality

Other indicators given (e.g. use of hazardous chemicals, certification status) were considered irrelevant.

For the economic dimension, all criteria and indicators were selected as relevant:

- Financial viability & stability with regard to profitability
- Subsidies dependency & stability of incomes with regard to stability of income
- Investment capacity with regard to investment capacity
- Still in business with regard to transmission of farm

3.3.2.1.2 Resilience assessment

For the resilience assessment in the environmental dimension, again only a limited number of criteria and indicators were selected, in concrete terms:

- Herbaceous soil cover and trees and shrubs with regard to contribution to resource protection
- Grassland species richness, herbaceous soil cover and trees and shrubs with regard to biodiversity conservation

All other criteria and indicators were considered irrelevant for the comparison of the status quo with the future scenario (arable crop diversity) or impossible to assess (e.g. soil organic matter, GHG emissions per unit of product).

With regard to the social dimension, half of the specified indicators were selected, these are:

- Short supply chain with regard to integration in a local network
- Trees, shrubs and animal diversity with regard to landscape revitalisation

The other indicators are not influenced by the compared scenarios and were therefore not considered.

With regard to the economic dimension, the two specified indicators were taken into account:

- Dependencies on external inputs with regard to autonomy
- Number of income sources with regard to stability of income.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.3.2.2 Impact of co-design changes on sustainability

3.3.2.2.1 Major changes at global scales

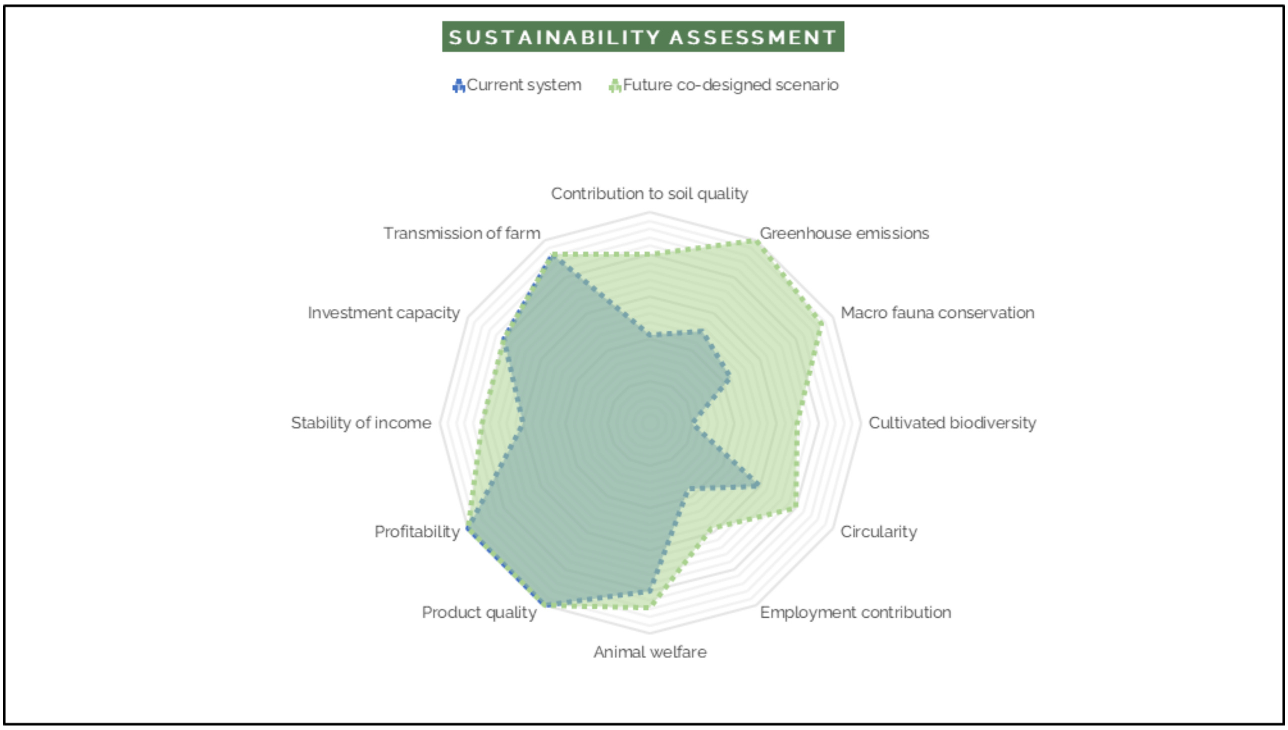

Figure 34: Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario

A comparative assessment of the sustainability of the urban farm with or without an integrated fruit and chicken farming system basically shows that the future scenario can achieve improvements or equally good values in all areas. The focus of the improvements is on the ecological dimension, while the social dimension improves only marginally and the economic dimension hardly at all. These results are largely in line with the expectations of the farm management. The planned concept has various advantages in terms of land use and the associated ecological benefits. However, according to what the co-design process has already shown, the potential to increase income or to generally increase the profitability of the farm is limited.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.3.2.2.2 Environmental impacts

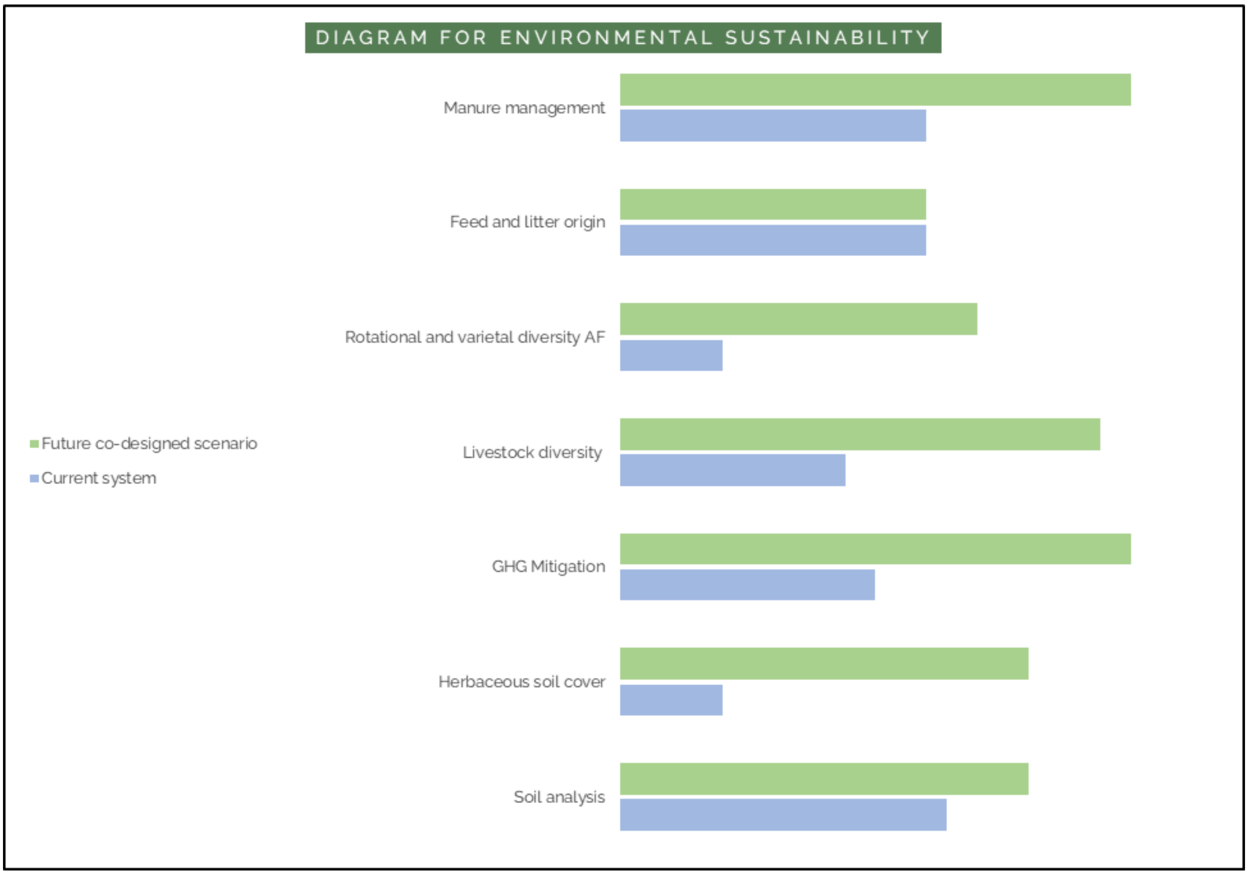

Figure 35: Scores of the environmental sustainability indicators, showing the current system and the future co-designed system

The planned future scenario includes the keeping of various traditional chicken breeds as commercial poultry. This approach can serve to diversify products (e.g. through different sizes and egg colours) and preserve old breeds not only in terms of their outer appearance, but also as a genetic resource for future breeding. In this respect, a significant contribution is made here with regard to the livestock diversity criterion.

Another significant advantage can be achieved with the "herbaceous soil cover" indicator. In the status quo, chickens are kept on the farm on a hobby scale in a permanent run, which means that the soil there is very stressed and sometimes due to a lack of professional management not covered with any significant vegetation. By switching to professional chicken farming with an appropriate land management and a larger grazing area in the future scenario, it is assumed that this situation can be significantly improved, even if the number of animals increases. As a result, an improvement in land cover leads to various secondary ecological benefits, for example in soil and water conservation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.3.2.2.3 Social impacts

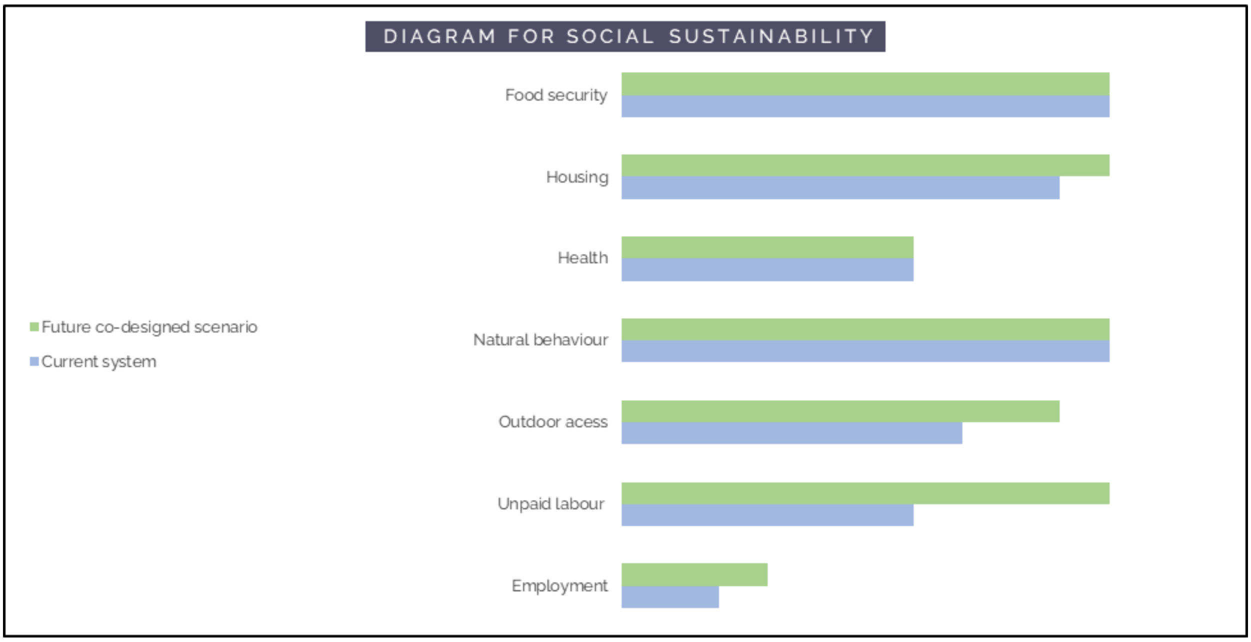

Figure 36: Scores of the social sustainability indicators, showing the current system and the future co-designed system

The social dimension of sustainability can also be improved by the future scenario, although to a lesser extent than in the case of ecology. The use of unpaid labour, i.e. the care of the chickens by a volunteer chicken team in the status quo, can be reduced by increasing the flock and professionalisation in favour of the employment of paid workers. Other social criteria such as animal welfare, better outdoor access, and housing, can also be improved through professionalisation.

3.3.2.2.4 Economic impacts

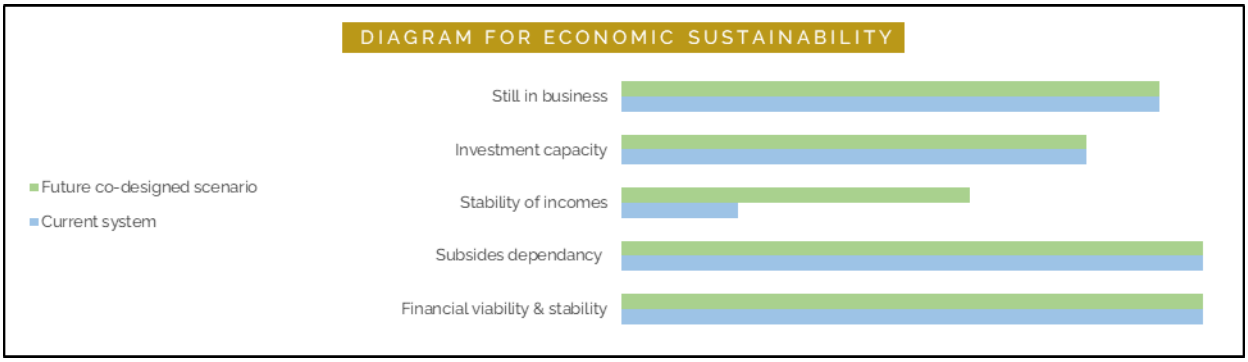

Figure 37: Scores of the economic sustainability indicators, showing the current system and the future co-designed system

In terms of economic sustainability, only an improved stability of income from the farm is to be expected. This is due to a diversification of the business branches and the products offered. The other categories were classified as unchanged in the evaluation. These results can only be regarded as provisional at this stage, as the general economic viability of the future scenario has yet to be demonstrated in real operations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.3.2.3 Impact of co-design changes on resilience

3.3.2.3.1 Major changes at global scales and comparison with sustainability assessment

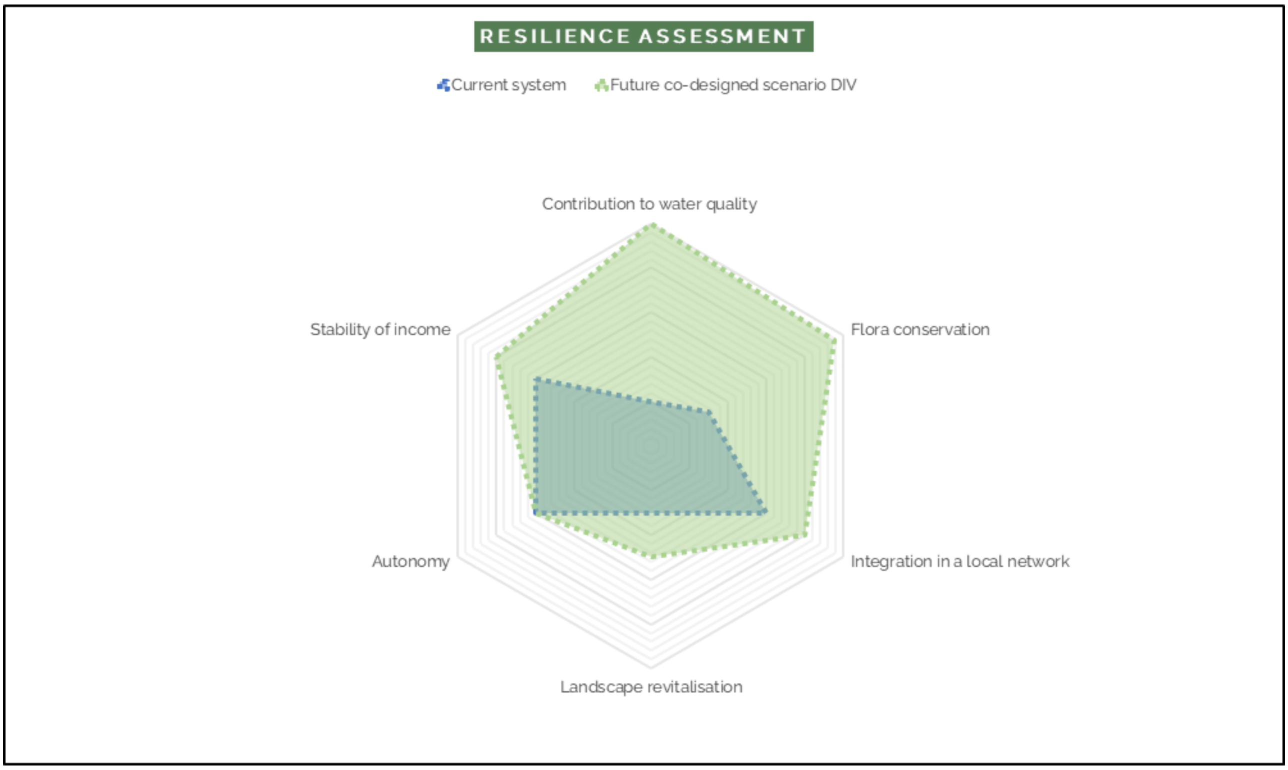

Figure 38: Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario

In terms of resilience, the future scenario also shows that there are no disadvantages in any category. In contrast to the sustainability assessment, the improvements in the area of resilience are even clearer. Once again, the advantages are greatest in the area of ecology (contribution to water quality, flora conservation), followed by the social and economic dimensions. However, as can be seen in the detailed explanations of the various dimensions below, the differences are partly due to methodological reasons.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.3.2.3.2 Environmental impacts

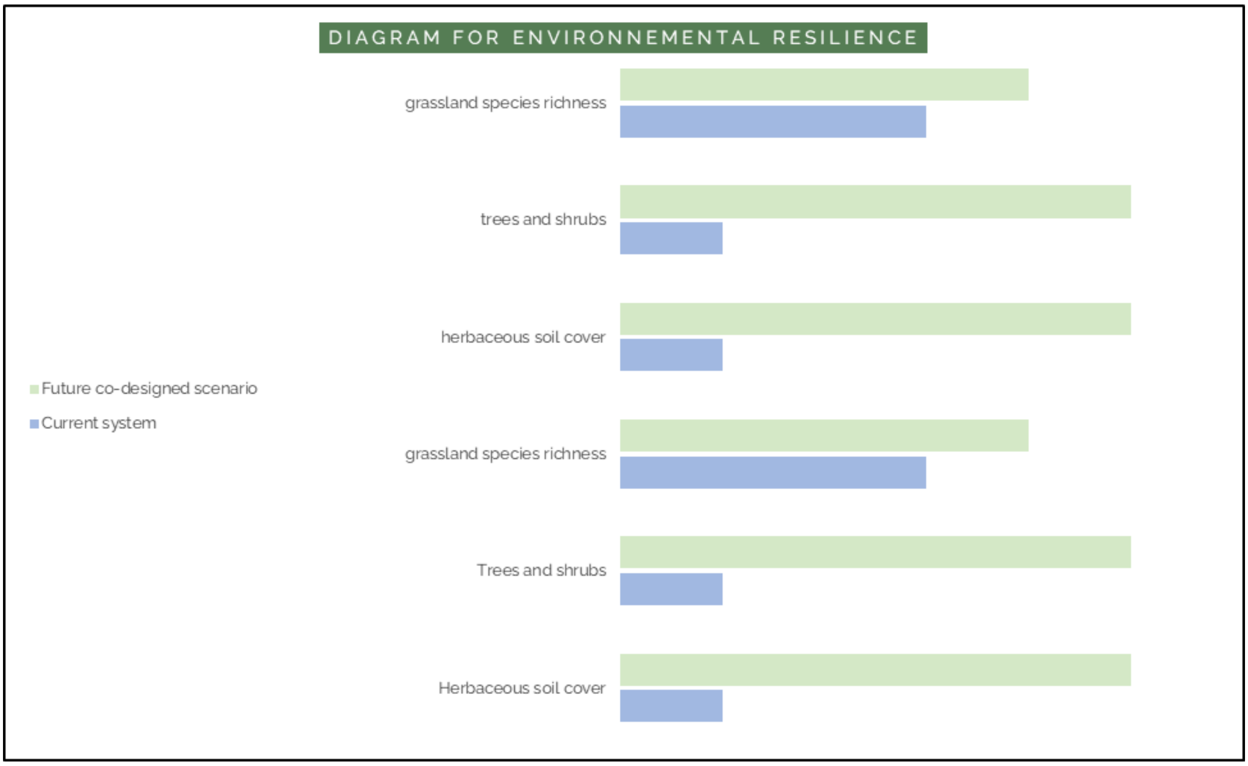

Figure 39: Scores of the environmental resilience indicators, showing the current system and the future co-designed system

When looking at the ecological dimension of resilience, it can be seen that the greatest differences result from an improvement in vegetation both with "trees and shrubs" and with "herbaceous soil cover". These two indicators have a particularly strong impact on the overall result, as they each come into play in two categories of the evaluation catalogue. The third indicator, "grassland species richness", is also used as a basis in two categories – the improvement here is smaller. Overall, it is clear that the good overall result of the ecological assessment is due to the double consideration of these indicators, which may be a methodological inaccuracy that should be adjusted.

3.3.2.3.3 Social impacts

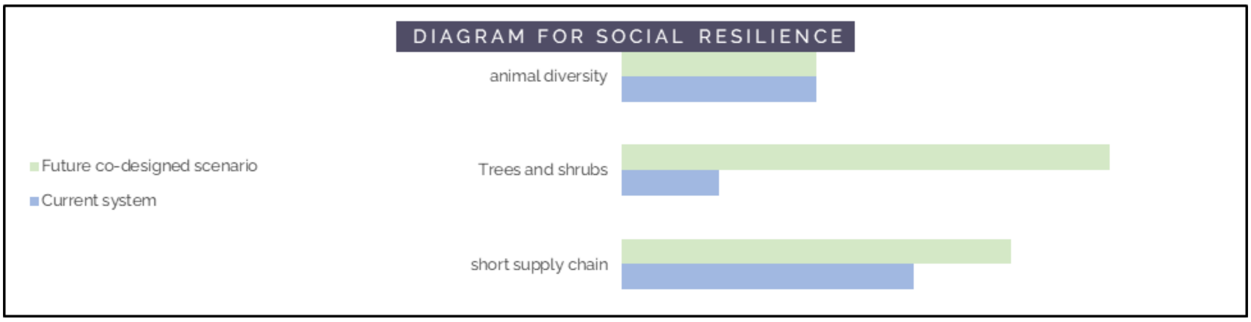

Figure 40: Scores of the social resilience indicators, showing the current system and the future co-designed system

In the social dimension of resilience, the increased stock of trees and shrubs – here as an indicator of landscape revitalisation – is also the main influencing factor for the positive overall result. A short supply chain also contributes to social resilience.

3.3.2.3.4 Economic impacts

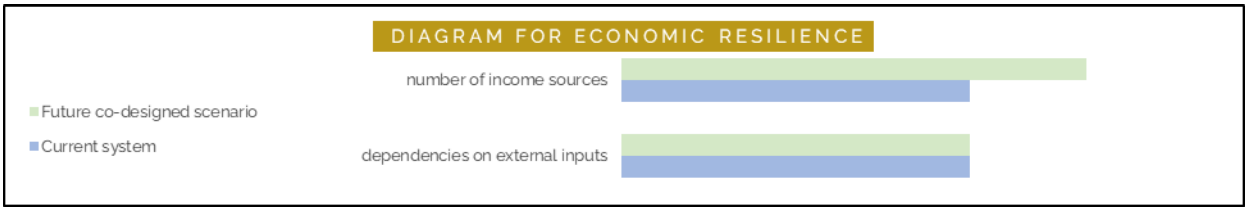

Figure 41: Scores of the economic resilience indicators, showing the current system and the future co-designed system

In terms of economic resilience, only diversification through the creation of two new farm branches, fruit growing and chicken farming, brings about a change. Since neither branch of farming significantly changes the dependencies on external inputs, and other indicators were not given, the bottom line is that the future scenario has only minor advantages here.

3.3.3 Tools and methods: feedbacks

The self-assessment of the sustainability and resilience of the status quo and a future scenario as part of task 4.1 of AGROMIX is a highly complex process. Given the experience from the assessment by IfaS on the example of the German pilot site Stadtbauernhof Saarbrücken, the following feedback on the methodology can be given:

1. The selection of indicators does not appear to be appropriate in all cases, even if the adaptation to the specific conditions of the pilot sites was explicitly planned.
    a. Some indicators appear twice in sustainability and resilience, some appear inappropriate from the perspective of Stadtbauernhof – for example, increasing the stock of trees and shrubs leads to an improvement in several categories.
    b. Some indicators that would have been interesting from the perspective of Stadtbauernhof are missing. For example, indicators such as the personal identification of customers with the farm or the regional products would be useful to include in the topic of social resilience. Concerning economic resilience, the integration of a "dependency on external financing" indicator (dependency on the capital markets) would be a good addition.
    c. If the number of indicators used is limited for practical reasons, as it was the case for the German pilot site, the results are sometimes considerably distorted. From the user's point of view, there is still a need to further develop the method and make it more consistent.
2. Many indicators and categories play no role or only a subordinate role in the assessment of an individual case (here: the integration of fruit growing and chicken farming). For the self-assessment, you must consider very carefully and in advance whether you want to
    a. assess the farm as a whole – then it may be that the changes, e.g. through the establishment of a new agroforestry system, only have a marginal impact on the sustainability and resilience of the farm, or

b. show only the changes with the future scenario – in this case the changes are more visible but cannot be seen in the context of the whole farm.

This decision makes a big difference and must be made in advance. The methodological introduction should provide clarity in advance of the assessment so that the method can be used in an even more targeted manner.

3. In general, a self-assessment of this kind can only provide a very subjective picture, i.e. the assessment result itself conveys little meaning. The actual value of the method therefore does not lie in the assessment itself, but rather in the process and the farm management's "awareness" of the various levers and their effects when planning future scenarios for the further development of agricultural operations. By examining the categories and indicators, reflecting on the initial situation (and the strategic direction), and weighting these factors ("What is important to me in terms of sustainability and resilience?"), farm managers are able to better evaluate their own plans and decisions.

4. With regard to practice, it must be said that the application of the developed method for the management of a farm requires a considerable amount of time. Based on the experience gained at the German pilot site, it seems appropriate to carry out the self-assessment only with professional support from a consultant trained in the method. The tool may also be particularly suitable for group processes and as a guideline for the discussion on sustainability and resilience within farmer organisations and farm networks, although this was not tested at the German pilot site.

3.3.4 Take-away messages

The most important results for Stadtbauernhof Saarbrücken in the self-assessment were as follows:

1. The future scenario offers mainly ecological advantages but offers only limited opportunities for the economic sustainability of the farm.

2. As ecological improvements can only be implemented in practice if they are also economically feasible, the economic performance of the scenario has to be further optimised.

3. Nevertheless, even if the profitability of a measure is only low, benefits for increasing economic resilience can be achieved by diversifying the sources of income.

4. A self-assessment of sustainability and resilience offers the opportunity for the farm management to deal with the strengths and weaknesses of future planning and thereby to use the results for further optimisation of planning. Nevertheless, the effort involved is high and the results are highly subjective.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.4 OIKOS Farm – Polish pilot (OSA)

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Reviewer	Florine Marie

3.4.1 Pilot site description

3.4.1.1 Pilot site environment

The OIKOS farm (49°29'59.9"N 21°19'13.1"E) is a farm located in Sękowa commune, Gorice District in Beskid Mountains, South Poland. Elevation is 550-650 MAMSL. The farm has been operating for 2003, it is organic for 2012. Before communism, agricultural activities have been conducted here by ethnic groups Lemkos and Boykos. There are numerous roadside chapels from the time of the settlement of those groups. Until 1950, communists have displaced the minorities to Western Poland and the area has been transformed into collective farm. In 1990s most of agricultural land was bought by Wójcik family. The area of the farm is located in the natural park buffer zone as well as in landscape protection zone. In theory this could imply land management restrictions on farm activities, but in fact it doesn't, because potential agricultural activities are already limited by natural conditions and in practice land regulations are often evaded in Poland.
The total area of the farm is approximately 300 hectares. The farm is located in a hilly area. Most of the agricultural land (70%) is covered by grassland grazed by cattle, partly with hedges. Pastures are mixed with individual trees and forest area in complex mosaics, where more than 200 Limousine beef cows are being kept. 25 % of the farm is covered by forest, of which approximately 5% is used as silvopastoral system.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.


Oikos

Figure 42 : Pictures of the farm

3.4.1.2 Current system

The farm is certified as organic. Main products sold on the market is beef meat (90% of the gross income, beef products are sold in the local and regional market.); sheep meat (maximum 10% of the gross income). Only a few percent of gross income are wood from the farm, mostly sold, in a minor part this is used for internal consumption.

The farm employs 4 people.

Trees and hedges are scattered across the farm. Hedgerows are located mostly (2 km length) along the roads to meet the role of fence for grazed animals. Some hedges (0,7 km) are located in the higher ground in places exposed to wind (windbreaks), there is also strips (0,5 km) located along the streams to protect them against pollution. All of them meet the role of additional fences, delineating paddocks. One place is covered by widely spaced fruit trees, another one by coniferous trees, while both are used for silvopastoral use. The main objectives of trees planted on grassland is to provide shade for animals, protect them against wind and improve biodiversity. An important element is also the constantly increasing area of wooded pastures in forest, taking the form of tree stands kept in a loose tether. The whole thing relates to the introduction of holistic methods of grazing.

3.4.1.3 New co-design system

The main challenge of the farm is to create environmentally friendly and cost-effective model of livestock grazing and beef production, fulfilling the highest standards based on 100% grass feeding and combining them with agroecology and agroforestry practices. The main objective is to build efficient and resilient supply chain for products of farmers' cooperative.

The farmer is going to improve his energy balance by increasing use of energy wood from his farm (biomass use for heating purposes) and installing new PV panels on rooves of livestock buildings. Establishment of new agroforestry systems is to improve macro-fauna biodiversity. Improve value chain by network enlargement, shortening product supply to customers and implementation of new quality systems is going to reduce subsidies dependency of the farm. New marketing strategy will enhance social interaction and technical watch.

3.4.2 Sustainability and resilience assessment

3.4.2.1 Selection of indicators for local assessment

Almost all sustainability criteria have been found relevant and weighted appropriately for the pilot site. However, we have found agroforestry indicators less relevant. The reason behind that is the pilot farm includes mostly large area of semi-natural grassland, managed in an extensive way. Our studies confirm biodiversity of the grassland biodiversity is very high per se. We have observed plants biodiversity is decreased nearby trees, although trees might have positive impact on fauna diversity and functional biodiversity at landscape scale. Considering that, we reduced the weight of AF in terms of cultivated biodiversity, assuming 10% of total impact in our case. The other element modified is rotational and varietal diversity crops. We removed that element from assessment as the mountain farm is grassland-based and natural conditions does not allow to cultivate crops. This applies to the question of buffer strips share in arable area as well.

For resilience assessment, conclusions are consistent with sustainability assessment, regarding trees and shrubs and crops diversity.

3.4.2.2 Impact of co design changes on sustainability

3.4.2.2.1 Major changes at global scales

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

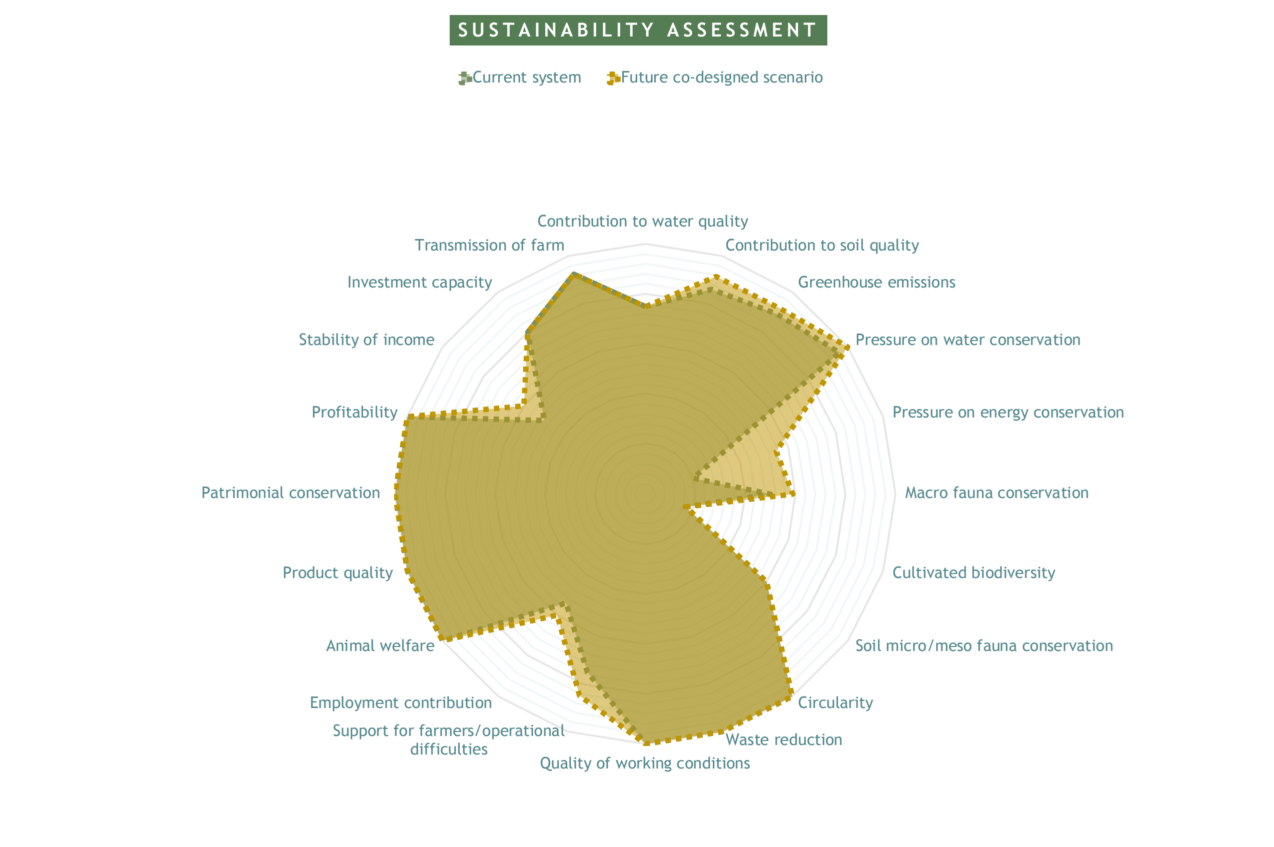

Figure 43 : Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario

In general, we can observe majority of the environmental indicators scores very high. It is because the farm is semi-natural grassland based and located in national park buffer zone. However, contribution to water quality and fauna conservation scores very low – it happened probably due to underassessment of the specific natural elements regulating the factors in the model. The farm territory is almost entirely covered by (semi-)natural grassland, which is found to be very good in soil protection and biodiversity increase. The model does not allow to differentiate botanical structure of grassland and it effect on soil and biodiversity protection under given environmental conditions. It compares different types of land management – i.e. cropland vs. grassland, but omits their subtypes, that might differ significantly. This is also the reason, why spur, called cultivated biodiversity scores very low.

Social sustainability assessment score is very high in general terms, due to strong embeddedness of farm and focus on high quality of organic products to approach customers. It stems also from experience of the farmer and his proactive and environmentally friendly attitude.

The assessment of economic sustainability highlights that the most critical factor is the high cost of production, which results in a dependence on subsidies for viability.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.4.2.2.2 Environmental impacts

A bit lower scores of soil quality and cultivated biodiversity indicate low natural nutrient capacity of the soil and already present high plant biodiversity, respectively, not explicitly expressed by model limitations. Greenhouse gas emission indicators are lower, primarily because the extensive farm area hinders the efficient implementation of agroforestry practices. The significant decrease in score value is found for energy conservation. This might be explained by lack of organisational and financial capacities to buy or sell renewable energy in combination to power grid network in remote mountain region. The production of renewable energy sources is also significantly restricted and costly. It should not be viewed as exerting pressure on energy conservation, given the substantial material and energy investments required for new infrastructure. Instead, the model overlooks the actual conservation practices related to farm fuel and the use of wood for domestic heating purposes. This oversight is crucial in this context as an energy sufficiency measure.

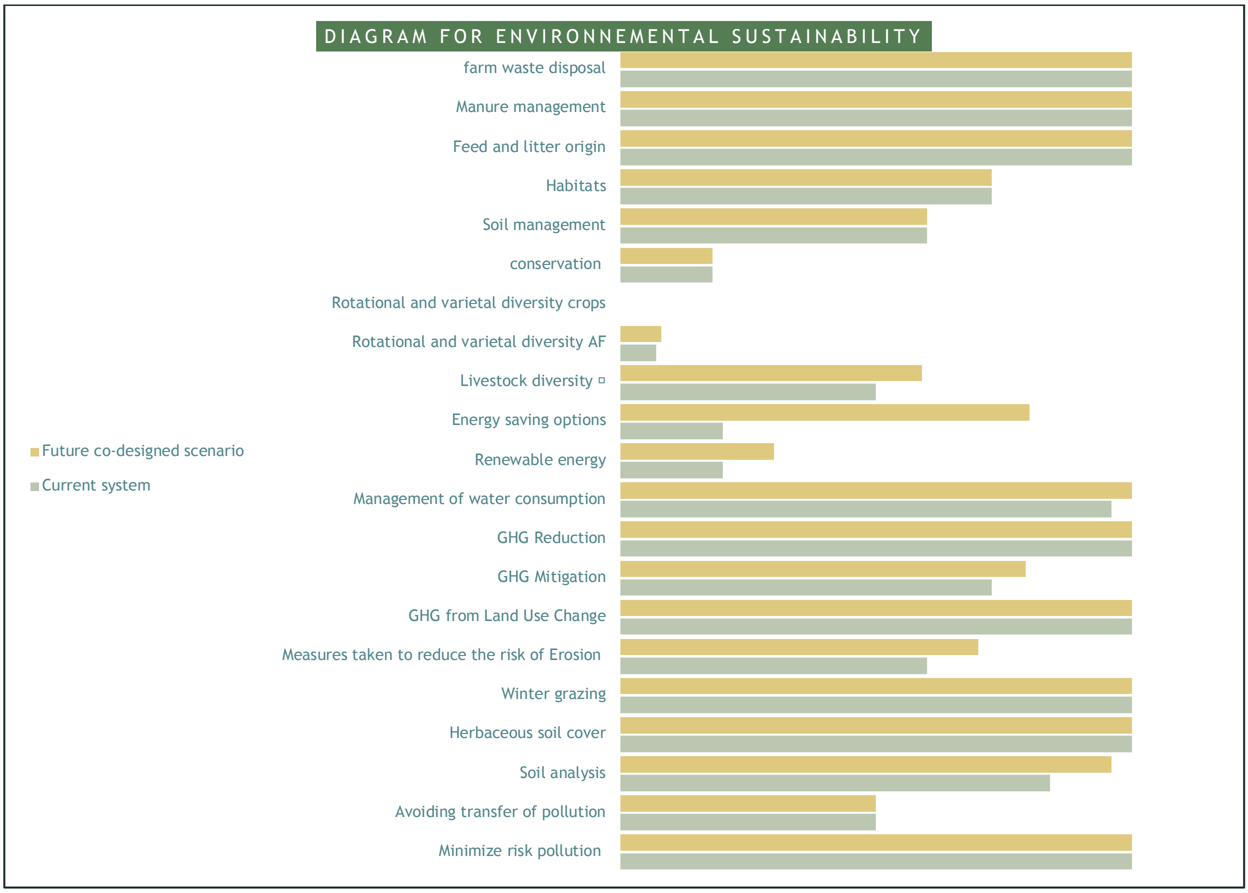

Figure 44 : Scores of the environmental sustainability indicators, showing the current system and the future co-designed system

3.4.2.2.3 Socials impacts

The lowest scores within the social impact category involve unpaid labour, employment, and social interaction. Farming activities remain distinct in Poland due to various social and economic factors. These include low environmental awareness among farmers and processors, underdeveloped value chains, a limited number of organic processors, bureaucratic barriers, and a low level of trust among producers. Moreover, the inadequate organisation of the livestock market constrains social interaction. Farming is still considered as providing less profitable jobs comparing to other sectors. In addition, poor quality of agricultural training, particularly about sustainable practices and globalisation processes, affects people willingness to work in agricultural sector. Those factors have strong impact on hiring high-skilled employees and large workload on the farmer's side. Given these challenges, the farmer is focused on activities improving local social capital, particularly of farmers. The farmer works on image building of Carpathian Grass Fed Beef Quality System initiative. He is also the owner of the Agricultural Processing Incubator, open to a wide range of livestock farmers to help them in beef carcass processing. He intends to achieve a strong market position by organising the cooperation of farmers in the region as part of the "Pasture" Cattle Breeders Association. The farmer is organising workshops and trainings for local farmers as well.

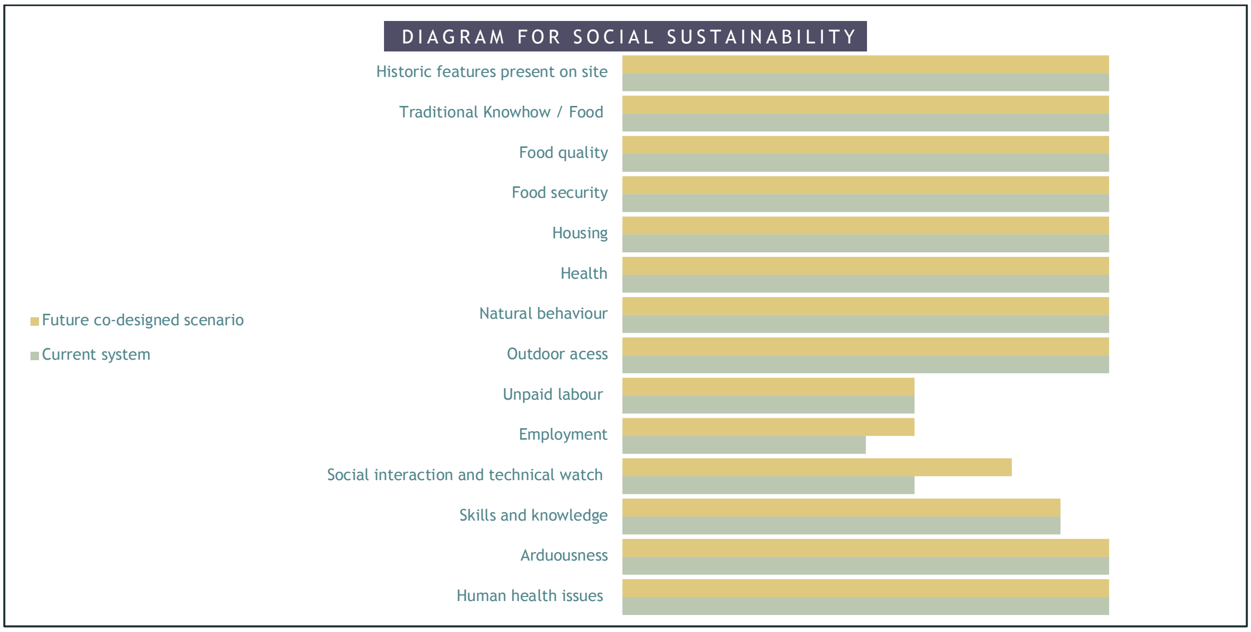

Figure 45 : Scores of the social sustainability indicators, showing the current system and the future co-designed system

3.4.2.2.4 Economic impacts

Economic sustainability is strongly connected to social context, described above. Barriers limiting market development force farmer to look for new sources of income and rely on subsidies to large extent. The farmer is preparing new marketing strategy, through which it will help him to reduce dependency on subsidies. Despite all kind of the efforts, the leverage points connected to economic conditions are largely dependent on political decisions. Numerous restrictions, commitments and poorly develop market of agricultural products are factors which are considered by farmers the biggest challenge in Poland, much more than market price and consumers perception. Institutional inefficiency reduces the efficiency of organic farming, which, being at an early stage of development, is characterised by an outstandingly high sensitivity to changes in the environment. Frequent changes in regulations increase uncertainty and destabilise conditions for organic farms. Access to land, the structure of plots of land and the way they are used can be factors that increase the cost of farming or farm control and, as a result, block the development of organic production.

Figure 46 : Scores of the economic sustainability indicators, showing the current system and the future co-designed system

3.4.2.3 Impact of co design changes on resilience

3.4.2.3.1 Major changes at global scales and comparison with sustainability assessment

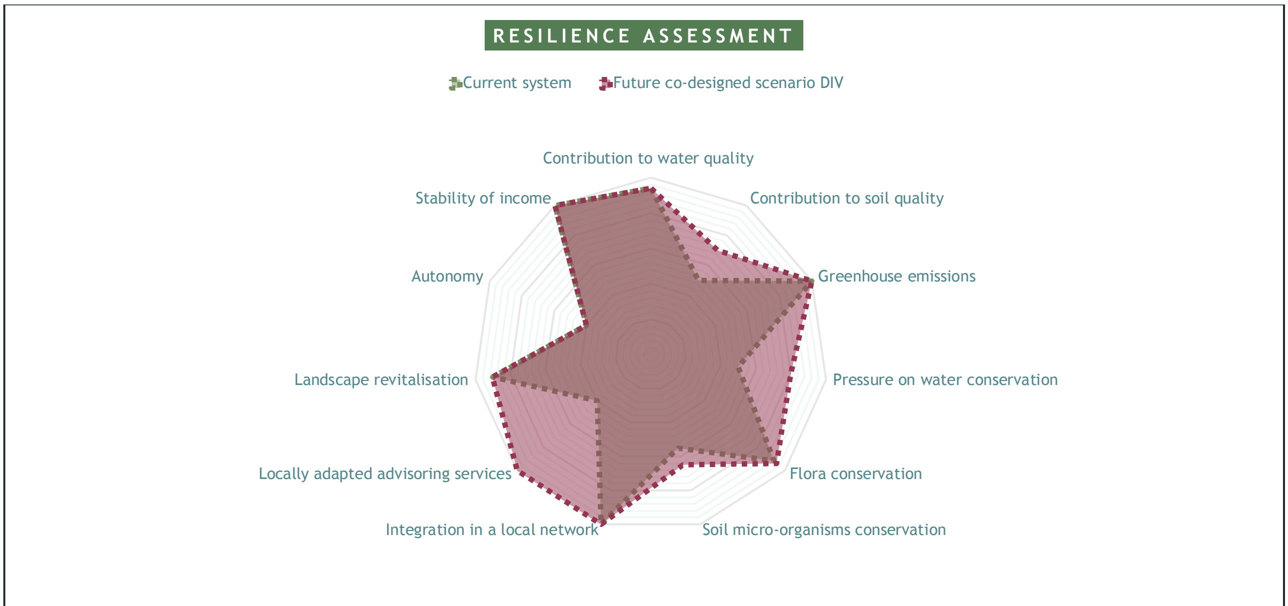

Figure 47 : Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario

Resilience assessment is in accordance to logics of sustainability assessment. The farm is firmly connected to natural conditions but in the same time limited by soil capacity. Social resilience is limited by reduced relevance of trees and shrubs in high biodiversity environment, comparing to the model assumptions. Economic resilience is weakened due to dependency on external sources of income. While poor environmental conditions might be a problem farmers can deal with by improving quality and branding of their products through improved collaboration, social and economic parts are much more complicated issues. It seems those are not fully captured by the general model of resilience. Economic impacts and interdependencies are explained in the section 2.2.2.3. Key to the development of high quality innovative production in future is the social context - the knowledge and skills of farmers, processors and agricultural advisors, openness to cooperation, consumer awareness, and transparent flow of information between practitioners and agricultural policy-making institutions. This context has to change significantly, but this is usually slow and long step during transformation process.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.4.2.3.2 Environmental impacts

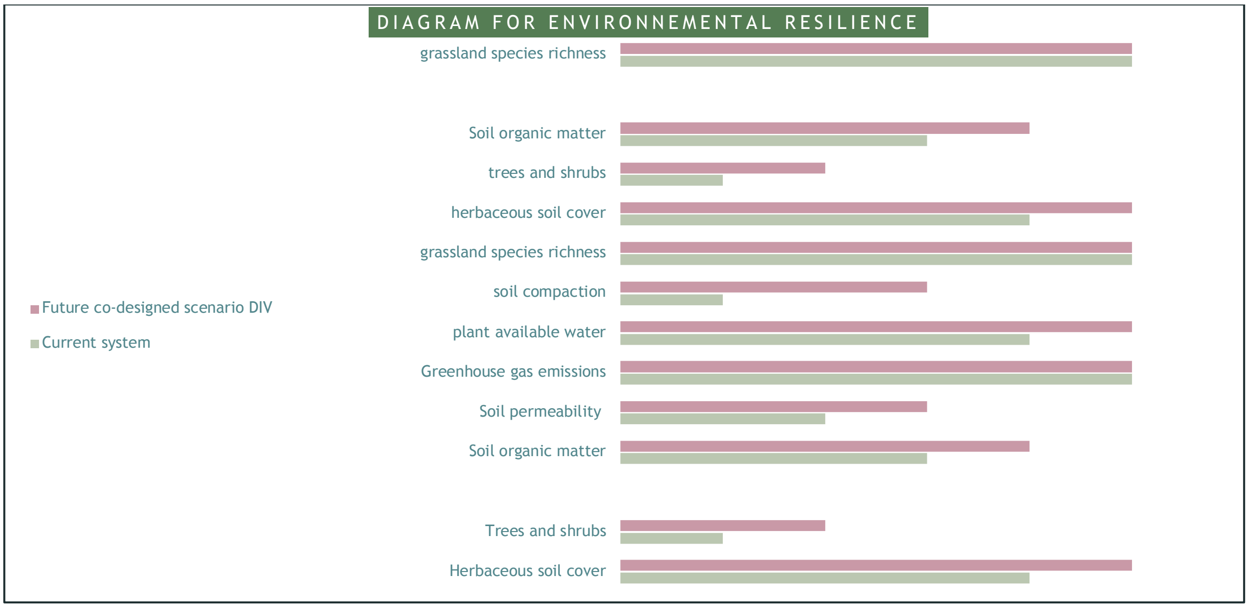

Figure 48 : Scores of the environmental resilience indicators, showing the current system and the future co-designed system

Agroforestry indicator (trees and shrubs) is less relevant. The reason behind that is the pilot farm includes mostly large area of semi-natural grassland, managed in an extensive way. The other element modified is rotational and varietal diversity crops. We removed that element from assessment as the mountain farm is grassland-based and natural conditions does not allow to cultivate crops.

3.4.2.3.3 Socials impacts

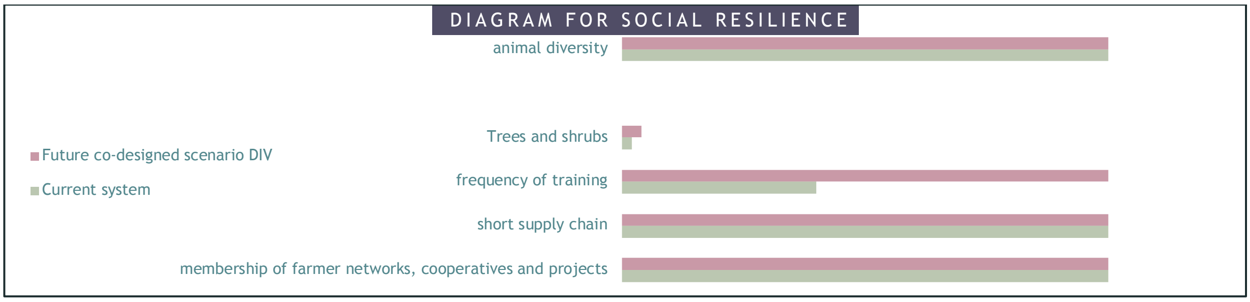

Figure 49 : Scores of the social resilience indicators, showing the current system and the future co-designed system

Social resilience is reduced in the model due to less relevance of trees and shrubs and this indicator should be recalibrated in line with adding other social factors, valid and specific for Polish conditions. Frequency of trainings might help but seem not sufficiently strong leverage point to make (organic) farming in Poland sustainable and resilient. For more details, please refer to claims, presented in sections 2.2.2.3 and 2.3.1.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.4.2.3.4 Economic impacts

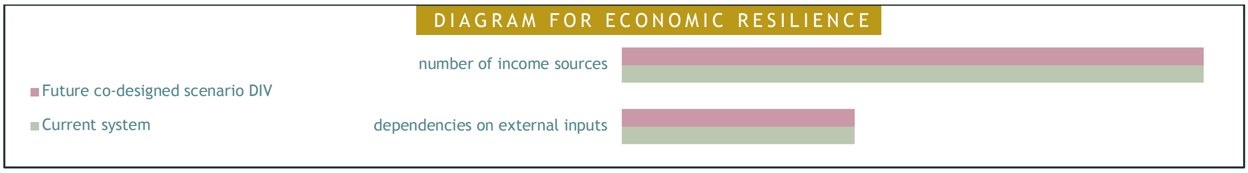

Figure 50 : Scores of the economic resilience indicators, showing the current system and the future co-designed system

Economic resilience is limited because of dependence on subsidies.

3.4.3 Tools and methods: feedbacks

The farm does not have arable land, this fact has implications on relevance of information, measured by indicators and comparability with other farms. For example, data on species/variety number of crops are not relevant.
Maintaining grasslands through long-term extensive grazing makes it difficult to increase soil organic matter, which is a slow process. Testing SOC at reasonable resolution at big farm is also expensive, however due to collaboration with university the farmer managed to perform some analysis.
CO_2 net equivalent emission is estimated based on calculations from 24-30 tons of beef, 72 hectares (ha) of forest, 8 hectares of silvopastoral area and 194 hectares of grassland.

3.4.4 Take-away messages

In general, we can observe majority of the environmental indicators scores very high. It is because the farm is semi-natural grassland based and located in national park buffer zone. Agroforestry indicator (trees and shrubs) is less relevant. The reason behind that is the pilot farm includes mostly large area of semi-natural grassland, managed in an extensive way.
Social assessment is high in general terms of scores, due to strong embeddedness of farm and focus on high quality of organic products to approach customers. It stems also from experience of the farmer and his proactive and environmentally friendly attitude.
Economic assessment indicates the most critical factor is high costs of production, leading to dependence on subsidies to strive.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

3.5 PHAE – Belgian pilot (ILVO)

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Reviewer	Ulrich Schmutz

3.5.1 Pilot site description

3.5.1.1 Pilot site environment

Figure 51. The arable farm PHAE in the rural municipality of Hansbeke (East-Flanders, Belgium).

PHAE (Project Hansbeke AgroEcology, www.ppaehansbeke.be/en) is a certified organic arable farm in Belgium covering 60 hectares, which crop rotation based on legumes, cereals, and temporary grassland. The soil texture ranges from loamy sand to sandy loam. The lighter textured soils have a low carbon content, while the heavier textured soils have a carbon content in the target zone. The soils show a historically high phosphorous content. The lighter textured soils are susceptible to drought and the poorly drained soils are susceptible to deep soil compaction.

The farm is located in Hansbeke (East-Flanders, Belgium). The region is rural, with habitation here and there, forestation, but mainly agriculture. The farm fields are surrounded to the southwest by a railroad line and bicycle highway (Ghent-Bruges) and to the northwest by the Ghent-Bruges canal. Along the fields there are many small landscape elements, such as rows of trees, hedges and hedgerows, and pollarded and solitary trees.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

Figure 52. Impression of the farm and its natural environment.

3.5.1.2 Current system

One of the farm's main interests is the improvement of soil quality through the implementation of agroecological principles, including 'reduced tillage' practices (farming with minimal soil disturbance and preservation of the natural soil stratification) and the incorporation of ponds, trees, hedges, and grass strips on the farmland. After years of conventional farming, farm manager Felix de Bousies observed the damage being done to the farm's main asset: the soil. After learning about studies showing that a reduced tillage approach can gradually restore soil fertility, improve soil drainage, and capture more carbon, Felix switched to this agroecological method in 2017. In a reduced-tillage system, shallow cultivation is performed before sowing a main or cover crop. Weeds are controlled by superficial harrowing or hoeing, early winter cereals' sowing after temporary grassland termination, the use of annual and permanent cover crops and goat grazing in newly established temporary grassland. It is hoped that PHAE will note an increase in soil fertility and biodiversity, improved drainage, and discover the additional benefits of reduced farm operating costs due to the reduced-tillage approach. The land managers also anticipate trees and hedges to benefit from the reduced disturbance of the soil, as well as from the additional fertilisation provided by biodegraded leaf litter in the absence of heavy soil tillage.

3.5.1.3 New co-design system

Although farmers have already come a long way towards more agroecological farming, there was still a long way to go. At the beginning of the process, a system analysis (Figure 53) was found very useful to identify all stakeholders and processes involved and to identify possibilities for the future. Mainly in terms of closing cycles and maintaining sufficient nutrients stocks and soil quality on the farm, there is still work to be done. The farmer collaborates with some nearby livestock farmers who take grass-clover from him and reintroduce nutrients in the form of slurry. Here, not only (excessive) phosphorus is a concern, but also potassium, a nutrient that disappears. Care must be taken to avoid clover fatigue and to improve nutrient retention. The overall fertilisation story with slurry from the neighbourhood, but also via farm compost (made on the farm) and organic fertilisers is being scrutinised. In addition, the pasture of livestock on the farm (grazing of winter cereals in winter to promote eradication, post-grazing of grass-clover, etc.) is included. One of the two co-

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design workshops organised covered this in detail. Various possibilities were explored, ranging from having your own herd to collaborating with shepherds. A local caterer with a passion for local and sustainable ingredients already buys baking cereals from Felix, and together they are now exploring the slope of installing an agroecological vineyard (with or without food forest) on the farm. This aspect was also covered at one of the co-design workshops.

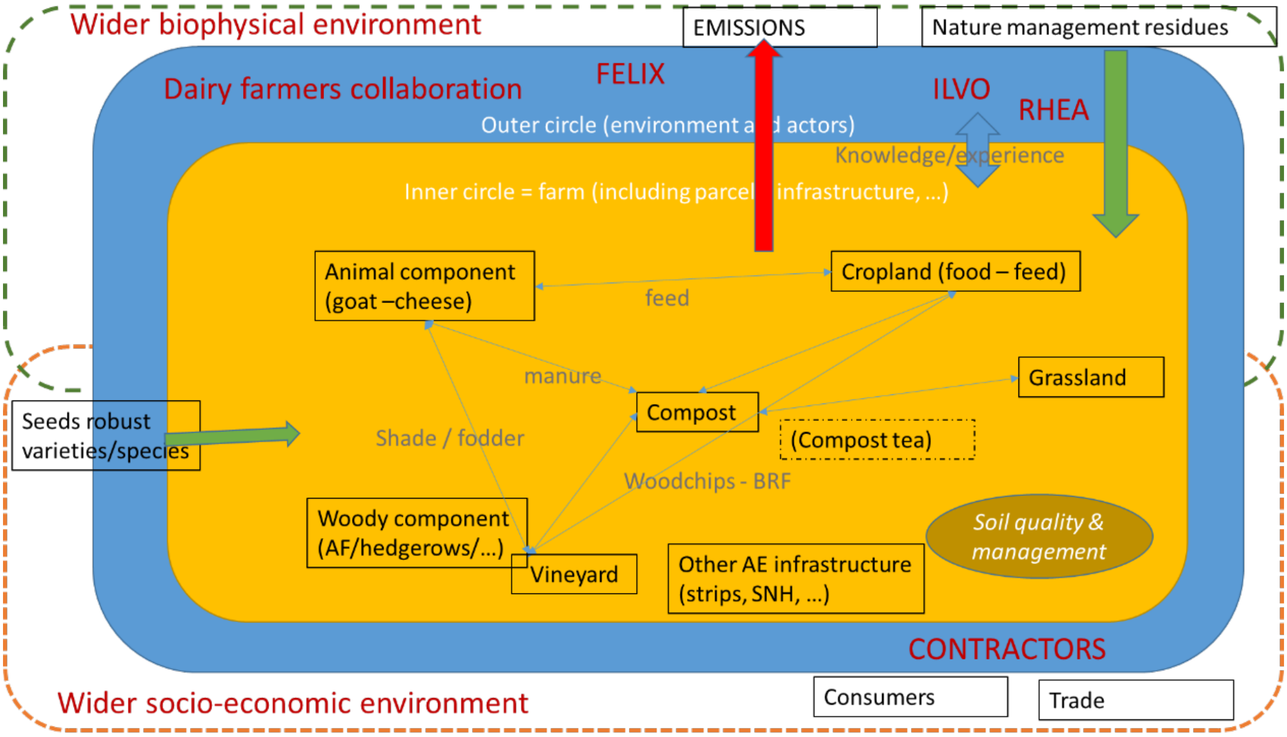

Figure 53. System analysis of PHAE with the main drivers involved in the farm.

3.5.2 Sustainability and resilience assessment

3.5.2.1 Selection of indicators for local assessment

When indicators were not supposed to be relevant (e.g., measures taken to reduce the risk of erosion), or no information was available (soil permeability, greenhouse gas emissions), they were set to zero. If not relevant, because for example there is no risk of erosion, this is considered to be no problem. However, in some other cases, ignoring indicators can give a distorted view. Sometimes you can assume they will increase or decrease, whether or not you know the exact values.

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3.5.2.2 Impact of co design changes on sustainability

3.5.2.2.1 Major changes at global scales

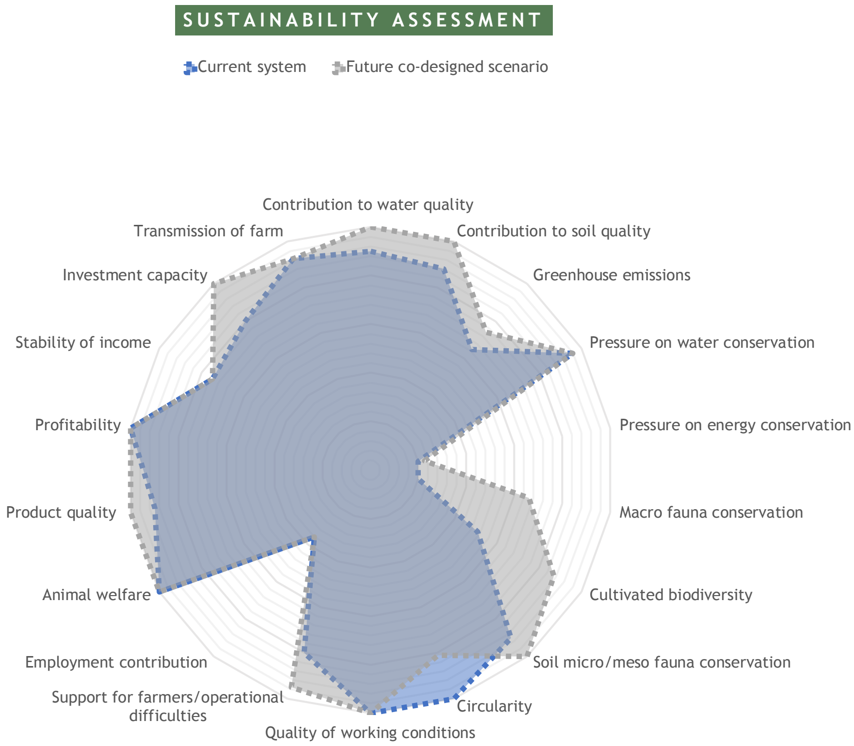

Figure 54 : Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario

Overall, most sustainability indicators increased in the co-designed system. Because important steps had already been taken at the start of the process and the low-hanging fruit had already been picked, the increase is often limited. The only outlier here is 'macro fauna conservation' (due to livestock diversity), as it comes from virtually zero. For the rest, there is usually a steady increase, except for 'circularity', which goes from 5 to 4. Parameters that are not important for PHAE, such as 'patrimonial conservation' and 'waste reduction' were not included.

3.5.2.2.2 Environmental impacts

Environmental sustainability was already quite good in the initial, organic, farming system (or at least at the chosen starting point). Nevertheless, little progress was still possible.
The biggest improvements concern 'conservation', 'rotational and varietal diversity of crops and agroforestry (AF)' and 'livestock diversity', indicators of cultivated biodiversity and macro fauna conservation, as shown under section 3.5.2.2.1. Although this latter parameter seems relatively important, it actually only involves a part of the farm area. This is perhaps a shortcoming of the method.

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One parameter decreases: manure management. This indicator answers the question 'What % of fertilisers applied is coming from of the site?', which was >80% but probably will decrease to 60-80% because today not enough nutrients are entering the system. After proper evaluation, this shouldn't be seen as a negative aspect.

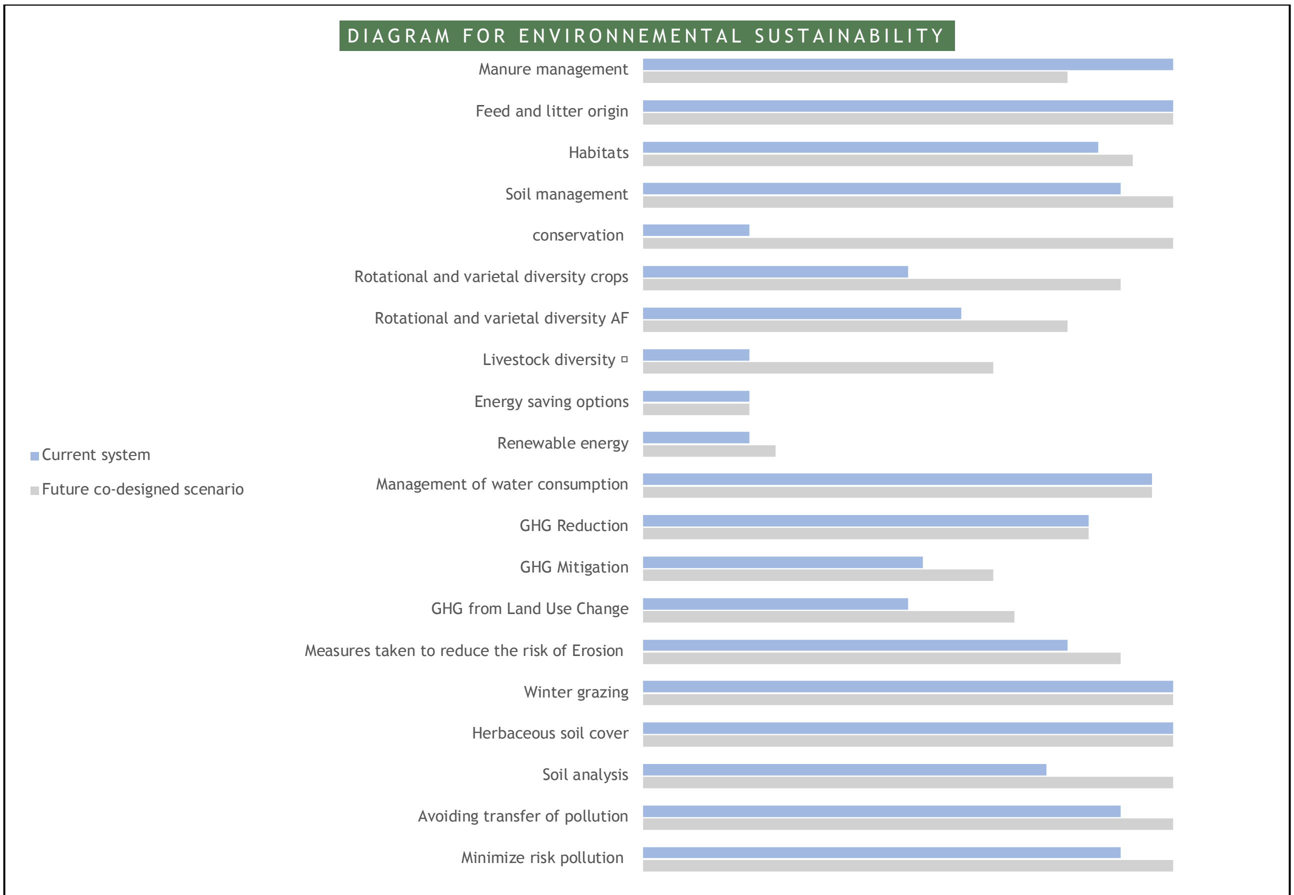

Figure 55 : Scores of the environmental sustainability indicators, showing the current system and the future co-designed system

3.5.2.2.3 Socials impacts

Considering social impacts, change is minimal. The score of most of them is already at maximum. PHAE is a one-man business with no staff but working with contractors for field work (low employment rate). The farm is organically managed, so no hazardous chemicals or antibiotics are being used. The farmer is already member of farmers networks and follows courses and will keep doing so in the future. He is also looking to collaborate more with others, for example to maintain an agroecological vineyard on the farm or to look after the livestock on the farm.

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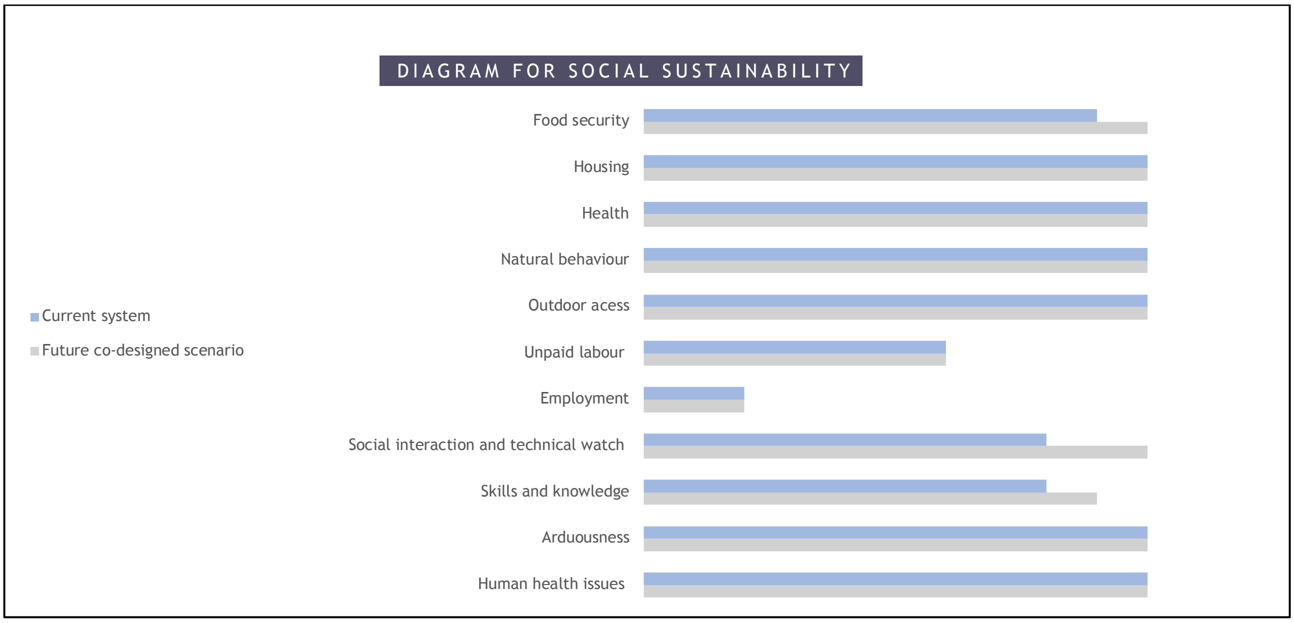

Figure 56 : Scores of the social sustainability indicators, showing the current system and the future co-designed system

3.5.2.2.4 Economic impacts

Because PHAE is already operationally in a short supply chain, the farmer generates a good income from his products. His yields are lower, but due to reduced costs, a steady revenue from his temporary grassland and the exclusiveness of certain arable crops (e.g., his baking cereals), he is able to be financially viable. The idea is to be able to invest more in facilities for animals, the vineyard, and possible also own machinery.

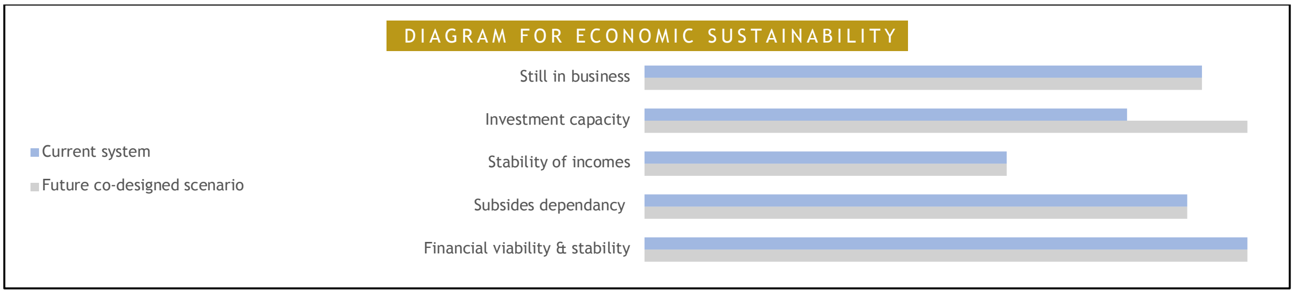

Figure 57 : Scores of the economic sustainability indicators, showing the current system and the future co-designed system

3.5.2.3 Impact of co-design changes on resilience

3.5.2.3.1 Major changes at global scales and comparison with sustainability assessment

As with the sustainability analysis, most parameters are slightly increasing (8 out of 10). It's not clear why the stability of income decreases, as it's indicators (3.5.2.2.4) remain constant. Compared to sustainability assessments, the overall system is scoring less good.

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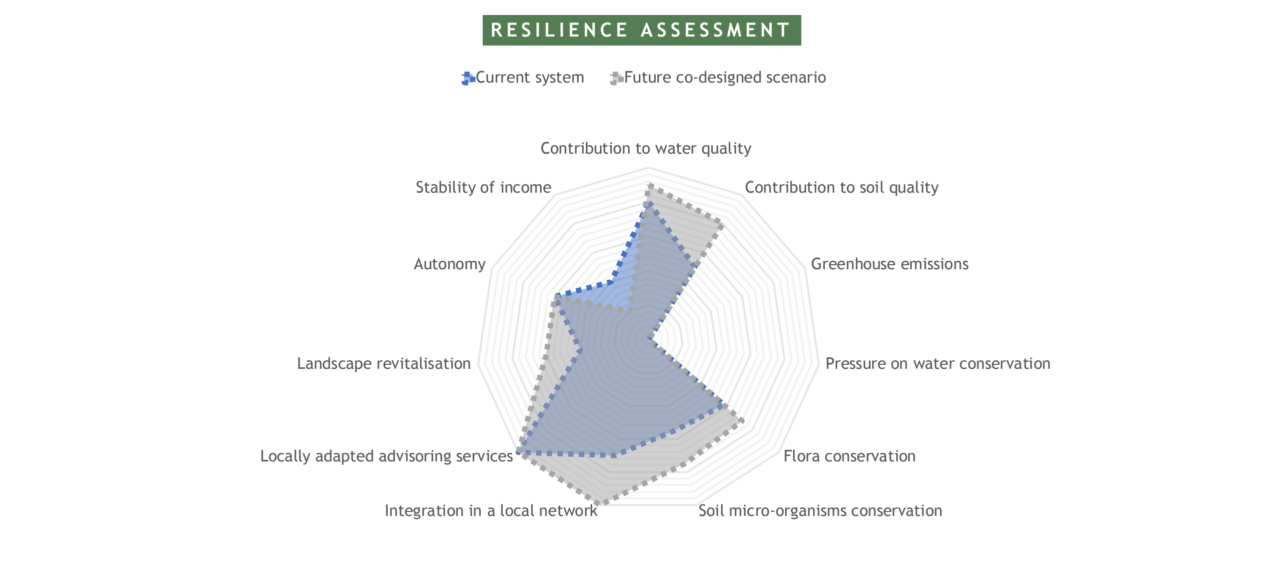

Figure 58 : Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario

3.5.2.3.2 Environmental impacts

The most important indicator for this part is the soil organic matter content, which is believed to increase significantly due to good management practices. Today, the soil organic matter content is 1,4 % on average, which is considered to be too low for the light textured soils (loamy sand) but in the target zone for the heavier textured soils (sandy loam). Given the efforts of the farmer, the expectation is that this content will increase. The combination of long-lasting cover crops, minimal tillage, inclusion of crop residues, the use of farm compost etc. should do the work. As the farm has made already serious efforts concerning environmental sustainability (organically managed, soil covered most of the time), other indicators change less. Generally, species richness (for grassland, arable crops and trees/shrubs) will increase due to further diversification.

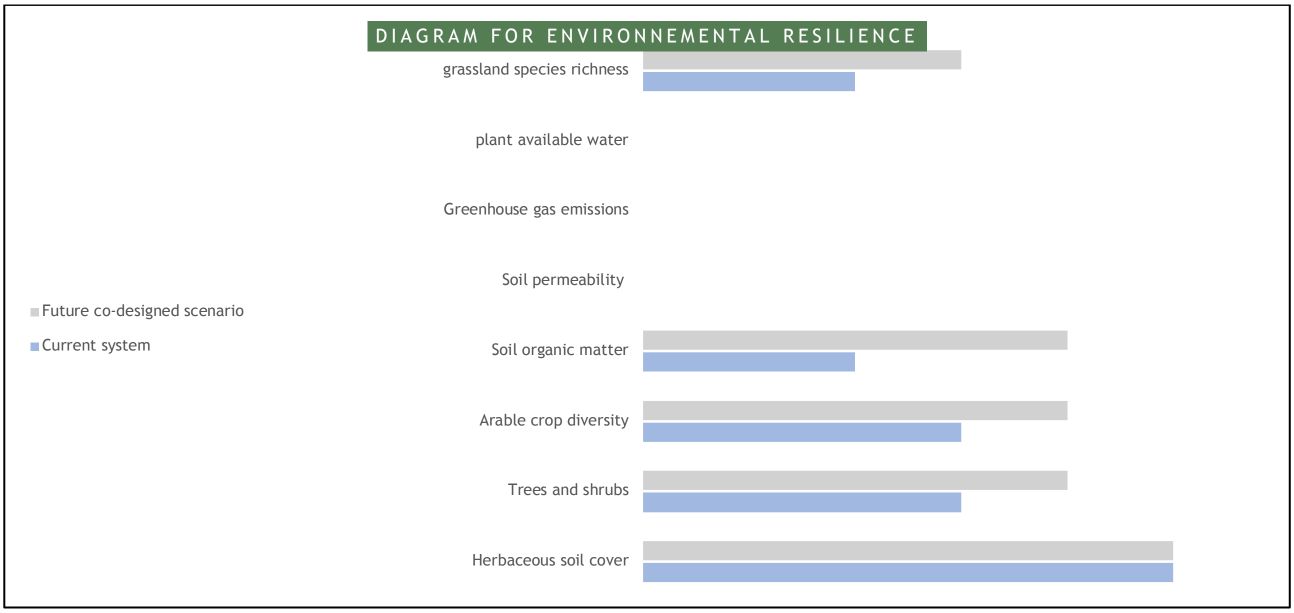

Figure 59 : Scores of the environmental resilience indicators, showing the current system and the future co-designed system

3.5.2.3.3 Socials impacts

PHAE is today mainly a one-man business, working with contractors for field work, but constantly looking at opportunities to cooperate with other partners (both on farm as in the surrounding region). The indicator 'membership of farmer networks, cooperatives and project' is there for supposed to increase (e.g., collaboration with the caterer for vineyard, with shepherds …). Animal diversity is supposed to increase as well: farm animals are now scarce but sustainable grazing (e.g., via bump grazing) will be implemented on the farm.

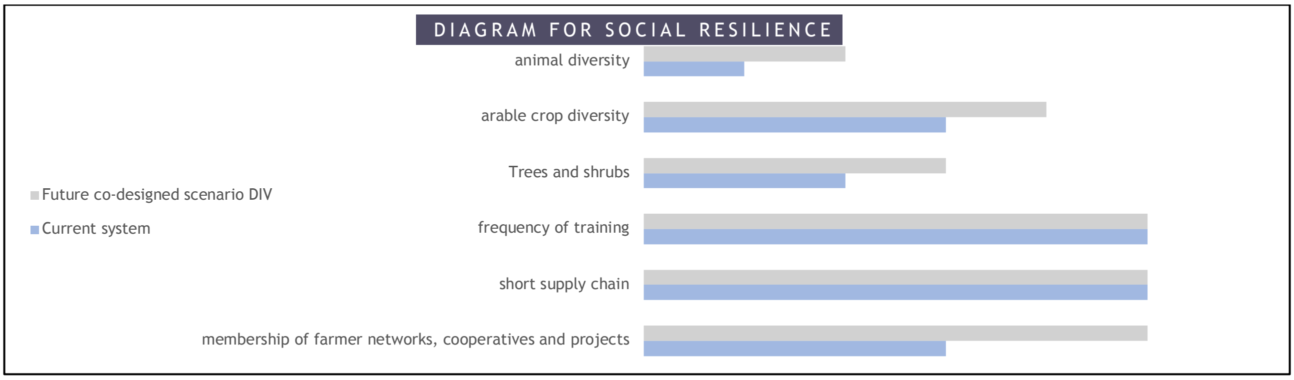

Figure 60 : Scores of the social resilience indicators, showing the current system and the future co-designed system

3.5.2.3.4 Economic impacts

Concerning the economic impact indicators, we do not expect a lot of change as a result of the co-design process. Nevertheless, we might have been a bit conservative in the assessment: the inputs are generally

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sourced locally, but perhaps this indicator will increase a bit, as will the number of income sources due to new cooperation forms.

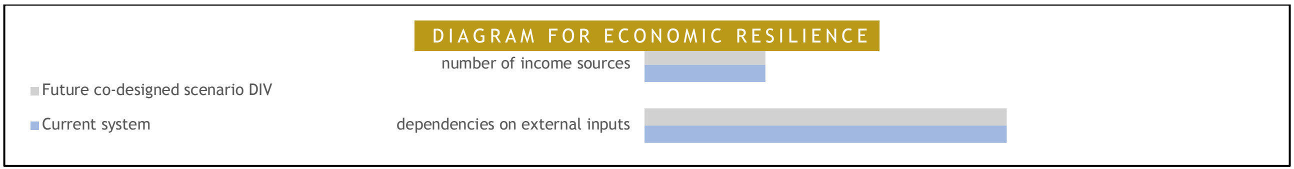

Figure 61 : Scores of the economic resilience indicators, showing the current system and the future co-designed system

3.5.3 Tools and methods: feedbacks

Because farmers were already in the midst of transitioning to more agroecological practices, the results of the change were sometimes limited. In retrospect, as with The Blue Pig Farm, we could have set the starting point in 2017, when the switch towards organic farming was made, although that feels a bit artificial. A business like PHAE is constantly evolving, but changes beyond the 'low hanging fruit' are slower. In practice, there are always factors that hold back changes as well (e.g., ownership, legislation issues, cold feet) which ensured that the desired change is not always realistic and makes it difficult to make accurate predictions.

Still, the tool is useful for comparing different scenarios. You can see very clearly the effect of change on the farm. The possibility to set the weight of the indicators yourself is useful and relevant, however, it does make it more subjective. Depending on what the user finds important, the results can vary greatly.

3.5.4 Take-away messages

Our assessment indicates an overall enhancement in the sustainability and resilience of the co-designed system when compared to the current system. However, the improvement is restricted due to the system's accomplished advancement in various sectors.

Regarding the farm's environmental impact, the assessment indicates that the implementation of the co-designed system, which includes adding different livestock breeds to the farm, extending crop rotations and improving soil health, improves the environmental sustainability and to a lesser extent the environmental resilience as well. Especially, including livestock increases the environmental impact, although the effect on the farm might be limited (depending on the stocking rate).

The assessment of social sustainability and resilience indicates little changes. Concerning sustainability, most indicators were already at maximum. In terms of resilience, a small increase is expected. Collaborations with other entrepreneurs or farmers might further improve the system. In terms of economic sustainability and resilience little to no impact is expected.

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3.6 Al Confin Organic Farm – Italian pilot (Venagro)

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Reviewer	Clemence Berne

3.6.1 Pilot site description

3.6.1.1 Pilot site environment

The pilot group VenetoMix includes seven farms located in the north-east of Italy (Veneto Region), which is an area characterised by a very intensive agriculture and high specialised crops, horticulture and animal productions systems. These farms are mainly organic and concentrated on horticulture and arable crops with direct selling on farm or by CSA (community supporting agriculture); one of them is specialised on vineyard and there is a large 'farm-biodiversity' between them considering location-areas (in low or high plain), size, soil characteristics, type of products, presence of animal productions.

All farms intend to improve the sustainability of their productions, soil fertility and biodiversity, mainly with introduction, or extending AF or multifunctional hedges plantation, in some cases, also enhancing animal productions. Recycling animal manure and vegetable by-products, by home-made compost, is another main aim of the group. Poultry (mainly hens) are the preferred animals to introduce in mixed farming in small-medium size, but also pigs and suckler cows achieved farmers interest, also to explore new market chains (CSA, e-commerce). Outdoor poultry system looks very challenging in the last years, due to outbreak of avian influenza; co-design for sustainability of this important activity is needed.

Main goals of the pilot group will be:

- farm's soil fertility improvement; how to monitor vitality and climate changes soil resilience;
- improving AF systems, experiencing their effects on crops, biodiversity, shading on vegetables/arable crops, fodder production and nutrient values for animal feeding;
- re-thinking the outdoor system for laying hens, according to veterinarian policy on avian influenza and in rotation with horticultural/arable crops.

For the sustainability and resilience assessment we've focused on "Al Confin Organic Farm" considering the type of productions and the high degree of complexity already managed within the mixed farming, as well as for the intention of increasing agroforestry system.

The farm is located in the up part of Veneto's plane (Figure 62); this area is characterised of strict interactions between urban and countryside, with continuous intersection of agriculture fields manufacture-industrial areas and small-medium villages.

Farm average size is quite small (with large number of units between 6 and 10 hectares) compared with other provinces where part-time farming is largely diffused. The very high price of land and the limitation of land rent market, probably represent the main obstacles to the developing of a more efficient farm size.

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With these limitations and land structures, farmers are motivated to find alternative markets to keep their activity profitable enough for life and family. Organic production, direct selling (farm shop) or on farm processing products and/or intensive animal production (mainly milk for cheese production) seem to be the farmers main options in the area.

Figure 62 : Veneto Region north east of Italy, and the area considered (Al Confin organic farm, Vicenza province)

Figure 63 : Al Confin organic farm: chickens' free range area bordered in blue

The farm superficial soil layer is sub-alkaline, loam in texture, with a moderate organic matter content. The risk of superficial crust is moderate. The permeability is moderately high, the drainage is scarce, and the water holding capacity is good enough. The soil is very rich in phosphorus and potassium (especially in the area used in rotation with the free-range field pigs), well endowed with nitrogen. The farmer is making efforts to enrich the soil with organic matter and limit the excesses of nutrients.

Figure 64 : The description of the soil profile during an AGROMIX seminar at the 'Al Confin organic farm', about soil fertility and methodology for soil analysis.

3.6.1.2 Current system

The farmland is about 12 hectares and includes: 5 Hectares of meadow and pasture area for free range pigs, poultry (small mobile barns, are available in fields in case of avian influenza precaution- decided by the local veterinarian authority), and a small heard of suckler cows, 5 Hectares of arable crops in rotation (barley, wheat, triticale and corn) and 2 of horticulture, with more than forty species/varieties and different cultivars of vegetables during seasons.

At the farm they have chickens and laying hens; with annual production now of about 1200 chickens (low growing breed – naked-neck), 200 guinea fowls; 250 hens assured a reasonable daily number of eggs for the farm shop. Outdoors, they have pigs (3 sows, who product about 20-25 growing and fattening pigs/year) which are a cross of Duroc-breed and common white pig breeds. All piglets are fattened in the farm with free range system until slaughtered in a near abattoir, as heavy pigs (age 10-12 months, and 200-250 kg liveweight). About the whole pork carcass (170-200 kg) is used for traditional homemade salami production, and a limited amount (loins) sold as fresh. Beef production at the farm just started four years ago with two suckler cows. One motivation for this was the need of manure for vegetables production and another was in order to answer to the increasing demand for beef meat from consumers who often buy vegetables at farm shop. Now the heard is about 9-10 heads, and they slaughter 3-4 beef/year.
Regarding the cropping system, crop rotation is based on cereals and vegetables. Cereals (triticale, barley, corn) and unsold vegetables are used for feeding pigs. Cereals area sold to local small milling plant, who works within the organic system; cereals by-products, such as bran, is taking back to the farm for animal

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feeding. Manure from the livestock is used to fertilise the soil to improve vegetable production. Weed control is facilitated by a rotation and use of mechanical methods.

Figure 65 : Free range chickens with "home made" mobile chicken coop.

Figure 66 : One of the pasture field where a mix of trees will be planted in the co-design plan.

The "Al Confin Organic Farm" represents a concrete example of mixed farming integrated into the province territory, as a result of more than ten years of development along the way of organic and sustainable agriculture; now they managed to keep together vegetable (horticulture and cereals) and livestock (poultry, pig and cows) production, on farm product processing (i.e. pork into traditional salami, tomato in tomato sauce, etc.) and selling large part of it in the farm shop. Still, some aspects need to be improved: soil quality and organic fertilisation (i.e. manure and vegetable waste into compost), animal welfare, reducing the amount feedstuff brought from the market and the energy consumptions.

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The new system coming from the co-design process will try to develop actions following that direction.

3.6.1.3 New co-design system

For improving animal welfare and vegetable feedstuff for free range chickens and hens, an agroforestry system will be designed; a mix of bushes and trees with different growing rate and size will be planted. Shadow, very important in hot summer months for welfare, will provide, in addition to different fruit bushes, some feed for animals.

With the same aims, improving welfare and feed integration in the pasture, an agroforestry system will be planted in the fields dedicated to a small suckler heard. A mix of different trees and bushes species (poplars, ash tree, mulberry, willows, etc.) will be planted in a line along the border (north-south direction) and protected from cows' potential damage, until they show adequate development and resistance, using shelter and electrical fence (normally used also for rotating grazing area).

Figure 67 : The co-design workshop in the organic farm was conducted indoors (left) but also visiting the farm (right); free range pigs where AF system will be plated (high density poplars).

Also, for pigs (2-3 sows and related grooving-fattening pigs) in a free-range area, used alternatively (every 2 years, with horticulture production) a specific agroforestry system is needed. Shadow in summer and other hot months, is essential for welfare and good health of piglets (at present, no shadow is provided). Co-design system will include high density and low-density poplars plantation in the border area between two main fields used alternately for pigs or horticulture. Poplars are fast growing trees in plane soil with good amount of water availability, assuring quickly good shadow and nutrients (release by pigs fecis/urine) absorption, preventing nitrogen leaching and water pollution in the defecation spots.

Because energy costs were much increased during the last 2-3 years, with serious threat on family income, the farm is planning a way to achieve the self-sufficiency (mainly for electricity) in 2-3 year; first step was implemented in 2022 with solar panels on the roof of the house and services building; the second step will consider the facilities with rebuilding the roof and install large area of solar panels (for this investment quite expensive, the farmer will receive contribution from the state within a national plan).

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3.6.2 Sustainability and resilience assessment

3.6.2.1 Selection of indicators for local assessment

3.6.2.1.1 Relevant/not relevant indicators regarding Pilot site specificity

Within the pilot group the discussions about excluding some of the indicators, lead to the decision that there aren't indicators to be excluded from the assessment, because the farming system has a very wide range of productions (animals, vegetables, cereals) within a mixed farming system, therefore all parameters were estimated to be more or less important to the final result.

3.6.2.1.2 Weighting indicators

In terms of allocating weights to indicators, the default was to weight indicators within a 'Leaf' equally, except for the following cases:

Sustainability assessment
Environmental
Within the 'Contribution to water quality' parameter, we reduced the weight in % of untreated land with pesticides (30%) because of the high standard of environmental sustainability (the farm system is organic and uses a minimal amount of allowed by OA pesticides) and the contribution of this parameter would not have margins for improvement. Within the same parameter we gave also less weight to the leaf '% of arable land (including permanent meadows) left as bare ground' because of the less potential of improvement than the other leaf '% of arable area contains buffer strips' in this farm case.
From the parameter 'Greenhouse emissions' we lessened the weight in '% of total woodland/grassland converted to arable in the last 20 years' (10%) and gave a higher weight (40%) to the '% of total arable area converted to permanent grassland or woodland in the last 20 years' because the farmers' intention is to give more space to grassland and limiting therefore the arable crop area.
Finally, we gave most of the weight (80%) at the parameter 'maintaining hedges' and reduced the other two from the same leaf, as the farm has nearly inexistent non-productive areas of ecological interest and has already a wide range of different crops.

Resilience assessment
Environmental
Within the 'Contribution of water quality' parameter, leaf of the Contribution to resource protection category, we gave more weight to herbaceous soil cover (70%), which is predominant in terms of land surface in the farm, compared with tree and shrubs (30%). In the same category we gave a minimal importance (5%) at the Arable crop diversity 'leaf' for the contribution to soil quality from 'different types of crop', because the diversity of crops is already at high level within the farm. The highest weight is for us to attribute to the 'change in soil organic matter' (from 2 to 2.6 %). The same differentiation of weight was made for leaf of Soil micro-organisms conservation within the biodiversity conservation category.

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3.6.2.2 Impact of co-designed changes on sustainability

3.6.2.2.1 Major changes at global scales

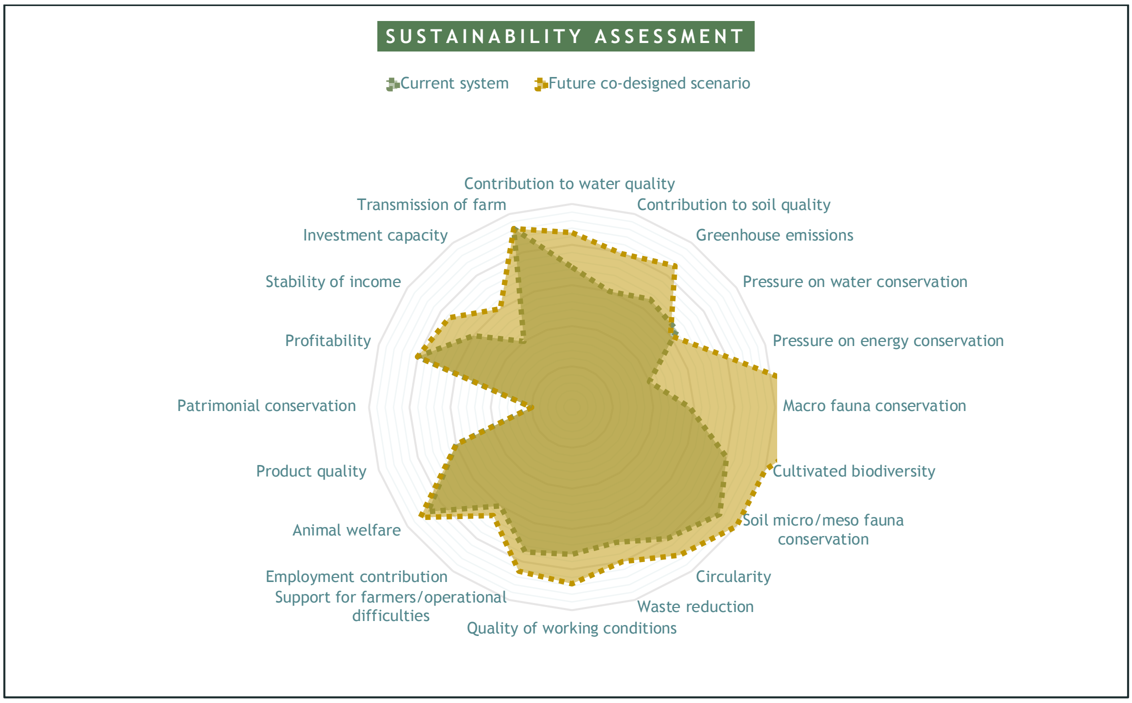

Figure 68 : Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario

This multicriteria analysis shows that the co-designed scenario improves in general the sustainability of the farm. For a limited number of indicators improvement was not expected between the current system and the future co-designed system, but there is no reduction of social, economic, or environmental impacts of the farm.
Major improvements concerning the environmental indicators were assess on concerned indicators of cultivated biodiversity, soil micro-macrofauna conservation as well as greenhouse emissions and contribution to soil quality.
Some changes are expected but less evident in the social dimension, as the farm was already quite good in the ongoing (ex-ante) system as concerns quality of working conditions and animal welfare. The economic stability and income forecasted not to worsen, with a minimal improvement in the investment capacity.
No changes are evident for other indicators, such as "product quality" when a new system will be implemented; that maybe depends on the complexity of improvement and the difficulty to assess (ex-ante vs. ex-post) variation considering the high number of products sold in the farm. As well as for "patrimonial conservation" no improvement is shown, probably due to the difficulty of the new system of effecting this economical trait. The following parts of the report will specify more analytically these assessments.

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3.6.2.2.2 Environmental impacts

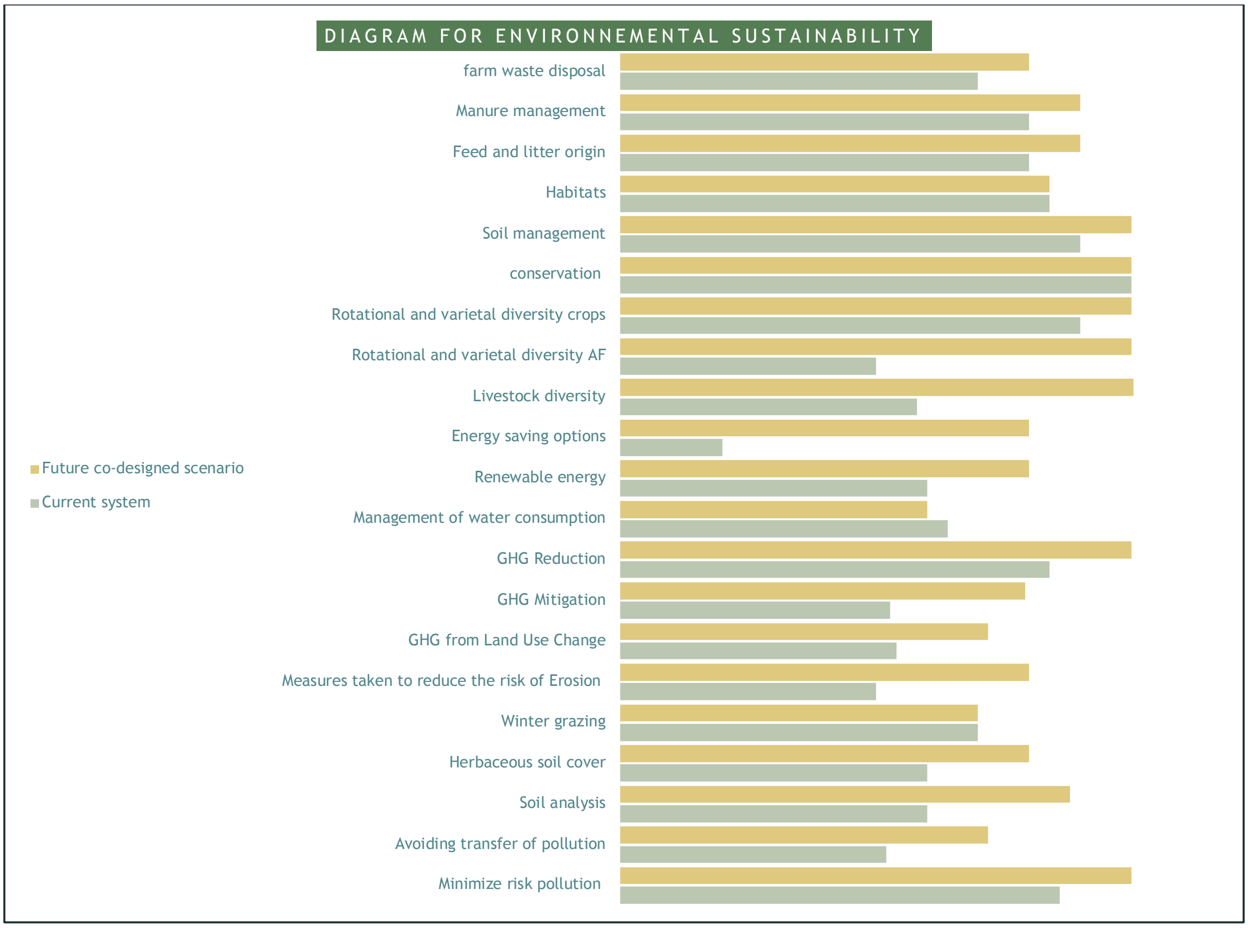

Figure 69 : Scores of the environmental sustainability indicators, showing the current system and the future co-designed system

Focusing on environmental sustainability assessment of the system, the parameters in general have not variated that much, as the farm has an organic standard certification and has already a quite good sustainable profile.

The future scenario is to cover at least 70-80% of fields with agroforestry (AF), and this perspective has given an increase in the cultivated biodiversity and GHG emissions. Also, the decision of increasing pastures with the reduction of arable land, has given a positive impact in different parameters such as greenhouse reduced emissions and GHG mitigation, even though the organic farm was already implementing a low impact management, even trying to improve it (minimum tillage or no tillage in horticulture and cereals). The farmer has never evaluated the total GHG emissions but has the intention to do an energy and GHG emissions audit on the farm in order to evaluate the farm efficiency. Part of the farm transforming plan is to increase grazing area of at least 2 hectares within 5 years, for a better management and more sustainable feeding of cow herd and small-scale pig production. This future improvement of the 'Al Confin' farm will probably affect the water and soil quality, in particular the risk of soil erosion. The introduction of additional AF (e.g. poplars, willows and fruit trees) will improve animal welfare due to better shadowing and also can reduce the risk of nitrogen leaching as the plants develop significant root systems. That is going to be very important and effective in

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terms of reducing potential pollution in the free-range pig's defecation areas, therefore improving the parameter that minimises risk of pollution.

3.6.2.2.3 Socials impacts

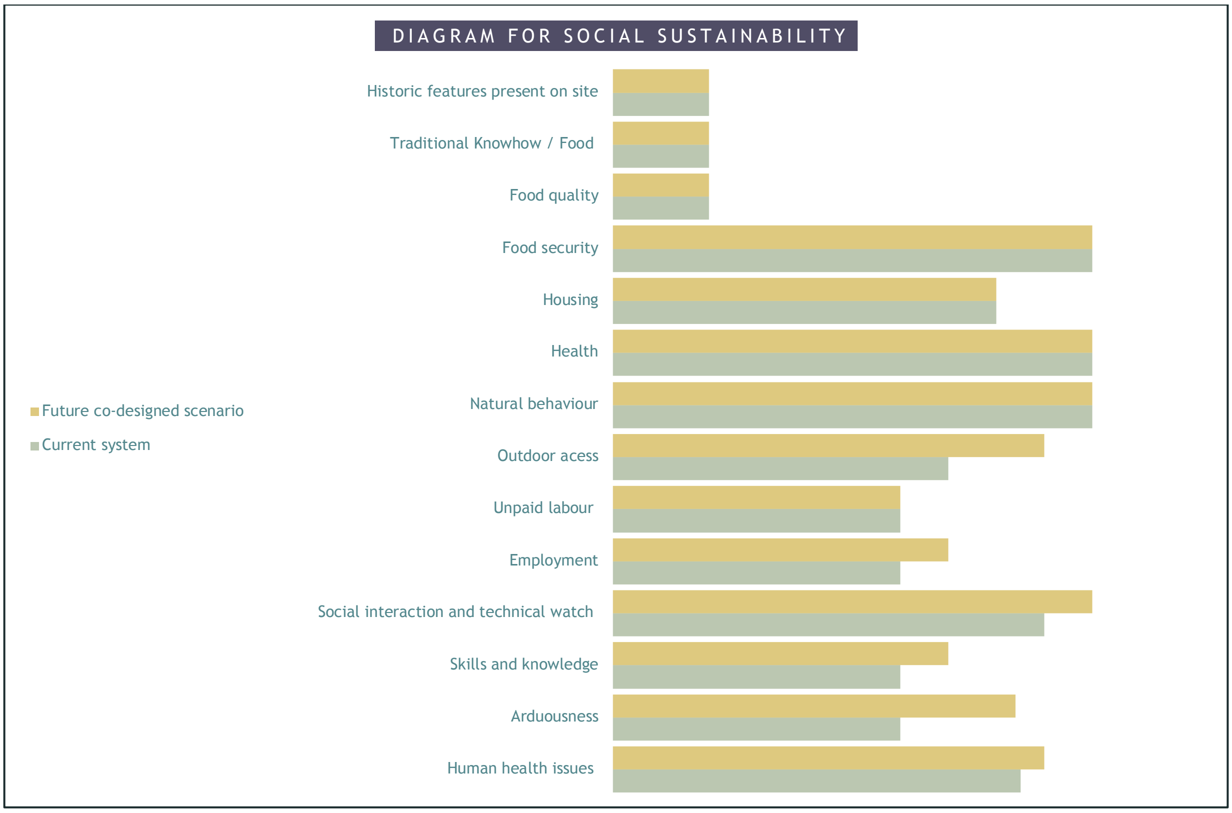

Figure 70 : Scores of the social sustainability indicators, showing the current system and the future co-designed system

Comparing ante and post social sustainability evaluation, the indicators show little improvement due to already good standard of considered parameters. Social interaction and technical watch for example are already at maximum scores, as the farm participates to various official and informal groups and associations. One of the parameters expected to be improved is the 'skills and knowledge' because of the intention of the farmer to increase the days of workers' training. Better field conditions with more tree shadows will provide better welfare for pigs. Animals are expected to spend more time outdoor in the field than in the barn. The shadow and better pasture conditions will probably affect positively also the labour conditions of the workers with their daily operations with pigs. A little improvement is forecasted for "employment" and "human health issues". For the first indicator, it depends on the availability in the area of motivated workers, to be included in the farm staff; the high turnover recorded in previous year suggests that it will not be easy to reach the improvement.

For human health issues, the new system planned will probably offer a better condition and standard according to the changes on animal husbandry and welfare and free-range daily activities.

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3.6.2.2.4 Economic impacts

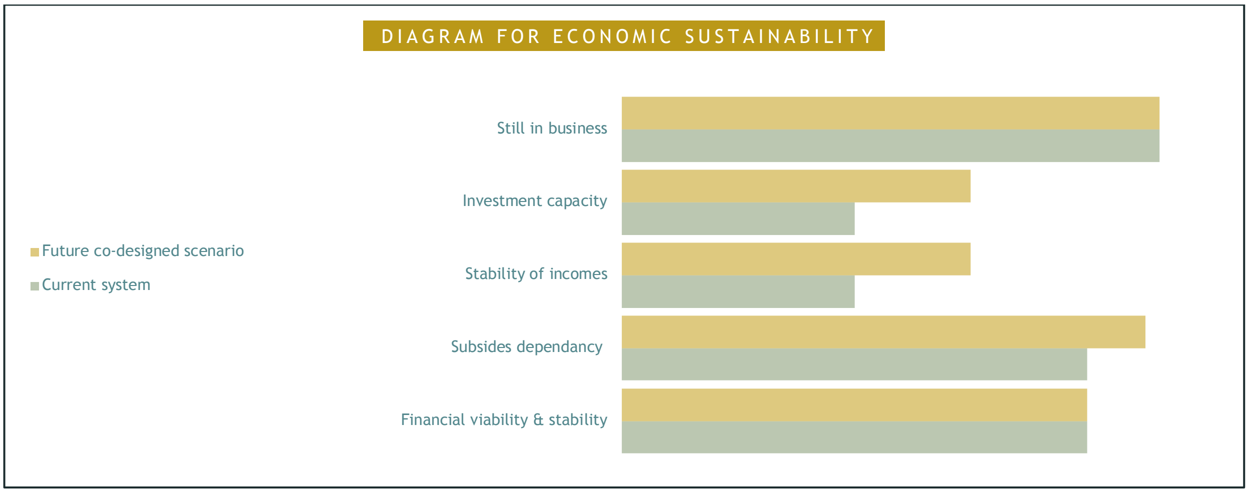

Figure 71 : Scores of the economic sustainability indicators, showing the current system and the future co-designed system

Almost all of the vegetables are sold at the farm shop, as well as eggs, salami (from processing pork), and bakery products (some are made with the help of another local farm). Generally, a large part of products is sold in the farm shop, and a small amount of their production is used to prepare meals for pupils of the on-farm kinder garden. For this reason, the normal price waves of the "general market" of main agriculture and vegetable products have a limited effect on farm trade and farmer income. Since the beginning, they opted for direct selling of farm products. The original small space they had for selling vegetables has been improved over the years and is now a small shop at the farm entrance, open five days a week. Today the customer base seems developed enough to absorb all of the farm's production, although there could be some improvements to the amount of meat (beef and chickens) produced.

Considering the economic sustainability assessment, one of the few parameters that variates from ante to post is stability of income, that comes from a reduction of buying feed on the market (because as we mentioned before, the enhanced grazing area will allow to feed cows with minimal amount of cereals) and more amount of 'on farm' processed products using mainly raw material from farm production (for instance selling on farm beef packet, processing pork in traditional salami). Reducing the necessity of selling part of the products on the general organic market, as the large majority of farm products are sold on already established chains, will contribute to maintain stability of prises in the medium-long term and have a direct positive effect on income stability. Furthermore, there is the perspective of establishing even other channels of short retail chain, such as Community Supported Agriculture.

Better planning on future activity will permit more mid-term successful investments, which is the other parameter which has had a little improvement, together with the subsidies dependency.

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3.6.2.3 Impact of co-designed changes on resilience

3.6.2.3.1 Major changes at global scales and comparison with sustainability assessment

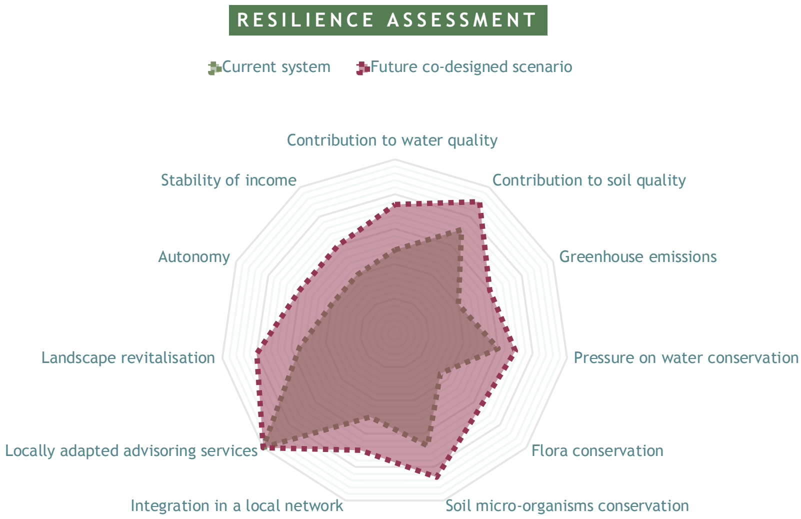

Figure 72 : Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario

Like for the sustainability assessment, the multicriterial assessment shows a general improvement of resilience, with 9 out of 11 parameters ranging from little to good improvements. The most benefits are coming from the environmental issues such as GHG emissions and biodiversity, water and flora conservation, but also the social and economic parameters seem to have some margin of improvement with the new co-designed system. Now we go for more in the details of each part of the assessment.

3.6.2.3.2 Environmental impacts

About the new system contribution to resource protection, there has been estimated an improvement of soil quality and GHG emissions: decreasing the area surface with arable crops and increasing more grass land pasture, will probably lead to more organic matter in the topsoil of 30 cm. The estimation was made from soil analysis on different areas (one area of cover crop after one year of pig pasture and another area of cattle pasture in rotation). By better management of pasture rotation of cattle, the water availability will probably increase, together with the aggregate stability, having more stable roots for longer periods in the topsoil. Furthermore, the whole farmland is intended to be planted with trees on the field borders, also with tree species for animal fodder (cattle), which is giving an improvement also to biodiversity conservation parameters. The planting of more trees is also impacting on indicator of greenhouse emission which is here related to CO_2 equivalents emission produced per ton of product.

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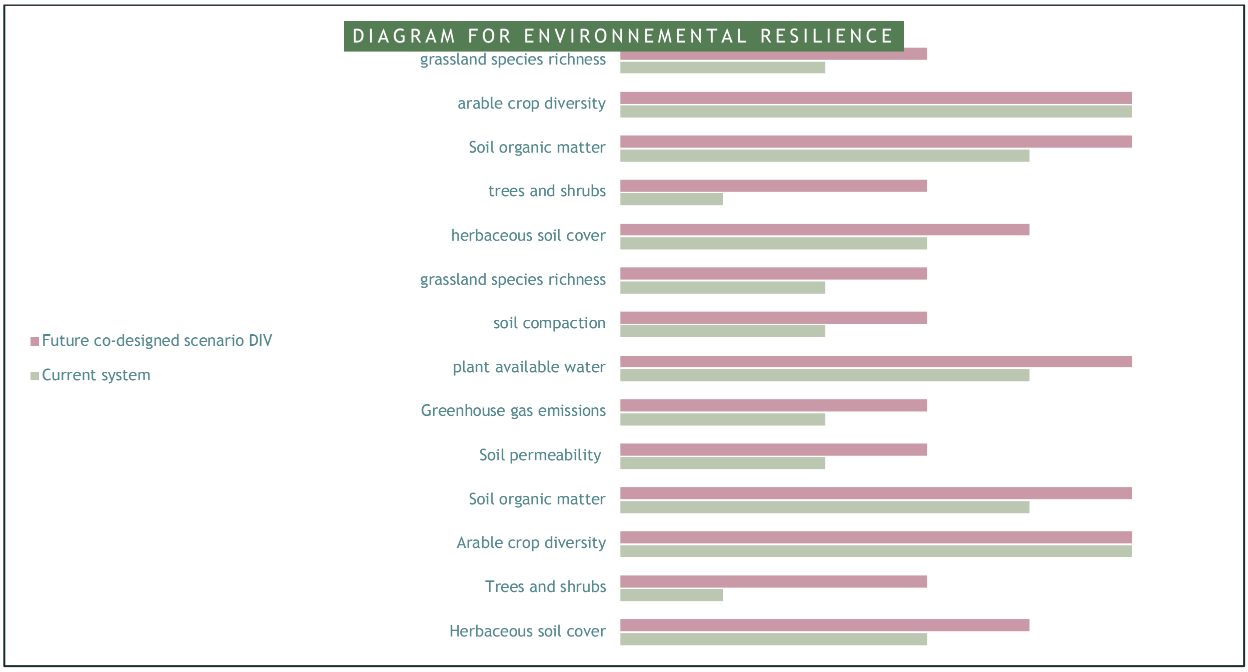

Figure 73 : Scores of the environmental resilience indicators, showing the current system and the future co-designed system

Even though we have no evidence of the actual amount of farm emissions for unit of product, also because of such a wide range of products (vegetables and animal), we expect that a consistent amount of CO_2 will be sequestrated in the soil by AF and planted shrubs, as well as different managing of animals and pastures (no tillage where before arable crops were tilled). From soil analysis made on the different farm areas, we found also an improvement of colloidal rate of organic matter which is giving a better value on water conservation parameter, thanks to the enhanced water availability and reducing most probably soil compaction.

3.6.2.3.3 Social impacts

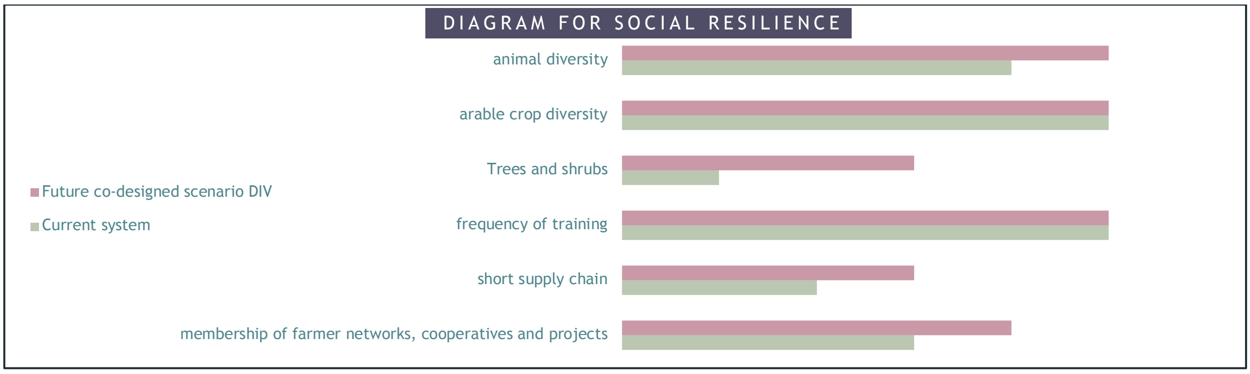

Figure 74 : Scores of the social resilience indicators, showing the current system and the future co-designed system

Regarding the social resilience assessment, the farmers' profile was already high because of his participation to official organic networks and other informal groups of farmers within the region, conducting several social activities, also hosting many events as seminars about regenerative agriculture, soil fertility and value chain improvement, and becoming a sort of opinion leader in this local organic farmers' network. There is therefore

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very little improvement possible on the advisory services, even though he foresees a potential expansion of this activity within cooperation group of farmers (specific subsidy on this will be provided by the National Rural Development Program. The integration in a local network is already good, given by his farm-shop and local GAS (ethical purchasing group) with home delivery, but the farmer himself wishes to amplify the offer with the beginning of a CSA (Community Supported Agriculture) local group.
The landscape revitalisation is going to increase by the much wider range of tree species and varieties of local breeds for cattle, pigs and poultry.

3.6.2.3.4 Economic impacts

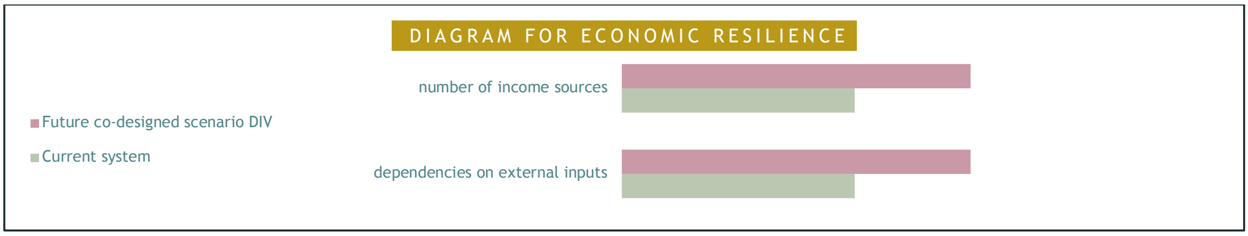

Figure 75 : Scores of the economic resilience indicators, showing the current system and the future co-designed system

The two indicators on which is based the economic assessment of resilience have both slightly improved from current to new co-designed system. The co-designed system plans to reduce the dependencies on external inputs by increasing the amount of animal feed through a different grazing system and using more by-products as feed (ex. vegetable waste, edible trees, etc). Also, the stability of income is going to improve, thanks to the diversification of the market channels as well as services given by the educational farm. At the moment the farm is selling vegetables and meat in the farm-shop and hosting a kindergarten but an additional source of income will be open the social-recreational activities to other age groups (e.g. recreational services for youth, elderly people, etc.).

3.6.3 Tools and methods: feedbacks

The multicriteria assessment was an interesting and useful tool to understand and evaluate how some innovations suggested by the co-design discussion within the pilot group (VenetoMix), were expected to contribute to meet the farmer goals.
The assessment was enough flexible to use, but it required some experience and explanation to users in term of contents and how it functioned (e.g. sometimes it was difficult to distinguish the different functions of parameters between resilience and sustainability assessments). Some indicators such as *greenhouse gas emissions per unit of product, plant available water* and *soil permeability* were highly specific and would require dedicated measurement and analysis to be better estimated. In the assessed "Al Confin organic farm", which hosts several productions, such as livestock and different crops (vegetables, cereals) the estimated values seem quite approximate and not enough representative of the whole system. Making a simpler version of these indicators, may represent a more valuable and approachable tool for the farmers, without the need of too specific measurements.

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Furthermore, in the future it could be interesting and useful to select other more representative indicators of the social and economic farm current situation to better represent the effects of transition toward higher resilience.

3.6.4 Take-away messages

The assessment of "*Al Confin organic farm*" indicates an overall enhancement in the sustainability and resilience expected with the co-designed scenario when compared to the current system; nevertheless, the margins of improvement seemed to be very limited by the quite good scores of large part of indicators in the *ex-ante* assessment, achieved by the farm. Several livestock and vegetable productions already present in the farm, the presence of farm shop and commercial local short chain network for selling products have affected the quite good score in ex ante assessment.

Co-design goals in *ex post* scenario, with increasing agroforestry (trees and hedges) and meadow-grazing field with reduction of arable crops, have potential positive impacts on several environmental indicators such as GHG emissions, soil fertility with better water retention and improved plant cover and biodiversity as well as landscape diversity.

The co-designed perspective to reduce dependency on external inputs by increasing the farm production of by-products for animal feed and by a different grazing system has a potential to affect the farm both economically (by improving income stability) as well as socially, with a better welfare for animals and workers having to manage them as a daily base, also because of the better shadowing of the AF system, in the typical Italian hot summer months.

The farm has the potential of further increase the diversification of the market channels giving more stability of income. The farm is going to be less dependent on market price fluctuation, increasing the by-services given by the educational farm activities, which will make the farm more sustainable and resilient both on social and economic profiles.

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3.7 Marstan Vale – UK pilot (CRAN)

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Reviewer	Ulrich Schmutz

3.7.1 Pilot site description

3.7.1.1 Pilot site environment

The UK pilot examined five farms in and around the Marston Vale in Eastern England (Figure 76). It is an area of about 16,000 hectares between Bedford and Milton Keynes with a population of around 64,000 including the new urban development at Wixams (Burgess et al., 2012; Office for National statistics 2021). The fertile land in the Vale means that it is a good location for growing crops such as wheat, barley, oats, oilseed rape and beans. Farmers also raise livestock such as sheep, pigs, and cattle. It was designated as a community forest in the early 1990s and there is an ambition to increase the previous 3% of tree cover to 30% by 2030 (Marston Vale Trust, 2000).

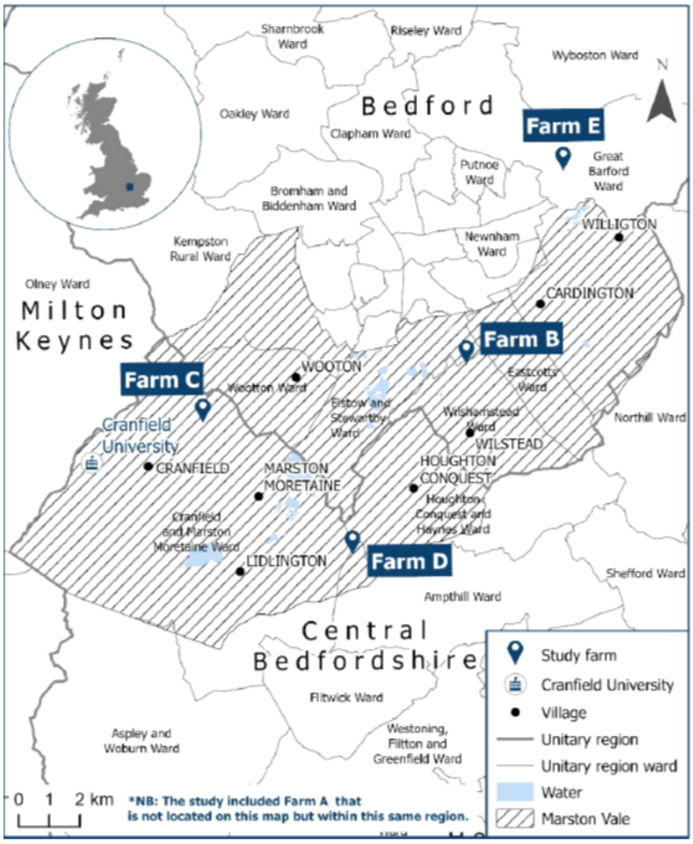

Figure 76 : A map showing the study area and location of four of the study farms in or close to the Marston Vale, Bedfordshire, UK. Farm A is anonymised but located close to or within the Marston Vale area.

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3.7.1.2 Current system

A meeting was held with farmers, in Marston Vale on 15 Nov 2021 where farmers were asked to identify their challenges, opportunities, and risks. In a subsequent meeting on 7 December 2021, assessing how close the farms were to net zero was identified as an objective. The United Kingdom (UK) has set a commitment to reach net zero greenhouse gas (GHG) emissions by 2050 (UK Government, 2019). The National Farmers Union (NFU) has committed to achieving net zero GHG emissions "across the whole of agriculture in England and Wales by 2040" (NFU, 2019), a sector currently responsible for approximately 10% of the UK's total territorial GHG emissions (UK Government, 2021).

To address the above challenge, we worked with five farms between February and May 2022, including a focus on the role of the integration of trees. The five farms studied included a livestock-only farm with beef and poultry, two arable and two mixed-farms (Table 1). Carbon accounting on the farms was carried out by using the Farm Carbon Calculator and AgreCalc tools. These were chosen as appropriate tools to assess GHG emissions for each farm. One year of operational data for input into the calculators were collected per farm using a survey and a follow-up visit to address any queries (Table 4).

Table 1 : Brief description of the five study farms including their area

Farm	Main enterprises	Farm area (ha)
A	Livestock with beef and poultry	45
B	Tenanted mainly arable	186
C	Arable	280
D	Mixed farm with beef and arable	519
E	Mixed farm with beef and arable	123

GHG emissions and sequestration were calculated for each farm using the Farm Carbon Calculator and Agrecalc.

<u>This multicriteria assessment will focus on farm E,</u> which is a mixed farm with beef and arable. Farm E is a mixed farm with both livestock and arable enterprises of 123 ha. The period assessed for this farm was from April 2019 to March 2020. During this period, 72 hectares of the farm was cultivated under feed wheat (27 ha), spring barley (24 ha) and winter oats (20 ha), with the remaining grassland (27 ha) and fallow (23 ha). The majority of the grassland is low-input and longstanding (50 years plus), although some parts are included within a 6-7 year crop rotation.

The farm contains a mixed herd of beef cattle (entered as autumn calving lowland suckler cows), predominately made up of Longhorn with some British Whites too. An average of 32 cattle were present over the period assessed. The cattle are grass-fed and tend to remain in the field throughout most of the year, if not the entire year, depending on the weather conditions. Woodland comprised 11 hectares and hedgerows were 6.23 km, both mature and planted over 20-30 years ago. No renewable energy production takes place

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with the entirety of electricity used on the farm provided by the grid. Most of the work is managed by the farm itself with only a small amount carried out by contractors (Jones et al., 2022).

Table 2 : GHG emissions, offset, and balance of Farm E from Farm Carbon Calculator and Agrecalc

GHG	GHG balance (t CO_2e yr^{-1})	
	Farm carbon calculator	Agrecalc
Emissions	280.0	332.6
Offset	-71.5	-123.4
Balance (t CO_2e yr^{-1})	208.5	209.2
Balance (t CO_2e ha^{-1} yr^{-1})	1.7	1.7

Both calculators predicted that farm E emitted about 209 t CO_2e yr^{-1} although the method by which the common values was achieved varied between the calculators. With one calculator the annual rate of carbon sequestration by woodlands and hedgerows was estimated to be 64 t CO_2e with one calculator, and 123 t CO_2e with the other (Figure 77).

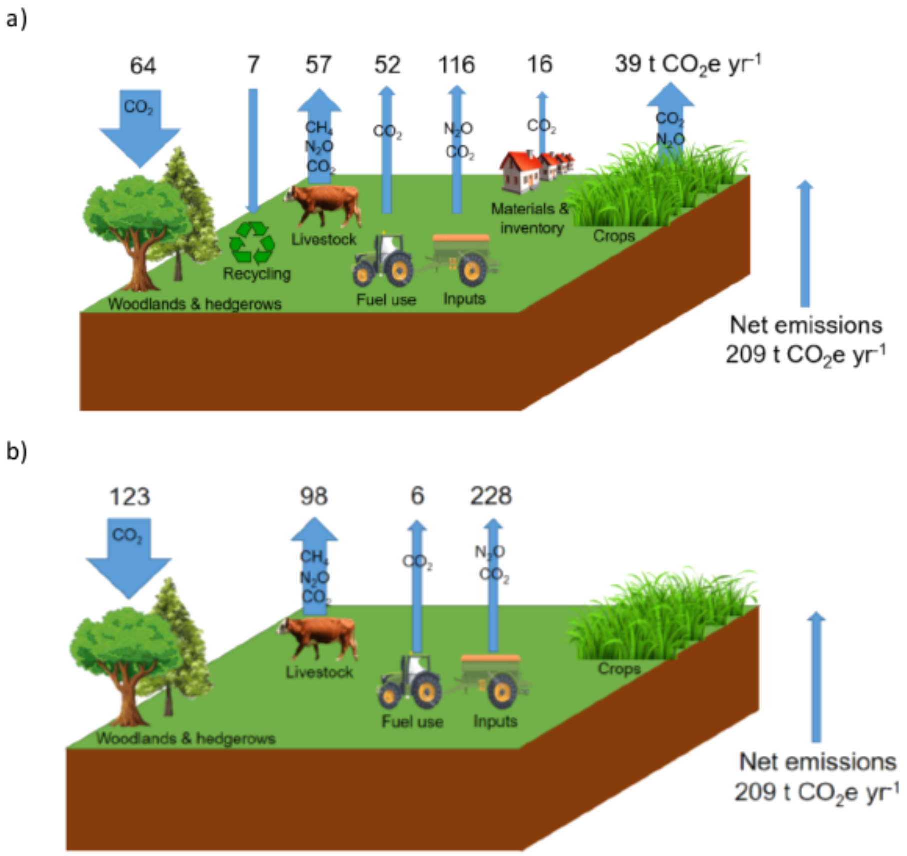

Figure 77 : Schematic diagram of farm E with GHG flows calculated from a) Farm Carbon Calculator and b) Agrecalc

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3.7.1.3 New co-design system

The next stage of the project was to investigate the role of integrating trees towards achieving net zero. In the UK, Forest Research has produced an excel-based carbon sequestration calculator (Woodland Carbon Code, 2020) which predicts the cumulative and annual carbon sequestration from planting to 200 years of stand of different species of different yield classes and specified initial spacing and thinning regimes. Because it is not possible to produce tables for each tree species, Forest Research sorts broadleaf tree species into three main groups: beech (B), oak (O), and a group comprising sycamore, ash and birch (SAB). For the purposes of this project, we considered a 40-year average sequestration value of 12.7 t CO_2 ha^{-1} yr^{-1} for a mixed stand (B = yield class 5, O = yield class 5, SAB = yield class 7) (100% planting). This value was calculated as a mean from the annual carbon sequestration rates for 0-10 years (2.3 t CO_2 ha^{-1} yr^{-1}) and 10-40 years (16.2 t CO_2 ha^{-1} yr^{-1}).

$$A_{tree} = \frac{-GHG_{farm}+1}{GHG_{tree}} \quad (1)$$

Using Equation 1, and the baseline emission of 1.7 t CO2e ha^{-1} yr^{-1}, it was estimated that the farm would need to immediately plant an addition 12% of the farm area with trees to be, on average, net zero over the next 40 years.

3.7.2 Sustainability and resilience assessment

3.7.2.1 Selection of indicators for local assessment

For Farm E (mixed farm), both the sustainability and resilience analyses focused on environmental, social and economic indicators. The environmental part included indicators such as minimising pollution and erosion, GHG mitigation, renewable energy, livestock diversity, soil management and habitats. The social focused around e.g. skills and knowledge, employment, unpaid labour, whilst the economic indicators revolved around financial viability, subsidies dependency or investment capacity. The environmental indicators within the resilience assessment, brought together indicators about soil organic matter, soil permeability crop diversity soil cover and greenhouse gas emissions. The social aspect focused on the amount of training or supply chain activities being undertaken, while the economic indicators were about the kind and number income sources. Apart from some indicators (Table 3), their weighting was equal within each basic criterion ("leaf").

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Table 3 : Indicator weight per basic criteria for the sustainability and resilience assessments

Assessment	Analysis	Basic criteria ("leaves")	Indicator	Weight (%)
Sustainability	Environmental	Cultivated biodiversity	Rotational and varietal diversity agroforestry	30
			Rotational and varietal diversity crops	50
			Conservation	20
	Social	Employment contribution	Employment	60
			Unpaid labour	40
Resilience	Environmental	Contribution to soil quality	Arable crop diversity	25
			Soil organic matter	50
			Soil permeability	25
		Flora conservation	Grassland species richness	25
			Herbaceous soil cover	25
			Trees and shrubs	50
		Soil micro-organisms conservation	Soil organic matter	50
			Arable crop diversity	25
			Grassland species richness	25

3.7.2.2 Impact of co design changes on sustainability

3.7.2.2.1 Major changes at global scales

The main changes among the current system and the future scenario, were noted in the environmental and economic dimensions. Macro fauna conservation and waste reduction appeared to result in the highest increase, whilst profitability and the possibility to still be in business in the greatest decrease. The reason for the reduction on profitability had mainly to do with farmer's concerns about the establishment and maintenance costs for integrating trees.

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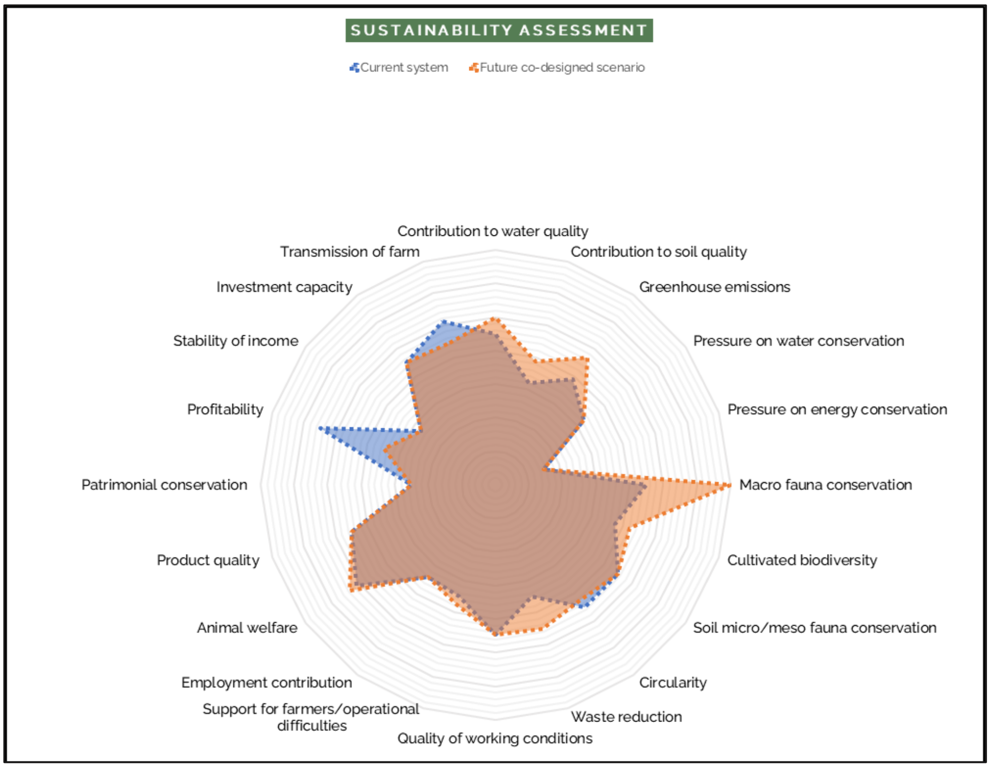

Figure 78 : Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario

Although the farmer acknowledged that there is governmental support available to cover most, of such costs, he did not anticipate much profitability change between the current and the initial years of the future scenario. Looking further into the future he underlined his concerns about the transition of the farm from currently "making a reasonable living" to "surviving", highlighting the high uncertain times the farming industry is currently facing. Regarding macro fauna conservation, he did not expect any changes in the livestock diversity in terms of number of species, breeds or rare breeds between the two scenarios. Furthermore, it was underlined the future goal of doubling the waste reduction compared to the current system.

3.7.2.2.2 Environmental impacts

The primary environmental sustainability indicators that showed the greatest increase in the future scenario than the current system were the farm waste disposal, livestock diversity, soil analysis and GHG from land-use change, GHG reduction and mitigation. On the other hand, manure management showed the greatest decrease between the two scenarios (Figure 5). As previously mentioned, it is anticipated the recycling will increase. Greenhouse gas mitigation practices such as recycling, currently account for scrap metal and oil, but in the future, this is anticipated to increase. This is estimated to contribute around 11% in reducing farm's greenhouse gas emissions, however this seems not to be sufficient in reaching net-zero.

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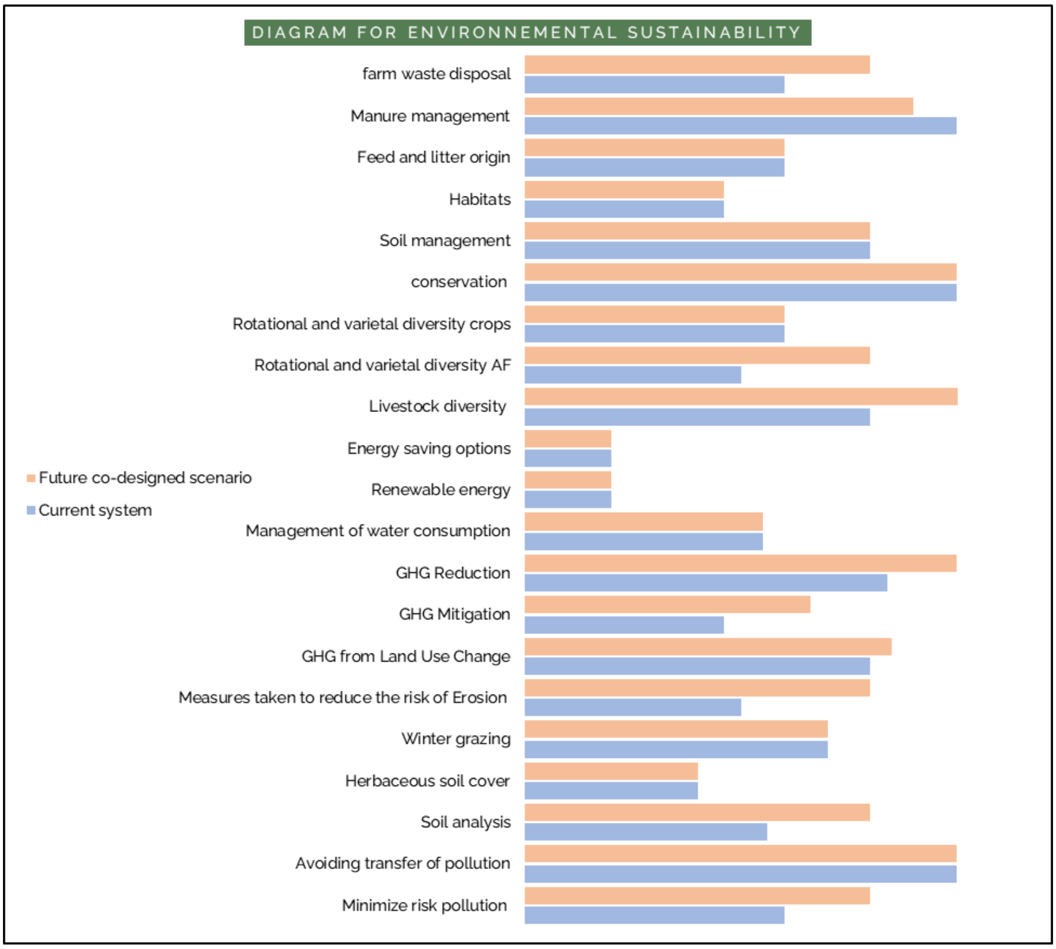

Figure 79 : Scores of the environmental sustainability indicators, showing the current system (business as usual) and future scenario (net-zero farm)

Additionally, only small, if any, manure surplus volumes remain on the farm per season and this not expected to change between the scenarios. However, quantities of off-site fertiliser used in the farm are foreseen to decrease (about 10-20%) in the future scenario compared to the current system. Although soil analysis on the farm is currently carried out, once approximately every five years, the farmer intents to increase soil monitoring frequency, for some fields, to once every two years. Finally, there will be a small increase of permanent grassland or woodland, by converting a proportion of the arable land. Hence, greenhouse gas emissions from the farm will be reduced in the future system than the current scenario. Something that will enhance such actions is farmer's aspiration to use carbon calculator tools in the future scenario to monitor farm-related emissions and aid his decision making on implementing mitigating measures to bring emissions down.

3.7.2.2.3 Socials impacts

In terms of the social dimensions, the current and future systems seem to be broadly similar, with only marginal advantages in skills and knowledge and animal welfare. In helping to achieve an improved animal welfare, the farmer plans to integrate scattered trees in the permanent pasture. Doing so, will provide shade and shelter for the animals reducing that way the effect of any temperature extremes or heat waves. According to the farmer, it is also planned to integrate fruit and berry bearing amenity trees in the hedgerows

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alongside footpaths, for birds and passers-by. The farmer also explained that training days per person per year, from being one in the current system will increase to two per year in the future scenario. Better investment in professional development, will lead to staff staying up to date with the evolving industry standards as farm-level innovation plays a vital role for instance on increasing productivity, sustainability and resilience.

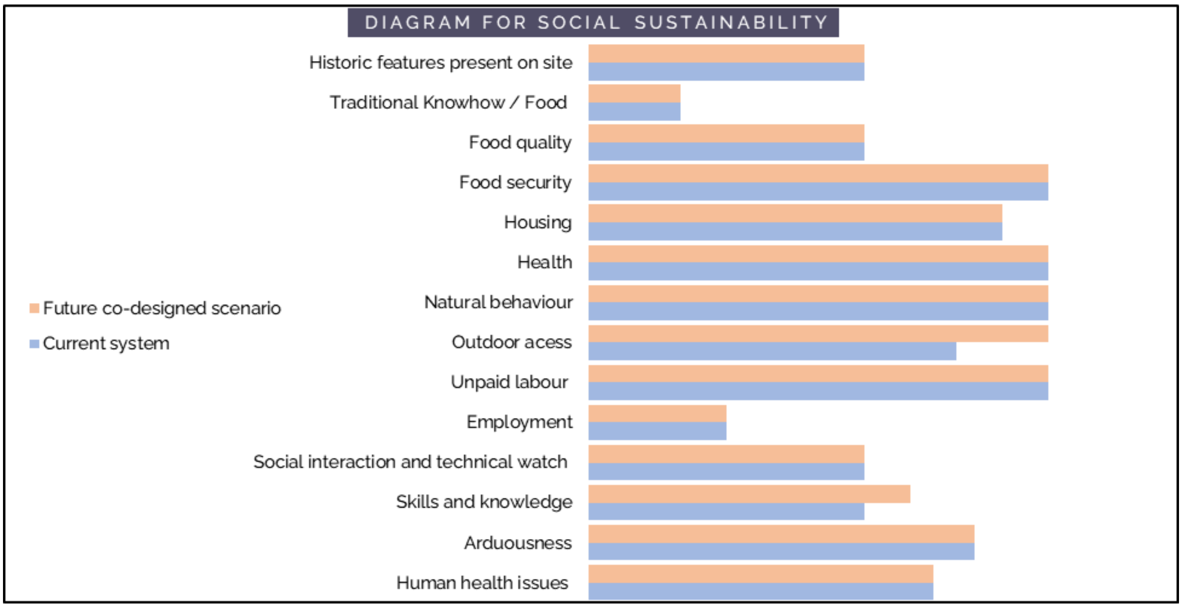

Figure 80 : Scores of the social sustainability indicators, showing the current system (business as usual) and future scenario (net-zero farm)

3.7.2.2.4 Economic impacts

In most cases, there seems to be no changes in the economic dimensions between the current and future scenario. However, as mentioned earlier, the farmer anticipates a potential reduction on profits within the future scenario as related with high uncertainty of the farming sector. The farmer also predicts that the net assets will not alter much in the future scenario compared to the current system.

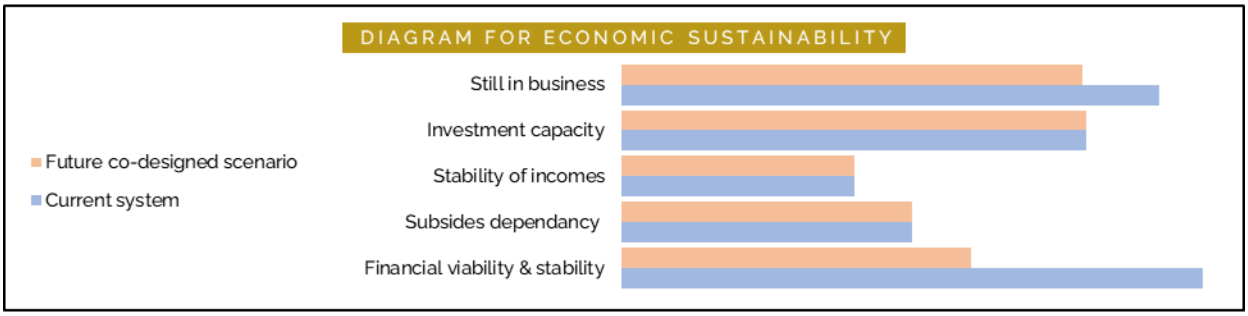

Figure 81 : Scores of the economic sustainability indicators, showing the current system (business as usual) and future

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3.7.2.3 Impact of co design changes on resilience

3.7.2.3.1 Major changes at global scales and comparison with sustainability assessment

Looking at the basic criteria ("leaves"), it can be observed that in the future scenario greenhouse gas emissions will substantially reduce, compared to the current system. Integrating trees on around 12% of the farm, will in turn bring about net-zero greenhouse gas emissions. Other than that, there was perceived to be an improvement in soil quality and a lower pressure on water conservation (Figure 8).

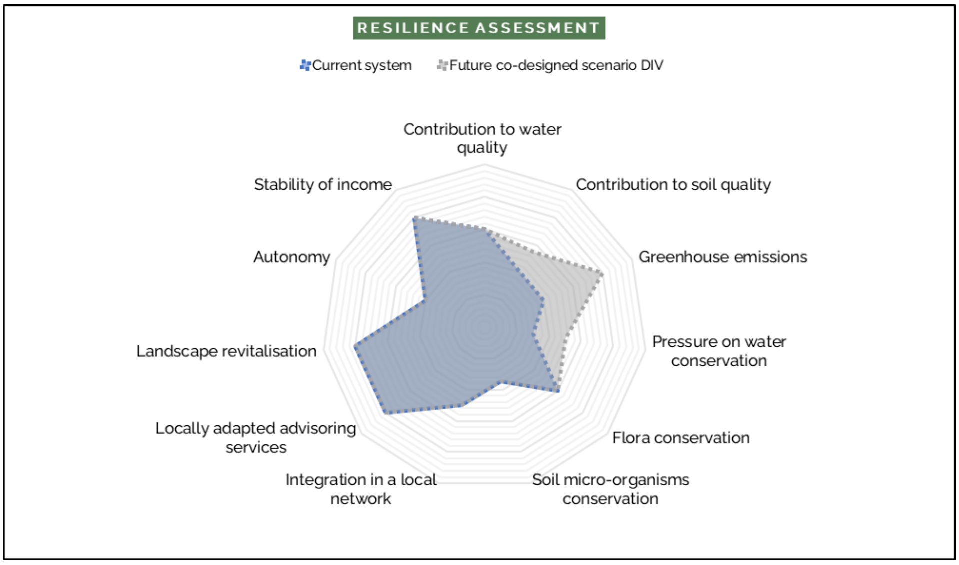

Figure 82 : Radar diagram of the results of the resilience assessment, showing the current system (business as usual) and future scenario (net-zero farm)

3.7.2.3.2 Environmental impacts

Overall, the future system generally resulted in similar results to the current system in the environmental dimension (Figure 9). Apart from the emissions reduction, the only other changes revolve around soils and soil quality e.g. soil organic matter, soil permeability soil compaction and plant available water.

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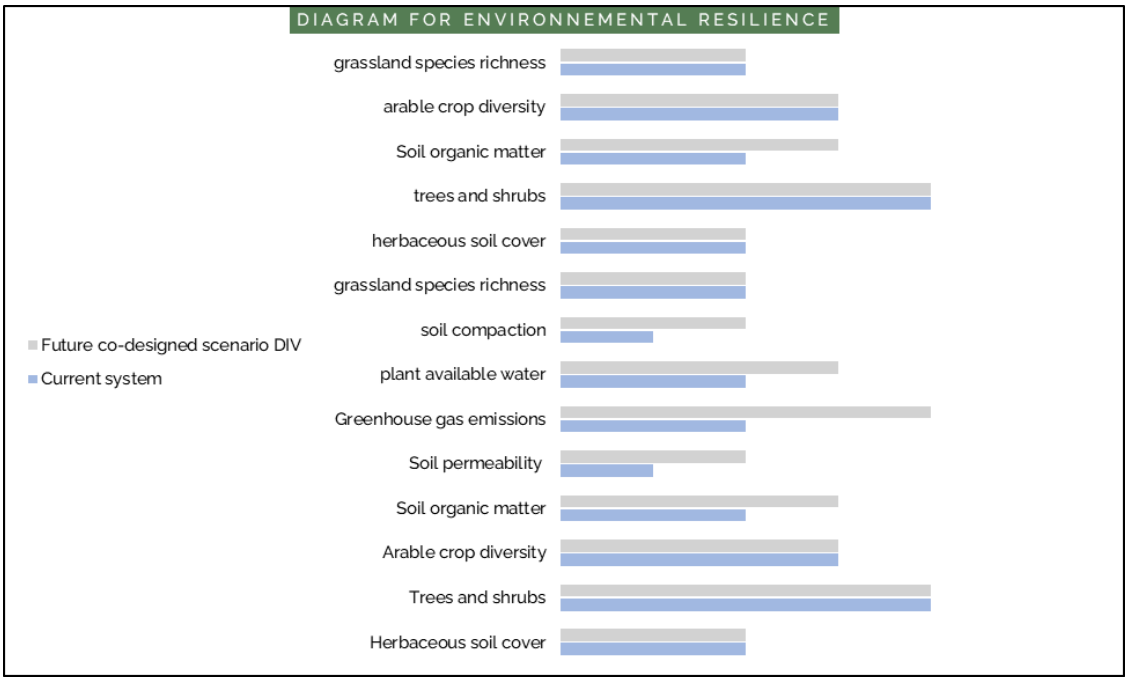

Figure 83 : Scores of the environmental resilience indicators, showing the current system (business as usual) and future scenario (net-zero farm)

At the current system, the farmer expects soil organic matter at the top 30 cm to be maintained, whilst in the future scenario to slightly increase. Potential reasons for the small increase can include the fresh input plant material from trees e.g. leaf fall, tree roots and root litter. This will in turn improve soil structure by reducing compaction in areas, which can translate into better water infiltration capacity and permeability.

3.7.2.3.3 Socials impacts

The social dimension of the resilience assessment, appeared to be stable and showed no changes between the current system and future scenario (Figure 10), with the farmer, responding for instance that no short-supply chain activities are taking place in the current system and it will remain so, in the future scenario. Likewise, he anticipates no change in number of animal species, rare breeds or crop diversity among the two scenarios.

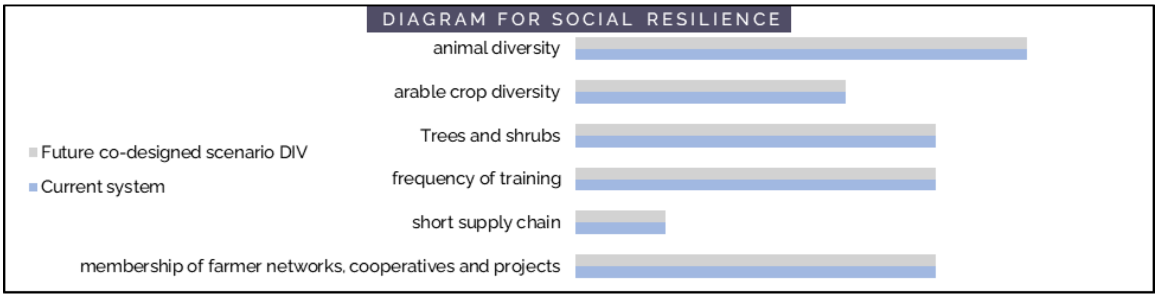

Figure 84 : Scores of the social resilience indicators, showing the current system (business as usual) and future scenario (net-zero farm)

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3.7.2.3.4 Economic impacts

In a similar way, he foresees that the number of income sources on his farm is and will probably remain four, between the current system and the future scenario respectively (Figure 11). Likewise, farm inputs are partly external and partly local and the expectation is to remain so in the future.

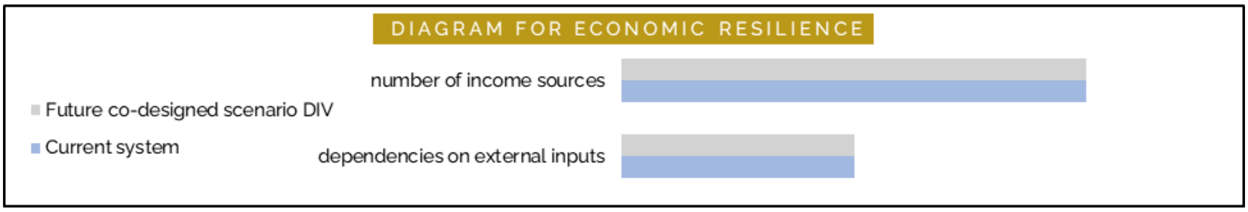

Figure 85 : Scores of the economic resilience indicators, showing the current system (business as usual) and future

3.7.3 Tools and methods: feedbacks

Overall, the sustainability and resilience multicriteria assessments were useful and straight forward to complete. The scoring system, including categories, leaves and indicators was relatively simple to understand in terms of both its structure and content. Such analysis is useful in the way that it can monitor the perceived evolution of the farm regarding resilience and sustainability over time. However, the duration of both assessments with the farmer took almost two hours, something that seemed quite demanding and quite difficult to organise in a busy farm schedule.

Although most of the indicators and questions were clear, on the other hand the farmer commented that more explanation should have been provided in the spreadsheets about some questions. Answer options given for each question, were flexible and the user could also select zero or non-applicable. All indicators were suitable for the surveyed mixed farm. Some indicator questions were too detailed by asking for specific numbers for example soil organic matter levels, soil permeability or grass species per square metre.

Hence, some of them had to be estimated, or followed-up with the farmer to provide a more accurate value, after for example looking for the farm's soil analysis records. Except for greenhouse gas emissions in both the current system and the future scenario, which were estimated using available carbon calculator tools. In fact it was estimated the amount of tree integration required, so that the whole-farm associated emissions reduce to null.

3.7.4 Take-away messages

Overall, the analysis was useful, and the future scenario proved to be more sustainable and resilient for a number of different indictors than the current system. The planned future scenario involved the farm achieving net zero greenhouse gas emissions by integrating trees on around 12% of the farm area. One substantial effect of this was a perceived reduction in the financial viability and stability of the farm, with a perception that there was a greater risk of not being in business in future years. In terms of environmental impacts, the higher planned frequency for soil analysis together with the expectation for a greater waste recycling and contribution to soil quality were benefits of the future scenario. By contrast, there was little change in terms of the social dimension, apart from some additional training for farm personnel.

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3.7.5 Appendix

Table 4 : Key inputs requested for each farm when considering both Farm Carbon

Category	Time period	Key inputs
Energy and fuels	Specific year	Estimates of electricity and fuel use (including liquid, gas and solid fuels). Also, fuel used for on-farm contractor operators. Details of any renewable energy supplies – percentage of renewables in tariff and any produced on the farm e.g., solar panels.
Materials	Specific year	Annual usage of aggregates, bricks and tiles, metal, wood, fencing, consumables (e.g., packaging) and water use.
Inventory	Last 10 years	Embodied carbon in large items such as buildings, machinery and infrastructure. Any vehicles, tractors, implements, building materials, water systems, constructions and agricultural buildings.
Crops and inputs	Specific year	Crop enterprise and type, including the area cultivated, production (e.g., yield) and use (e.g., sold, allocated to livestock etc). Fertiliser, organic mature, lime and minerals, herbicides, insecticides, fungicides, growth regulators and molluscicides applied and details of areas applied.
Livestock	Specific year	Numbers, ages, weights, performance (e.g., calving percentage), purchases, sales, deaths, and yields for each livestock enterprise. Details on manure handling, grazing, bedding and any purchased feed.
Waste	Specific year	Quantities and endpoint (i.e., landfill or recycling) of different waste categories (e.g., aggregates, batteries, scrap metal, oil, wood, organic, cardboard plastics etc.)
Sequestration	Specific year	Details on any hedgerows and woodlands.

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3.8 Cheese Valley – Italian pilot (SSSA)

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Reviewer	Clémence Berne

3.8.1 Pilot site description

3.8.1.1 Pilot site environment

As part of the twelve AGROMIX co-design pilots, we established the 'Cheese Valley' Italian pilot for the dry Mediterranean region, focusing on the Pecorino Toscano PDO value chain in Tuscany (Figure 86). The main objective of the pilot is to support the transition towards mixed and agroforestry sustainable systems. The pilot involves a multi-actor group composed by local farmers, local advisors, the cheese factory board, regional policy makers, AGROMIX scientists, and retailers. Located in southern Tuscany, the Caseificio Sociale di Manciano is a cooperative cheese factory bringing together roughly 200 farmers who manage a total of 56,000 sheep and produce more than 7 million litres of milk per year.

Figure 86. Pecorino Toscano PDO.

Figure 87. Typical landscape in the Manciano area.

The cooperative's members face several environmental challenges, including soil erosion (Figures 87-88), unpredictable rainfall, and higher frequency of drought during the summer.
To tackle these challenges, some members have begun implementing climate-smart techniques, including the reduction of soil tillage, the intercropping of grass and legumes, an increase in the share of legume meadow in crop rotation (to boost long-term temporary grassland in crop rotation), and planting trees at the perimeter of the fields.

Farmers that consulted by AGROMIX project reported positive results from these experiments, highlighting that to receive the benefits of these techniques farmers must implement a combination of these regenerative techniques at the field and farm levels. In terms of the future of regenerative systems in the region, members of Coop Manciano highlighted the need to increase and spread the know-how of implementing agroecological practices. Much work is needed to increase advisory services, carry out research in pilot farms, establish living labs for farmer-to-farmer learning, and to strengthen farmers' networks.

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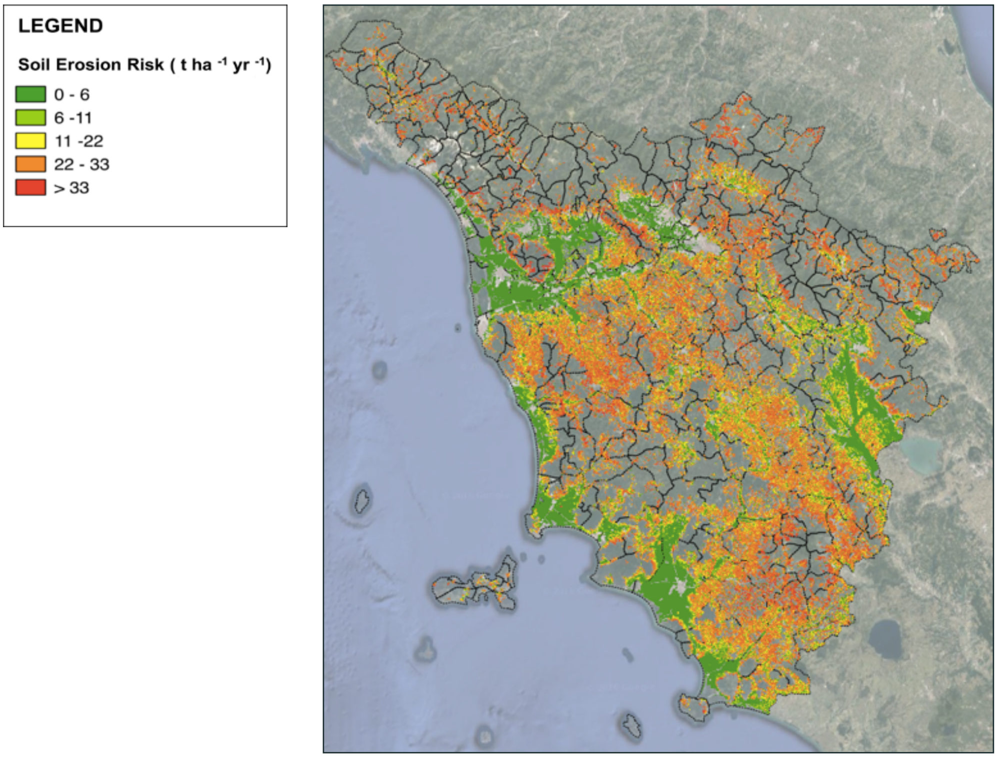

Figure 88. Soil erosion risk in the Tuscany region.

3.8.1.2 Current system

Typically, mixed cereal-livestock farming system represents the standard design of dairy sheep farms located in the inland hilly areas of Grosseto Province (Figure 89). There rainfed cool-season annual grasses and legumes are cultivated. Wheat (*Triticum durum* L.) is the main cash crops while oat and clover (*Trifolium alexandrinum* L. and *Trifolium incarnatum* L.) mixtures represent together with Alfalfa (*Medicago sativa* L.) the most important feed and grass for the livestock production. In 2010, lucerne together with other grass-legumes mixtures, covered about 13% of the total arable land in Grosseto Province. Sheep could extensively graze the annual forages before and after the harvest, according to the vegetative development of the crops and the pasture availability. Because of the presence of wild predators in the territory, sheep were housed in stables or restricted in fenced areas to avoid losses.

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Figure 89. Selected photos taken in the Province of Grosseto highlighting (a) topography and settlement, (b) landslide in a cultivated field, (c) typical diversified land use, as annual forage crop, temporary grassland, olive trees and forest, and (d) sheep grazing in a mixed species meadow.

Generally, the sheep sector is unattractive, characterised by fragmentation and ageing, with low capabilities to attract investments and to innovate. The unbalanced value chain' relations among strategic stakeholders favoured the strong contractual power of large-scale distributors and the farmers' profitability is strictly dependent on public financial aids. In the last 40 years, the number of farmers involved in the sheep rearing activity decreased at both national and regional levels. In 2010, the number of farmers involved in the sheep rearing activity in Grosseto Province was less than 1000, representing more than 40% of the total sheep farmers present in Tuscany and a decrease of 72% compared to the beginning of the 80's. In 2021, on average there were 150-200 sheep per farm and the diverse breeds. In order of breed adoption, were the rude Sarda (71%), the high-productive French Lacaune (13%), the traditional Massese (6%), followed by the original Mestizo (5%) and the ancient Comisana (2%).

3.8.1.3 New co-design system

The challenge of our pilot was to introduce a new way of communicating and promoting their products. The people involved in the pilot already knew each other and this proved to be a double-edged sword. We had to rebuild trust and respect between stakeholders in order to have a positive interaction. We've learnt to avoid too open discussions and to facilitate each interaction carefully so that stronger personalities don't take over.

As a future perspective, we have several ideas we would like to turn into reality, and we need to build a structure to help small farms survive. Most of the farmers are rather old and do not have the next generation of farmers to take over. At the same time, there is youth that would like to start farming, a return to the land, yet have no access to land. We believe that this could be turned into an opportunity to train young farmers but willing to farm.

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Additionally, we have started a practical process of transition with agroforestry field trials. We have had good results so far and the next step would be to extend the trials to other farms.
To improve the communication and promotion of the product (pecorino cheese) and the territory of Maremma, we have developed, together with a design university from Northern Italy, a rebranding process of the Caseificio Sociale di Manciano. The idea would be to work together with the cheese factory board to implement one of these projects. For now, the main issue is to find a way to continue this vision without the support of AGROMIX.

3.8.2 Sustainability and resilience assessment

3.8.2.1 Selection of indicators for local assessment

No changes have been made to the weights of the sustainability and resilience assessment indicators.

3.8.2.2 Impact of co-design changes on sustainability

3.8.2.2.1 Major changes at global scales

➢ **Farm 1**

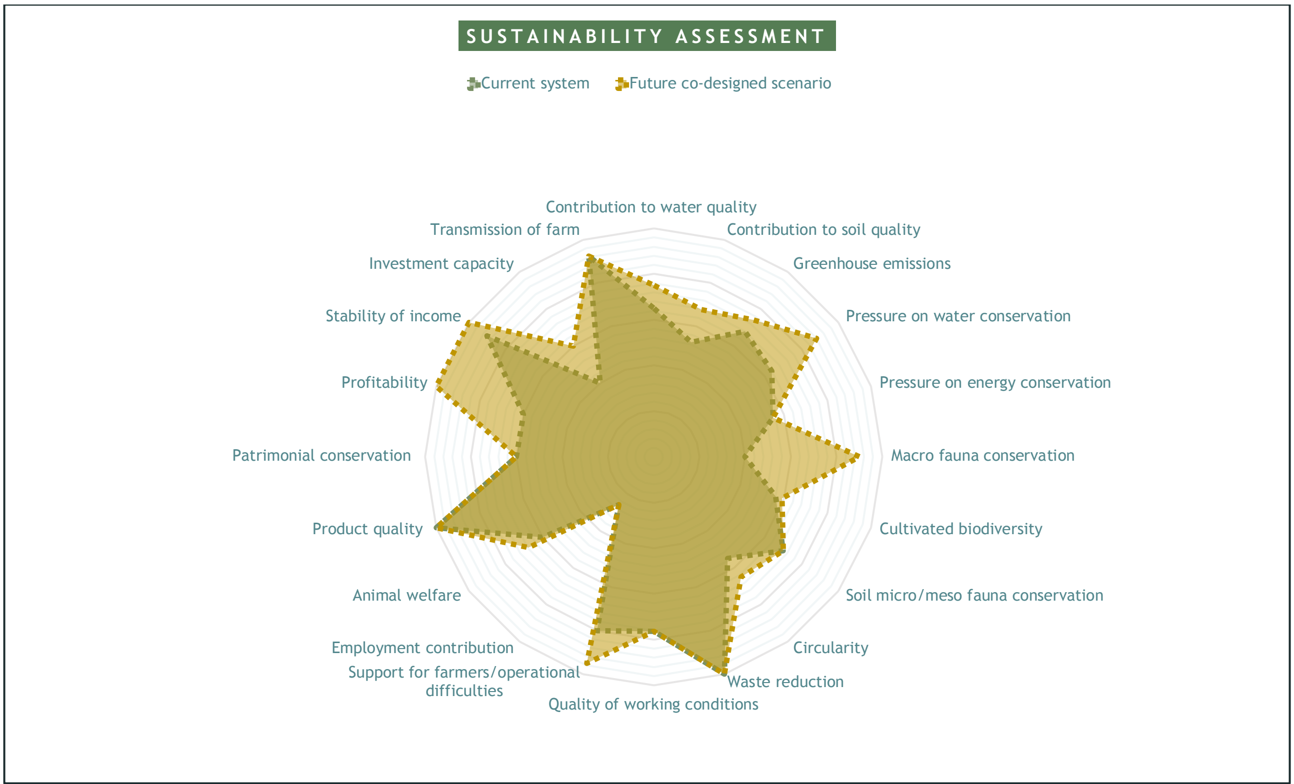

Figure 90 : Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario (farm 1)

The results of the assessment showed that a future co-designed scenario 11 parameters out of 20 scored higher than in the current system, leaving 9 parameters unchanged. More specifically, contributions to water and soil quality, reduction in greenhouse gas emissions, pressure on water conservation, macro fauna

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conservation, circularity, support to farmers / operational difficulties, animal welfare, profitability, stability of income and investment capacity all scored higher.

One notable aspect is the transition towards reduced use of chemical fertilisers, contributing to improved soil and water quality. Farmers have recognised the importance the adoption of more sustainable practices, such as organic fertilisers, and of the implementation of precision agriculture techniques. Simultaneously, there has been a notable increase in the interest in water and soil analyses. This heightened monitoring has proven instrumental in assessing and mitigating the environmental impact of agricultural activities. Additionally, the incorporation of tree planting initiatives as compensatory measures has emerged as a key strategy to balance greenhouse gas emissions. Integrating trees within farming systems not only sequesters carbon but also promotes biodiversity. Furthermore, a shift towards reduced soil tillage in more complex farming systems has gained traction, helping to preserve soil fertility, reduce soil erosion, and mitigate carbon release. These agroecological approaches will possibly lead towards a more sustainable and environmentally conscious livestock farming.

Conversely, pressure on energy conservation, soil micro/macro fauna conservation, cultivated biodiversity, waste reduction, quality of working conditions, employment contribution, product quality, patrimonial conservation and transmission of farm remained unchanged. These results could be explained by a lack of economic and political support for improving these aspects. Despite employment contribution remaining considerably lower than all other parameters, we consider this to be an overall positive result as it shows that environmental sustainability can be improved without significant negative impact on profitability.

- **Farm 2**

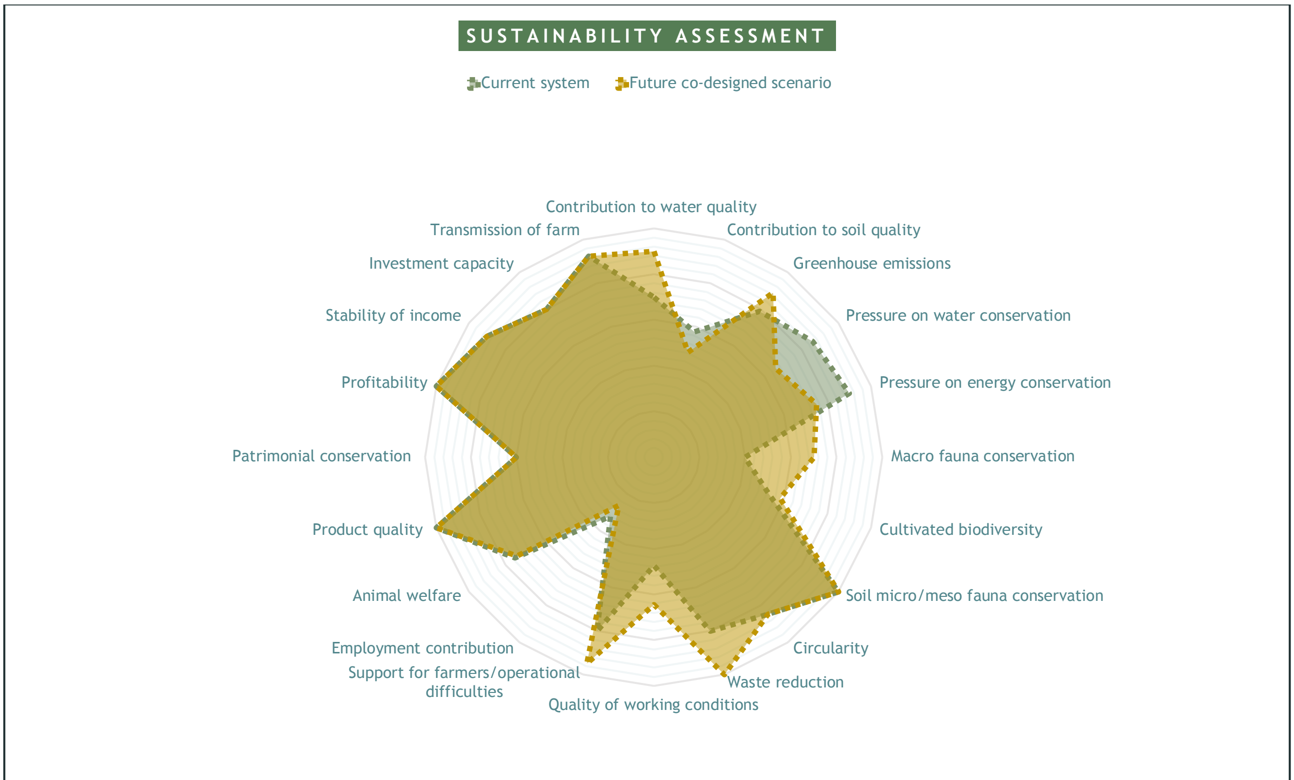

Figure 91 : Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario (farm 2)

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The results of the assessment showed that a future co-designed scenario 7 parameters out of 20 scored higher than in the current system, 11 parameters did not change, and 3 scored lower than the current system. More specifically, parameters that saw an improvement were: contributions to water quality, reduction in greenhouse gas emissions, macro fauna conservation, cultivated biodiversity, waste reduction, support to farmers / operational difficulties. The reason for improved parameters such as contributions to water quality and reduction in greenhouse gas emissions, are likely to be similar to the farm n°1, while the improvement in macro fauna conservation, cultivated biodiversity, waste reduction, support to farmers show that: macro fauna conservation, has gained prominence as farmers recognise the crucial role of larger organisms in maintaining ecosystem balance. The integration of hedgerows, cover crops, and natural habitats within agricultural landscapes has fostered a more hospitable environment for beneficial insects and organisms, promoting natural pest control and soil fertility. Farmers are increasingly diversifying their crops and implementing agroforestry practices to enhance resilience against pests and diseases while promoting ecosystem health.

Waste reduction is crucial for sustainable farming, with farmers adopting practices like composting/use of plants and manure, precision farming, and circular economy principles. These measures not only will minimise environmental impact but also contribute to cost savings and resource efficiency.

Parameters that saw a depreciation were: contribution to soil quality, pressure on water conservation, pressure on energy conservation, employment contribution. These could be because of a general loss in organic matter content in soil noticed by farmers, increasing droughts which make water conservation not easy, while employment seems to be challenging for bureaucratic and economic reasons. Parameters that did not change were soil micro/macro fauna conservation, circularity, animal welfare, product quality, patrimonial conservation, animal welfare, profitability, stability of income, investment capacity, and transmission of farm.

These results are interesting because in this case pressure on water and energy conservation would have a negative impact on the overall sustainability of the system in a future co-designed scenario. Similarly, the contribution to soil quality and to employment would be slightly worse in the future scenario. However, quality of working conditions and support to farmers / operational difficulties would improve. Possibly, a longer-term assessment would shed more light on the dynamics behind these results, given the negative impacts on some environmental and economic parameters.

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3.8.2.2.2 Environmental impacts

➢ **Farm 1**

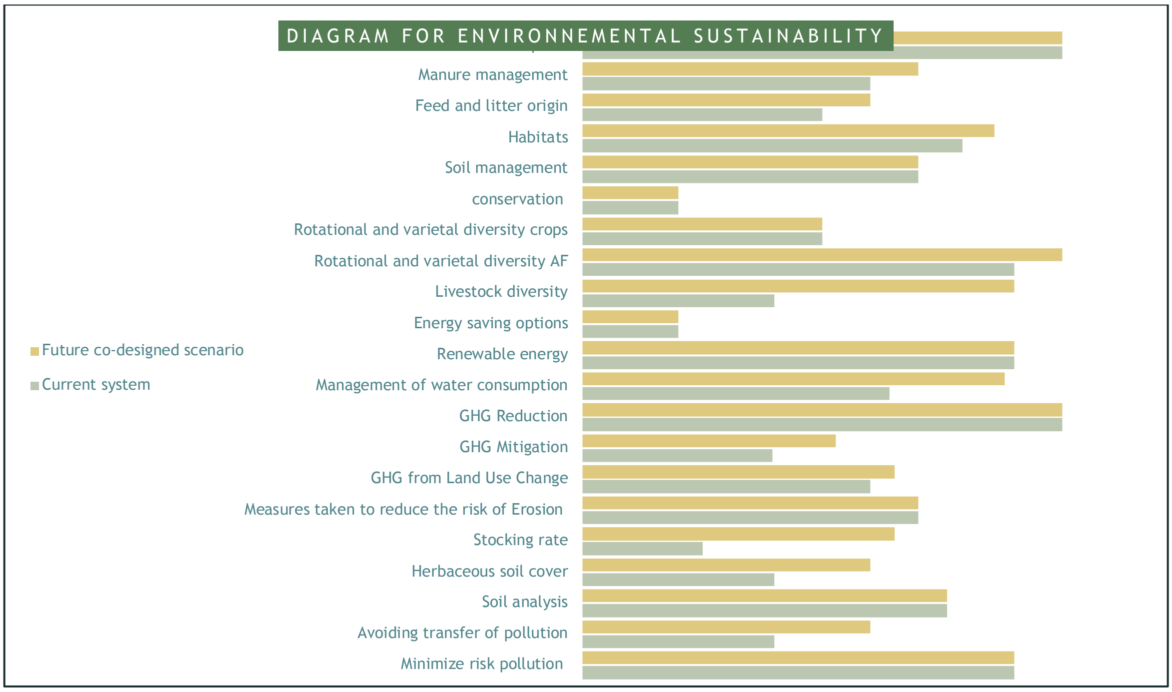

Figure 92 : Scores of the environmental sustainability indicators, showing the current system and the future co-designed system (farm 1)

The most significant improvements in a co-designed scenario would be on the one hand the increase in habitats and rotational and varietal diversity; and on the other hand, the improvement in GHG mitigation, compensated by a steadily high performing GHG reduction and a slight increase of GHG from land use change. Additionally, stocking rate increased significantly, as well as herbaceous cover and the avoidance of transfer of pollution. Overall, the scores indicated that the co-designed scenario would be more biodiverse and climate friendly.

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- **Farm 2**

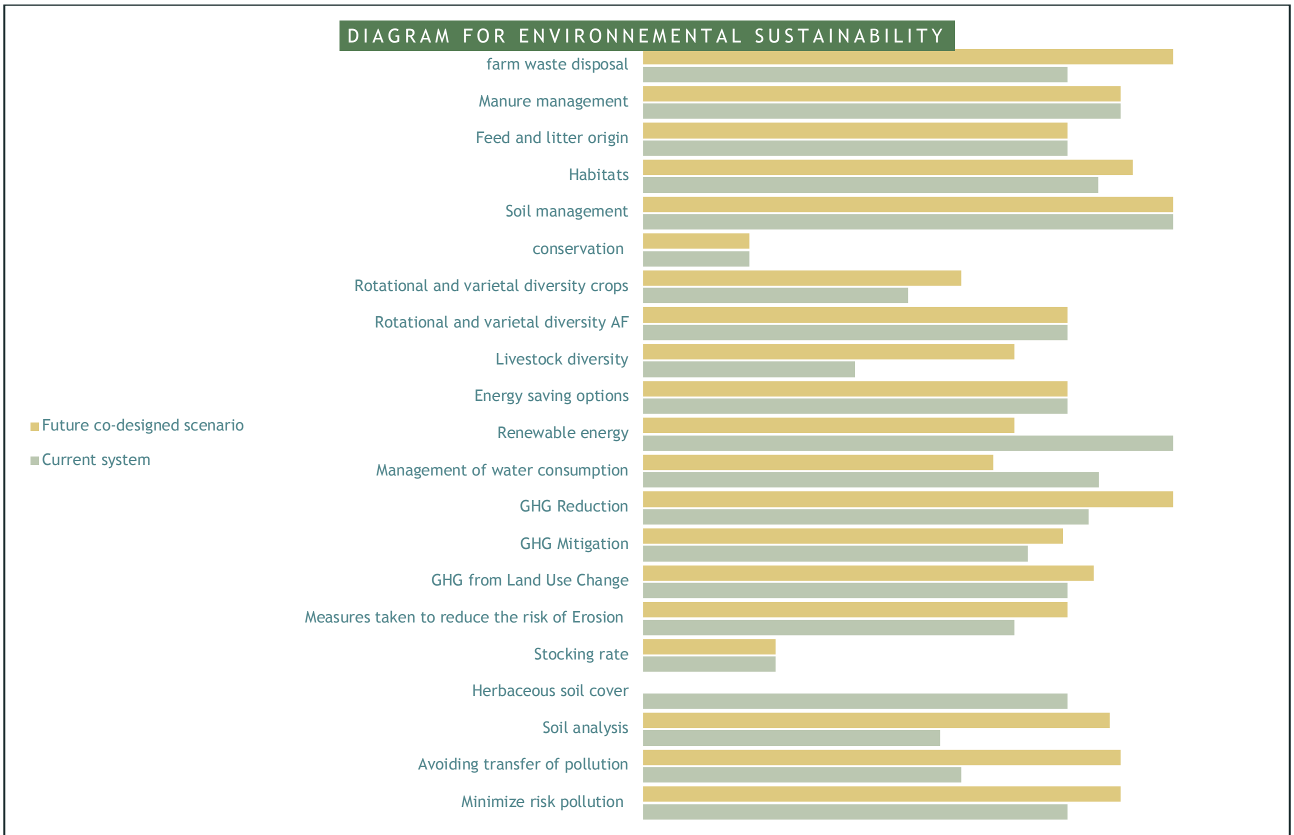

Figure 93 : Scores of the environmental sustainability indicators, showing the current system and the future co-designed system (farm 2)

All GHG parameters show a potential improvement in the co-designed scenario; similarly, the farm would be more biodiverse and manage waste and pollution more efficiently. However, renewable energy and management of water consumption scored significantly worse in the future scenario. This highlights the difficulty in finding a sustainable approach in the running and management of farm operations that would not counterweight the improvements expected in other areas of environmental sustainability.

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3.8.2.2.3 Social impacts

- **Farm 1**

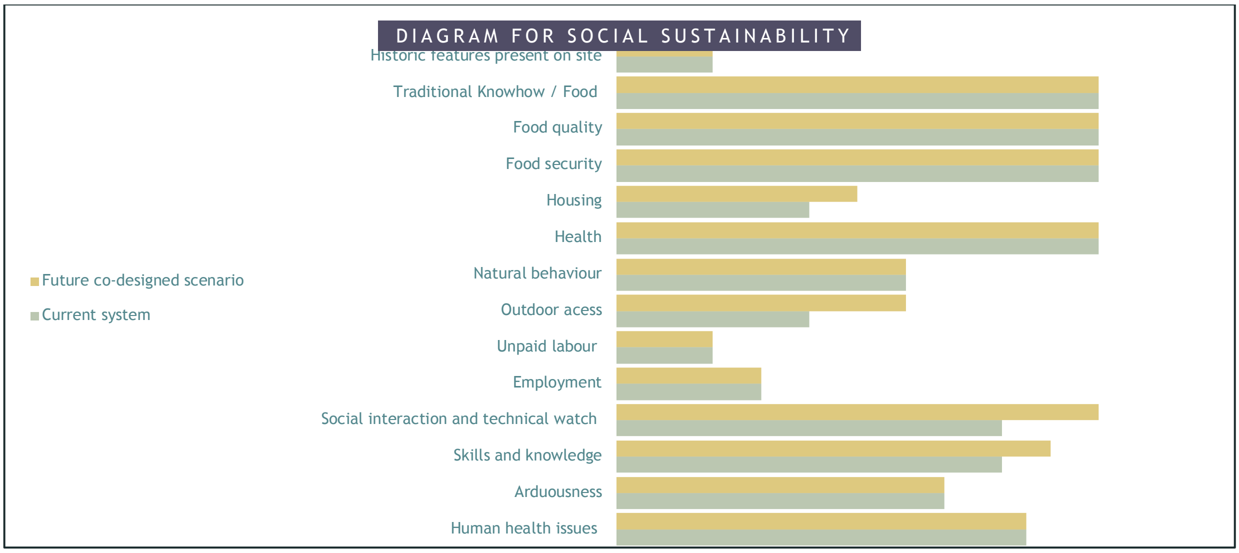

Figure 94 : Scores of the social sustainability indicators, showing the current system and the future co-designed system (farm 1)

Overall, parameters remained unchanged, except for the improvement in housing conditions, outdoor access, social interaction and technical watch, as well as the skills and knowledge of staff at the farm. Despite the limited improvement, we consider these changes in a co-designed scenario would to be positive for the farm and its future trajectory.

- **Farm 2**

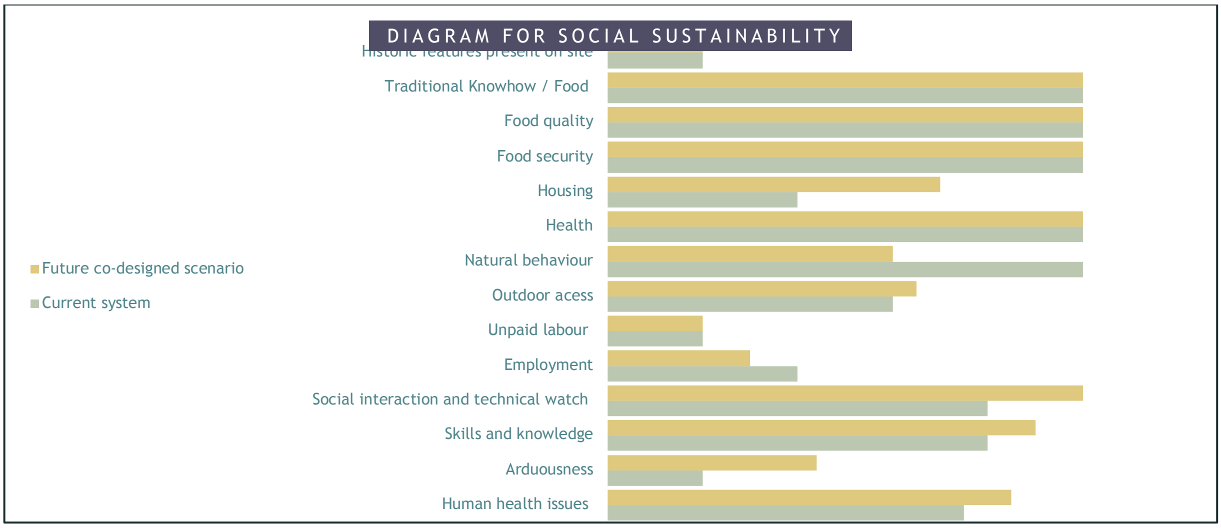

Figure 95 : Scores of the social sustainability indicators, showing the current system and the future co-designed system (farm 2)

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Interestingly, arduousness and human health issues showed an improvement, while employment and natural behaviour scored worse in the co-designed scenario. A possible explanation for this might be that in the future, thanks to better technologies and innovations, the challenges faced now concerning human health and arduousness could be overcome, while on the other hand, fewer people will be working in agriculture (less employment). Concerning natural behaviour, new very specific and strict animal welfare standards are potentially threatening those extensive systems that do not provide sufficiently structured housing or adequate outdoor facilities, which could force farmers to move livestock indoors because extensive systems can be considered by Italian authorities a higher risk for public health than intensive systems.

3.8.2.2.4 Economic impacts

- **Farm 1**

Figure 96 : Scores of the economic sustainability indicators, showing the current system and the future co-designed system (farm 1)

Overall, the scores show an improvement in financial viability and stability of the farm in the co-designed scenario and no negative impacts on any economic parameters considered in the assessment.

- **Farm 2**

Figure 97 : Scores of the economic sustainability indicators, showing the current system and the future co-designed system (farm2)

The future co-designed scenario did not seem to generate any change in the economic sustainability of the farm.

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3.8.2.3 Impact of co-design changes on resilience

3.8.2.3.1 Major changes at global scales and comparison with sustainability assessment

- **Farm 1**

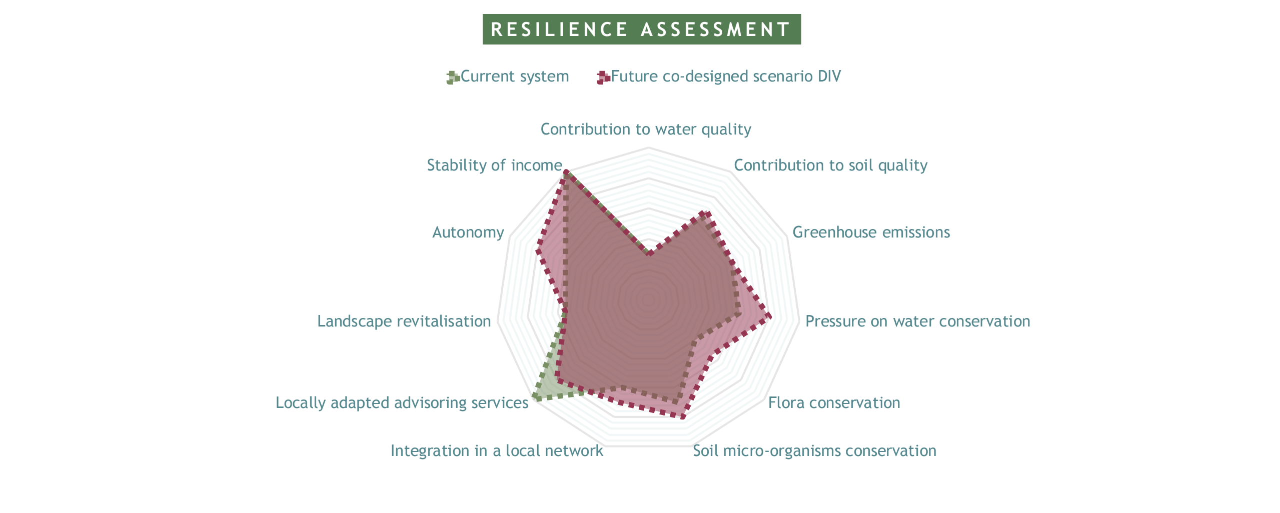

Figure 98 : Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario (farm 1)

Results include positive, neutral, and negative impact on resilience parameters. Contribution to water and soil quality, GHG emissions, landscape revitalisation and stability of income remained unchanged. Pressure on water conservation, flora conservation, soil micro-organisms conservation, and farm autonomy showed an improvement. This is term of resilience could be explained by the adoption of advanced water conservation techniques, such as precision irrigation, optimising water utilisation and improving overall farm efficiency. In tandem, a heightened focus on flora conservation has seen the integration of native plant species, cover crops, and hedgerows, fostering biodiversity and providing crucial habitats for pollinators and beneficial insects. Farmers have embraced conservation-oriented approaches, including reduced tillage, use of cover crops, and the application of organic fertilisers. Moreover, farm autonomy has gained importance, marked by crop diversification, the incorporation of agroforestry and mixed farming principles, and exploration of sustainable energy sources. However, the co-design scenario would have an adverse impact on locally adapted advisory services. This will be discussed in detail in the following sections.

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➢ **Farm 2**

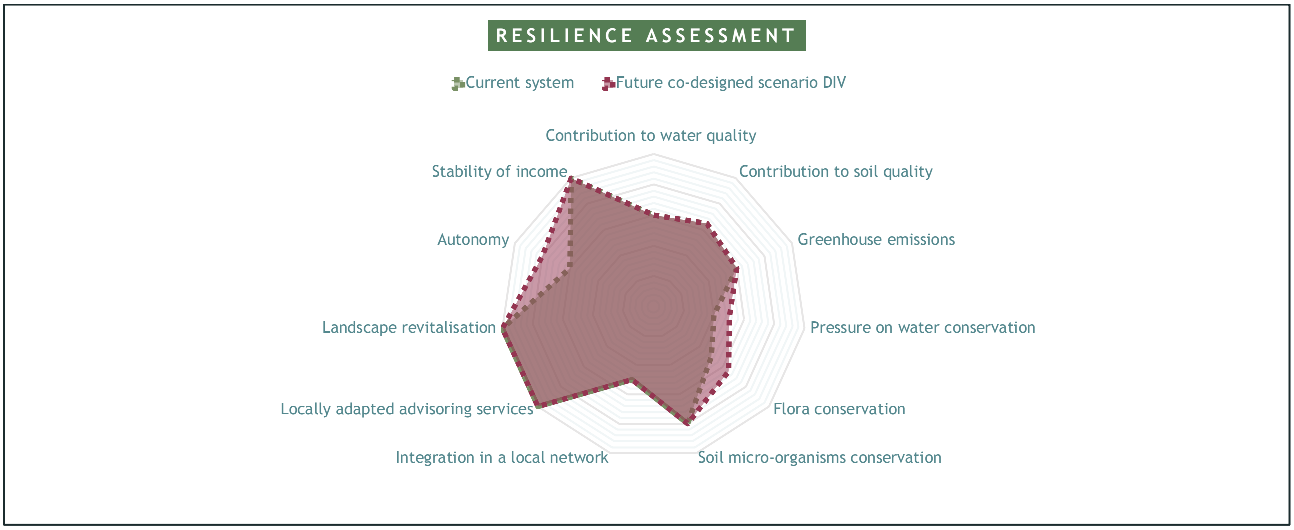

Figure 99 : Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario (farm 2)

Overall, the future co-design scenario did not lead to significant changes, except in the autonomy of the farm and in a slight improvement in flora conservation and pressure on water conservation. All other parameters remained unchanged, contribution to water and soil quality, GHG emissions, and integration in a local network still scored at or below 50% in both resilience assessments. This could be because the economic sustainability of the mentioned farm is overall positive, therefor in terms of resilience, it seems they feel less pressure for change. Nevertheless, the co-design scenario did not have any negative impact on any aspect of resilience, which we find very encouraging.

3.8.2.3.2 Environmental impacts

➢ **Farm 1**

The most significant factors influencing the improvement of the environmental resilience in the co-design system are arable crop diversity and soil compaction. Overall, better soil conditions and increased crop diversity positively impacted on the whole system, while all other parameters remained unchanged despite possibility to score higher. The latter is not considered a source of concern; however, it would be interesting to do further research on the reasons for a lack of improvement.

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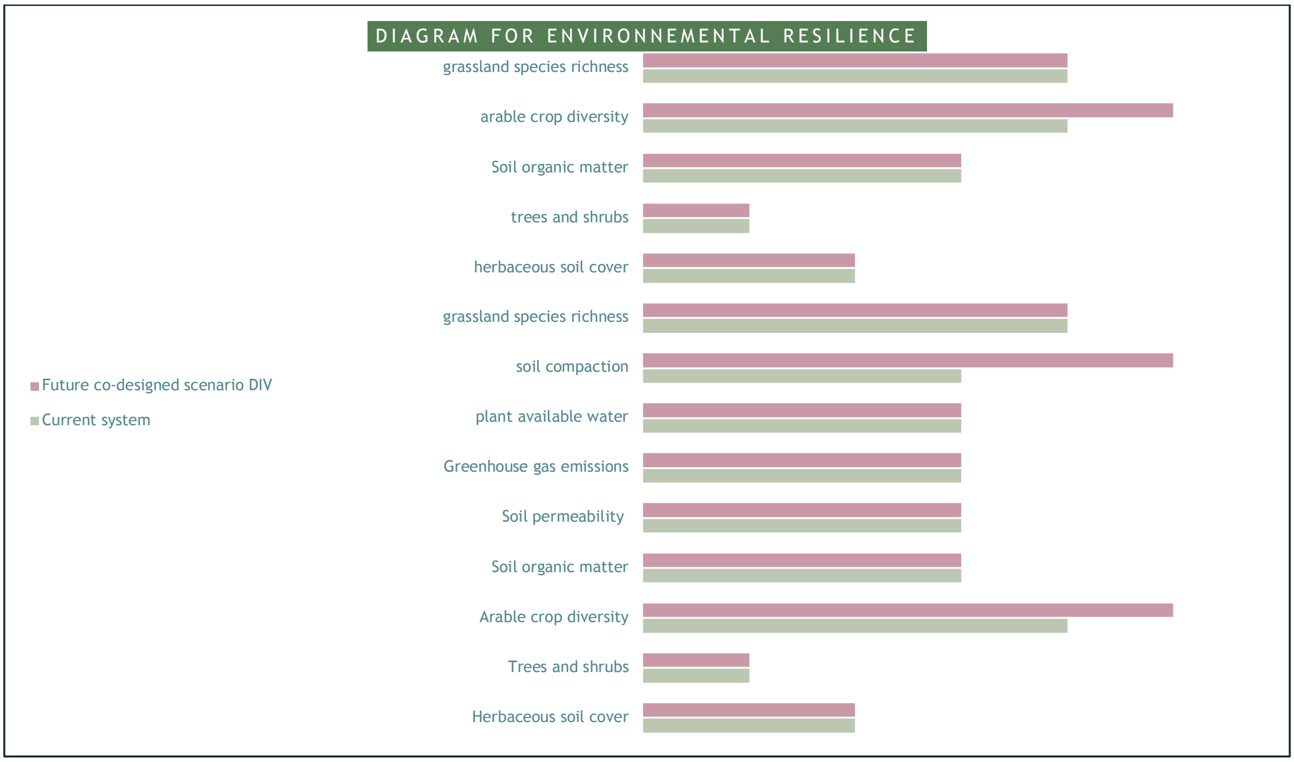

Figure 100 : Scores of the environmental resilience indicators, showing the current system and the future co-designed system (farm 1)

- **Farm 2**

In this farm, most parameters remained unchanged, alike in Farm 1. Trees and shrubs, herbaceous soil cover, and soil compaction showed an improvement in the co-designed scenario. This indicates a link between the farm environmental resilience, soil conditions and overall plant species diversity.

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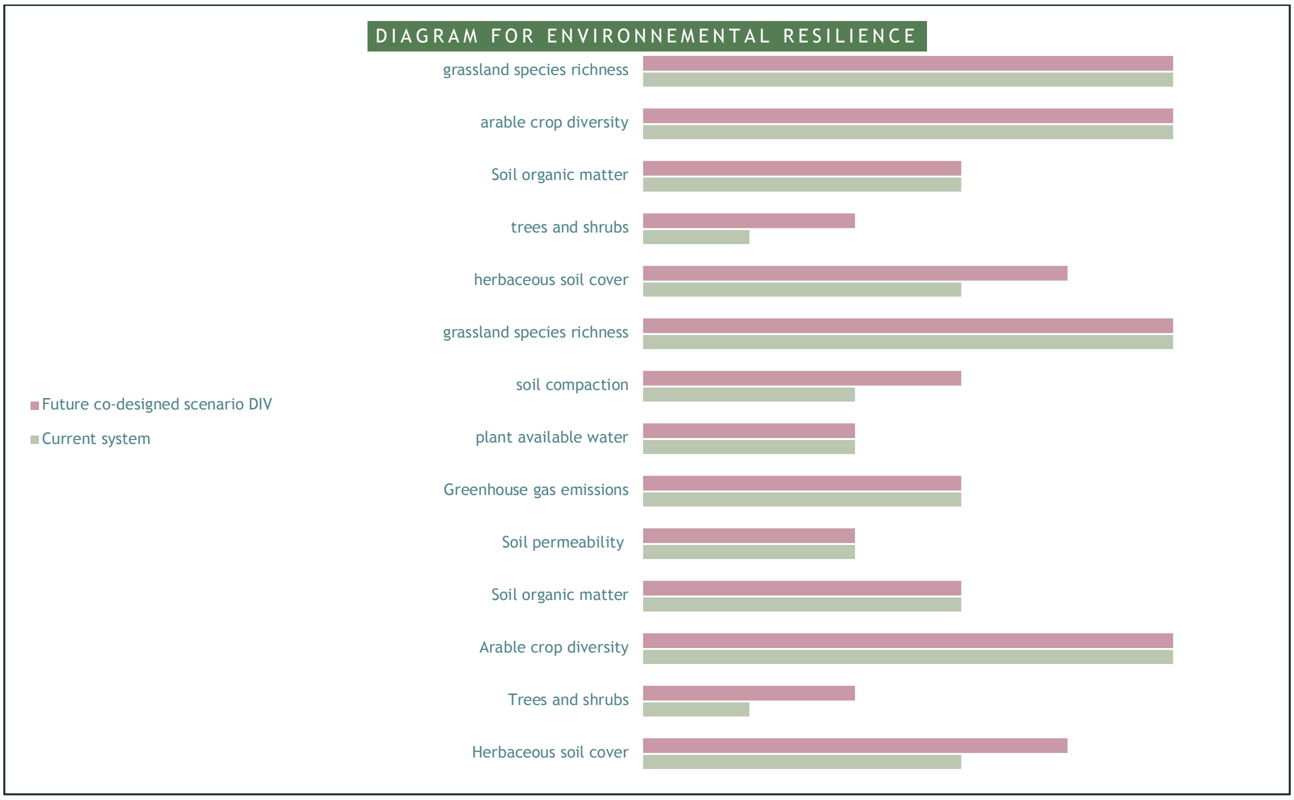

Figure 101 : Scores of the environmental resilience indicators, showing the current system and the future co-designed system (farm 2)

3.8.2.3.3 Social impacts

- **Farm 1**

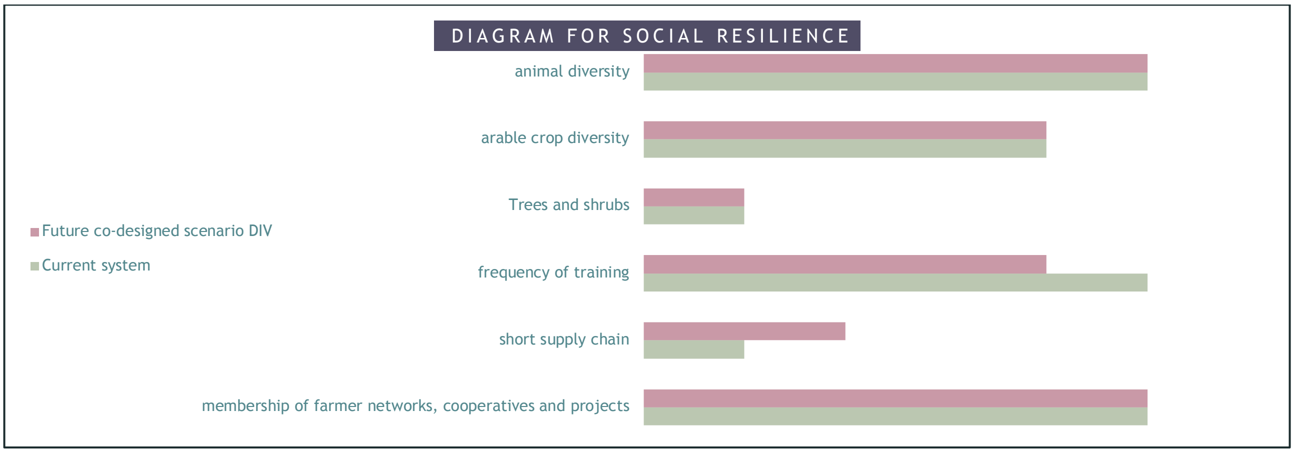

Figure 102 : Scores of the social resilience indicators, showing the current system and the future co-designed system (farm 1)

Despite a positive impact on short food supply chain dynamics, the future co-designed scenario resulted in a negative impact on the frequency of training of staff. This finding highlights the specificity of systems and farms, and the highly variable social dynamics a farm can operate in.

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➢ **Farm 2**

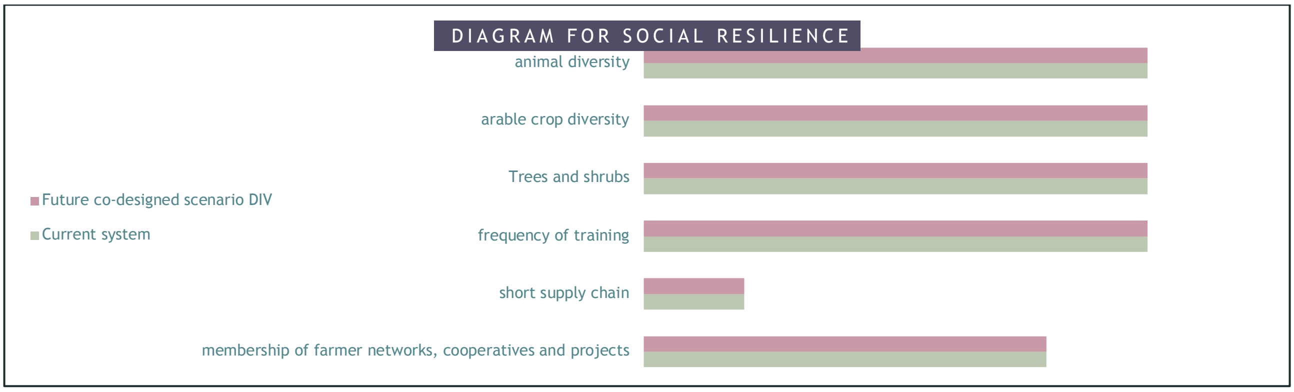

Figure 103 : Scores of the social resilience indicators, showing the current system and the future co-designed system (farm 2)

The farm scored very high on most parameters for social resilience. No changes were found in any parameter, not even in the improvement of the short supply chain, which instead scored very low and did not change. This may be explained by the fact that both farms are part of the Pecorino cooperative, beside an oil consortium and a wine consortium. Formally, they are not allowed to sell their products directly, and that in turn can lead to a certain degree of stability of the value chain of which they are part of.

3.8.2.3.4 Economic impacts

➢ **Farm 1**

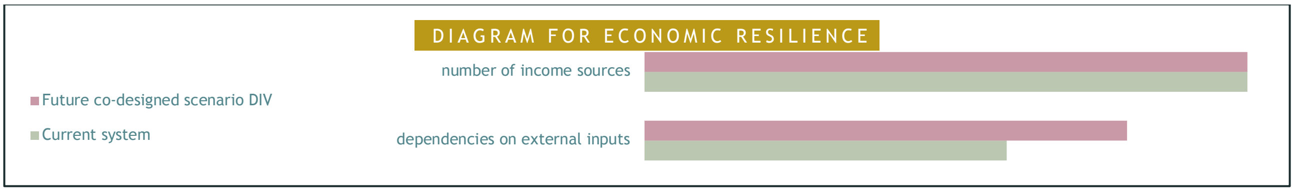

Figure 104 : Scores of the economic resilience indicators, showing the current system and the future co-designed system (farm 1)

➢ **Farm 2**

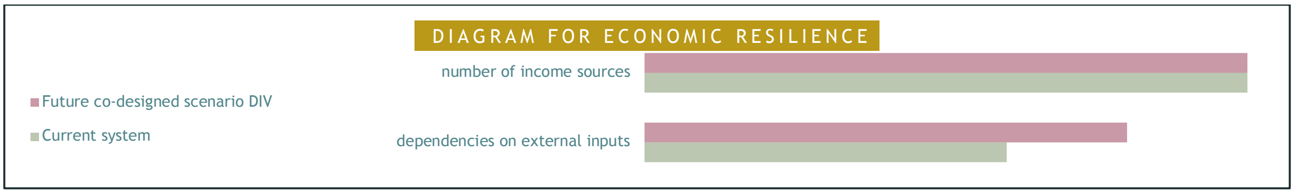

Figure 105 : Scores of the economic resilience indicators, showing the current system and the future co-designed system (farm 2)

In both farms, the only improvement observed was in the reduction of the dependence on external inputs. This is a key result and shows how the co-designed scenario would have a positive impact on the economic resilience of the farms assessed.

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3.8.3 Tools and methods: feedback

Feedback on Farm Sustainability and Resilience Self-Assessment Tool

The Farm Sustainability and Resilience Self-Assessment Tool is a valuable resource for farmers looking to enhance their understanding of their farm's sustainability and resilience. However, there are several key points that deserve attention:

1. **Data Availability Challenges:** One of the primary concerns is the difficulty in obtaining accurate data for the various indicators used in the assessment. Many farmers, especially those in resource-constrained settings, may struggle to access or collect data for all the required indicators. The tool should address this challenge by providing guidance on data collection methods or by allowing for approximations when precise data is unavailable.

2. **Practicality Issues:** Some farmers may find the tool to be less practical in its current form. It could be time-consuming and resource-intensive to gather all the necessary information. To make it more practical, the tool could offer streamlined data entry options and prioritise the most critical indicators for a basic assessment, with the option to delve deeper for a comprehensive evaluation.

3. **User-Friendly Results:** While the self-assessment tool is undoubtedly comprehensive, it may need improvements in terms of user-friendliness in presenting results. Farmers might require a more straightforward interpretation of the results, with actionable insights and recommendations. Visual aids, such as graphs or charts, can help make the findings more accessible and engaging.

4. **Monitoring Challenges:** The self-assessment tool should also consider the long-term sustainability of the farm. Regular monitoring is essential to track progress and adapt strategies as needed. However, it can be difficult for farmers to maintain consistent, ongoing assessments. To address this issue, the tool should include features that facilitate periodic check-ins and reminders to encourage continued monitoring.

In conclusion, the Farm Sustainability and Resilience Self-Assessment Tool is a valuable resource, but it should address challenges related to data availability, practicality, user-friendliness in presenting results, and long-term monitoring. By enhancing these aspects, the tool can become a more effective and user-friendly instrument for farmers seeking to improve the sustainability and resilience of their farms. This, in turn, will contribute to the overall success of the tool and support farmers in their sustainable agriculture endeavours.

3.8.4 Take-away messages

Results from the assessment of two farms within the pilot of the Caseificio Sociale di Manciano, in the Grosseto province, in southern Tuscany, highlight how the co-designed scenario impacts on sustainability and resilience of the farms.

Biodiversity and climate friendly farming are key positives, although energy and renewables need to be considered as possible negative impacts, in a comprehensive environmental sustainability assessment. In terms of social sustainability, the results showed a highly-context dependent sustainability where social

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dynamics and interactions may vary greatly between farms and have considerably different impacts, including negative ones. Financially, however, the assessment showed a promising improvement of the overall financial stability, including improved investment capacity, in one farm and no change in the other farm: hence, no negative impact financially.

In terms of resilience, biodiversity is again a key factor in improved scores under the co-design scenario. Soil compaction proved to be another key factor that contributes to environmental resilience. No changes were found in any of the parameters for economic resilience. However, social resilience appears to be a more complex matter, with conditions and dynamics that are highly specific to each farm. In one case the co-designed scenario negatively affected the social resilience of the farm. A more detailed assessment of the social dynamics involved may possibly clarify some of the results or help refine the assessment methodology to allow a more accurate capture of farm specificities not only from an environmental point of view.

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3.9 Swiss Agroforestry Network – Swiss pilot (ZHAW)

Author(s)	Mareike Jäger
Contact	**Mareike.jaeger@zhaw.ch**
Reviewer	Ulrich Schmutz

3.9.1 Pilot site description

3.9.1.1 Pilot Site Environment

The Swiss co-design pilot "Swiss Agroforestry Network" includes interested persons from practice, consulting and research. A farm from this network was selected for the sustainability and resilience assessment. The farm remains anonymous. It is a family farm in the canton of Zurich.
The farm is located in the eastern part of the canton at the foot of the Albis Mountain range. The landscape is richly structured and consists of arable and grassland areas, forests and small towns and villages.

Figure 106: The assessed farm is located in the south-west of Canton Zurich in the transition from the Swiss Central Plateau to the foothills of the Alps (graphical source: https://de.wikivoyage.org)

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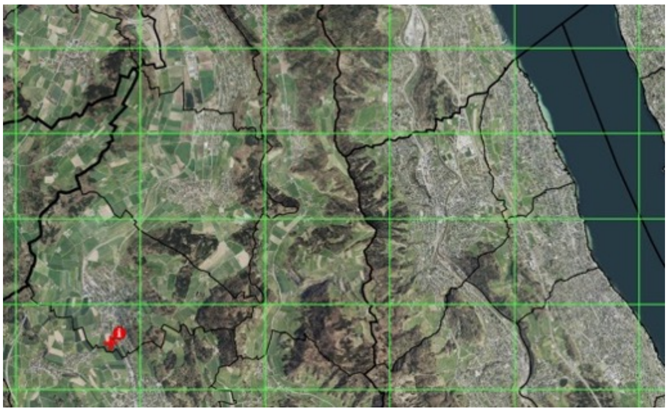
The farm is located east of Lake Zurich towards the foothills of the Alps and the Albis Mountain range;



↑*Figure 107 : Geographical Place of the farm (source: GIS-Browser KtZH)*

→*Figure 108 : Assessed farm area (orange line) and the farmhouse (red circle)*

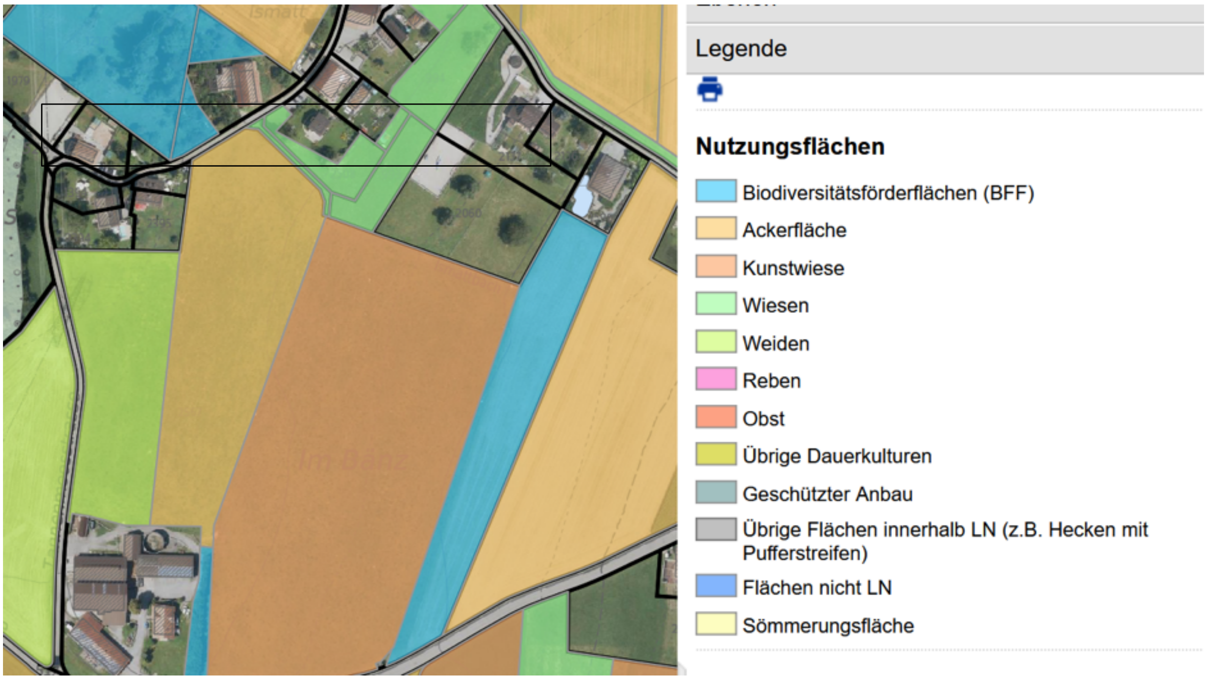


Figure 109 : Current land management on the farm includes arable land, pasture, clover grass and biodiversity promotion area (source GIS Kt ZH)

The soils on the farm are predominantly deep, normally permeable brown soils, which are typical for the valley region of Switzerland.

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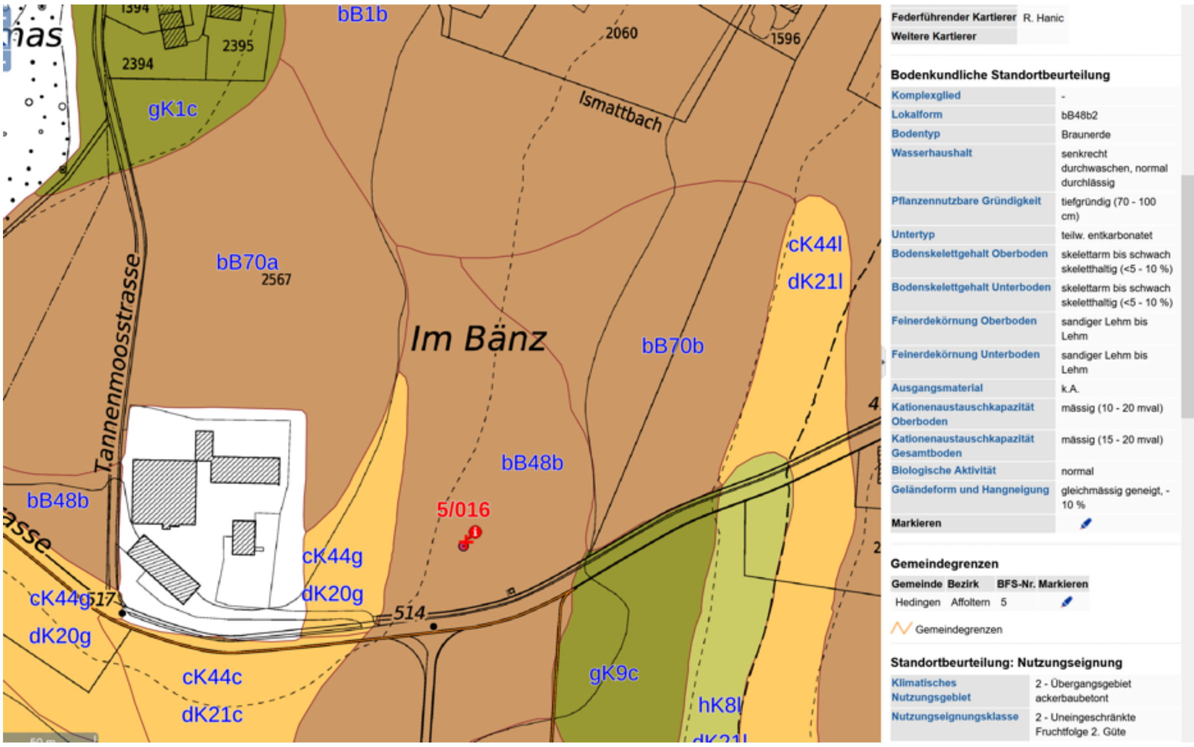

Figure 110 : Soil science site evaluation (Source: GIS-KTZH)

3.9.1.2 Current system

The analysed farm produces organically on a total of 18.5 hectares and is south-east exposed. The humus content is relatively high (4%) on good, although there is a risk of soil erosion due to the hillside location and the frequent cold north wind.
Besides arable farming (cereal crop rotation: wheat, spelt and oat and temporary ley (grass-clover mixture)), the farmer operates a suckler cow fattening with Limousin and Angus breeds, but in the future, the focus should be on Angus because they are smaller and less heavy. The fodder is produced on pasture, temporary ley and extensively used meadow. But in recent years the precipitation in the region decreased by around 50% (currently around 800 mm), according to the assessed farmer. During dry spells, pastures and meadows do not provide sufficient feed for the animals, therefore fodder shrubs and hedges are planned.
Since 2018, the assessed farm has been cultivated without a plough, only with a rotor spade. Also, catch crops (inter-tillage) with up to 20 species are sown, a grain seed 17.5 cm row spacing is applied, camelina are always undersown and manure compost is spread.

3.9.1.3 New co-design system

3.9.1.3.1 Agro-silvopastoral agroforestry system

A diverse agroforestry system is to be implemented on the farm. Double rows of trees with different types of timber trees, fruit trees and nut trees are planned. The idea of the double rows came from the farm manager himself. The aim is to create additional forage areas for ruminants. In the first few years, when the trees are still small, ecological compensation areas are to be created between the double rows of trees, which

will not be grazed (wildflower strips). A tree row spacing of 9 meters between the double rows is envisaged. The further row spacing should be a multiple of the seed drill width, usually a multiple of 3 meters. The farm manager would like to avoid particularly dry, gravelly areas for tree planting on the plot. The tree spacing within the row should be between 10 m (fruit trees) and 15 m (timber trees).
The following species are proposed for the fruit trees: pear apple, walnut, hazel, pecan.
The following tree species are proposed for timber utilisation: chestnut, oak, lime, walnut, wild pear, bird cherry, and maple.
Timber tree species such as oak, maple etc., are not eligible for direct payments in Switzerland.
As the increasing drought is a problem on the farm, tree species that are particularly drought-tolerant are recommended: Chestnut, sessile oak, downy oak, wild cherry, Norway maple, walnut, small-leaved lime and wild pear.
It should be noted that high-stem field fruit trees in silvoarable agroforestry systems place high demands on management in terms of pruning and variety selection. The fruit harvest must take place in a narrow time window between harvesting the sub-crop and sowing the following crop.
Drainage systems: Drainage systems are partially present on the site. Distances to drainage systems are regulated in the municipal regulations and must be taken into account in the planting plan.
Root pruning: It was pointed out that root pruning is recommended along the row of trees and also along the planned fodder hedge (also due to the reduced soil cultivation on the farm) so that the tree and shrub species spread safely below the main root zone of the cultivated plants.

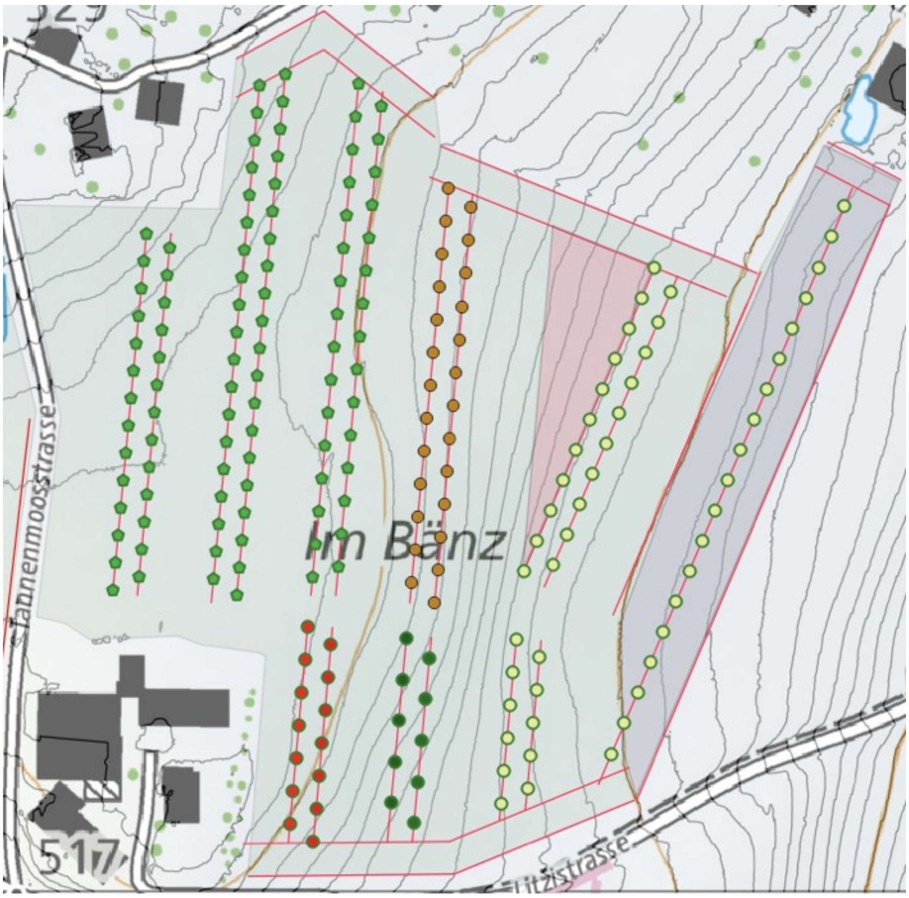

Figure 111 : Planned agro-silvopastoral system with fruit trees and timber-trees

3.9.1.3.2 Forage hedge/multi-use hedge

A forage or multi-use hedge is to be created on a pasture area. Valuable timber trees are supplemented with shrub species that can be used both for leaf fodder and biomass utilisation (wood chips for livestock bedding, production of biochar, mulch material for arable farming, etc.). Species for fodder hedges include: Ash, elm, oak, poplar, hazel, willow, elder and hornbeam. The hedge elements are provided with passages so that the animals can circulate better around the individual elements. In addition, complete elements can be fenced off if they need to recover from browsing by the animals.

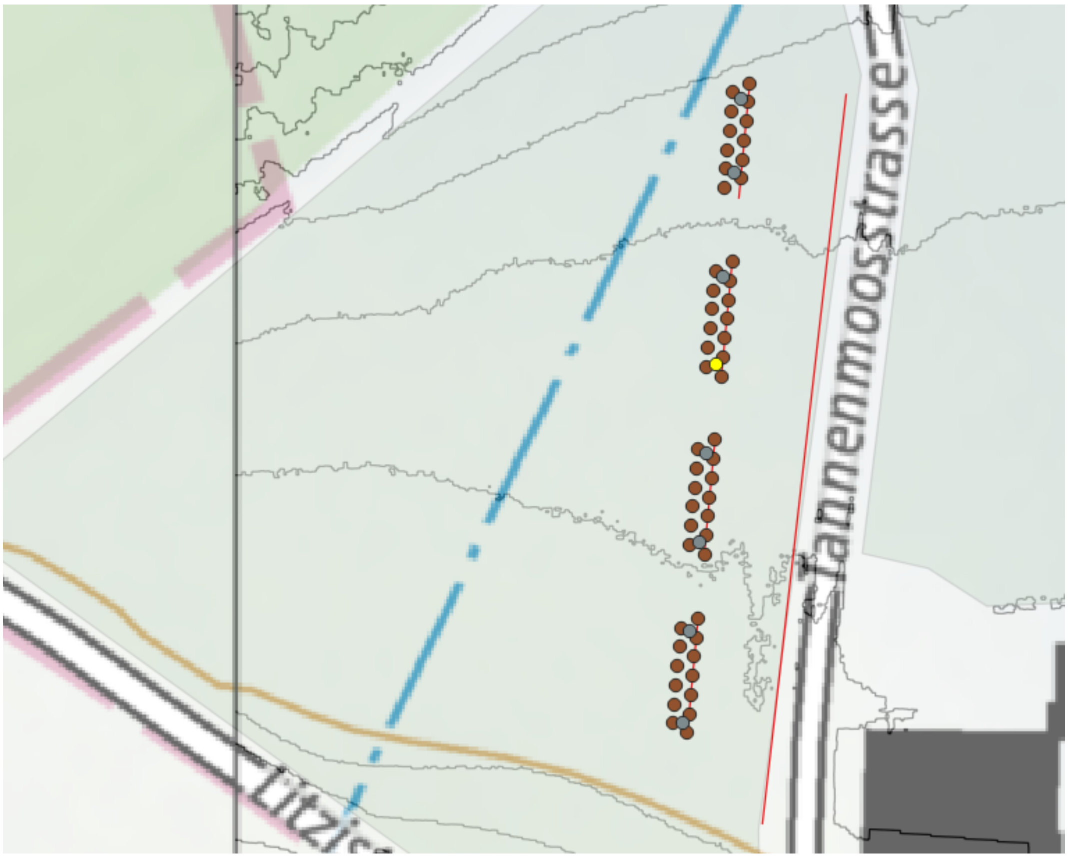

Figure 112 : Planned fodder hedges concept on a pasture area

3.9.2 Sustainability and resilience assessment

3.9.2.1 Selection of indicators for local assessment

When selecting the indicators, the pilot group discussed which would best suit the individual situation and the possible development of the farm. Those indicators were selected that could contribute to improving the current situation. In the case of the resilience assessment, the following environmental indicators were selected:

- Contribution to resource protection
- Pressure on abiotic resources
- Biodiversity conservation

The environmental indicators for the sustainability assessment area were more diverse and also included the circular economy and the reduction of greenhouse gas emissions.

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Weighting indicators:

In most cases, the indicators within a leaf were weighted equally. The following are some notable exceptions.

- **Assessment of Resilience**

Environment: We rated the indicator of how many CO2 equivalents are emitted per ton of product as 0, as no figures were available for this. Otherwise, we also weighted the area of soil analyses lower, as these only have to be carried out very irregularly and at long intervals in Switzerland, so this indicator was assessed as weak.

The permanent soil cover indicator was also given a lower weighting, as strict requirements already have to be met in the existing system and the effect of change is rather small.

- **Assessment of sustainability**

In the area of "Social", the personal working environment was weighted higher than the possible exposure to chemicals, as the company operates organically and therefore comes into less contact with toxic chemicals. In the area of employment, the use of seasonal workers was rated as a more important indicator than the employment of permanent workers, as seasonal workers generally receive less employment protection. The issue of unpaid labour was also classified as very relevant, as the unpaid work of female farmers in the form of care work or direct marketing often plays a role here.

3.9.2.2 Impact of Co-design Changes on Sustainability

The discussion of the results of the sustainability assessment within the pilot team focused on those points that differed the most between the current scenario and the future scenario.

3.9.2.2.1 Major changes at global scales

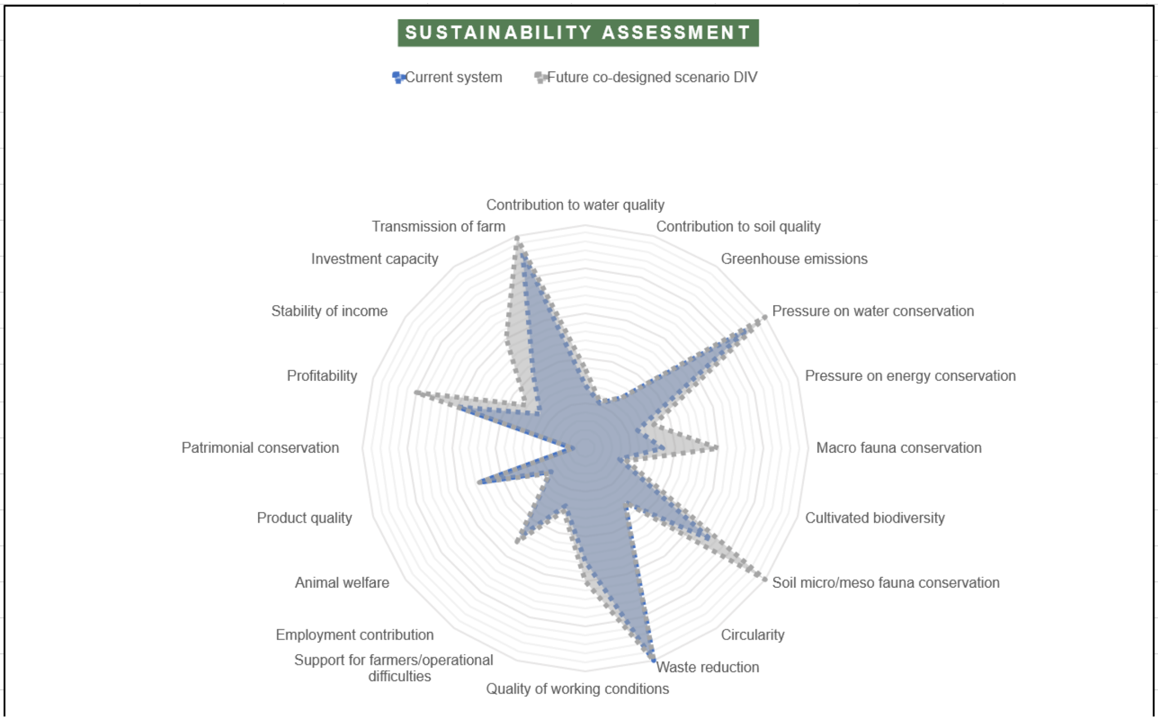

Figure 113 : Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario

The radar diagram shows improvements for the future scenario, particularly in the areas of soil (micro/meso fauna conservation), macrofauna, income stability and profitability. The result reflects the farm manager's expectations that the income situation on the farm will improve through product diversification and that additional value can be generated through the agroforestry system.

3.9.2.2.2 Environmental impacts

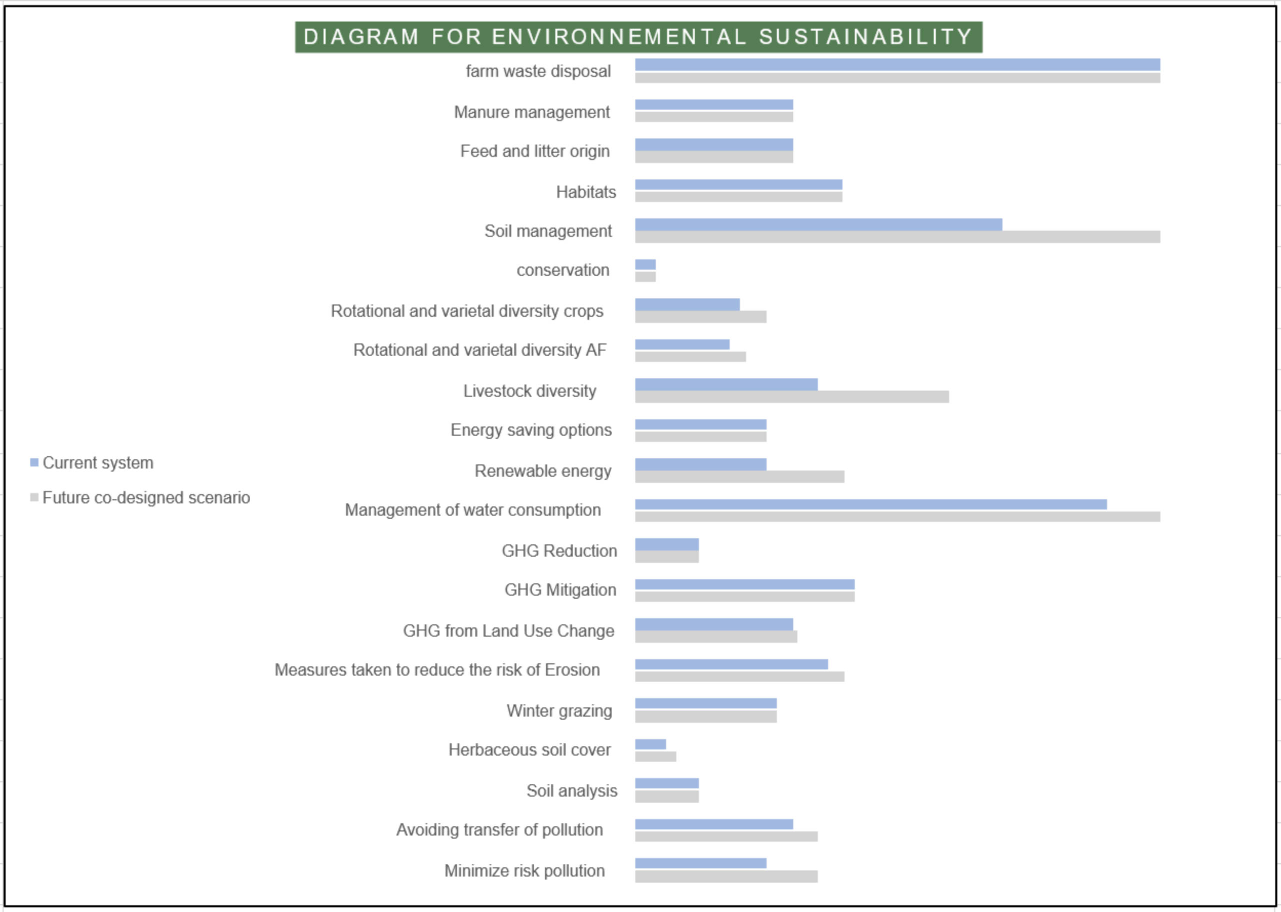

Figure 114 : Scores of the environmental sustainability indicators, showing the current system and the future co-designed system

A look at the detailed evaluation of the topic of the environment shows possible advantages of the future scenario in sustainability. An improvement can be expected in most sub-areas. Possible advantages in the area of soil management and the management of water consumption should be emphasised. As the farm tends to have very heavy, clayey soils, the planned agroforestry system has the potential to improve the soil structure through the increased turnover of organic matter. This can have a positive effect on soil management.

As increasingly scarce water resources are also a major issue on the farm, benefits are expected in terms of water management. These benefits can include saving irrigation water, contributing to groundwater recharge and less evapotranspiration on the land through hydraulic lift of soil water.

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3.9.2.2.3 Socials impacts

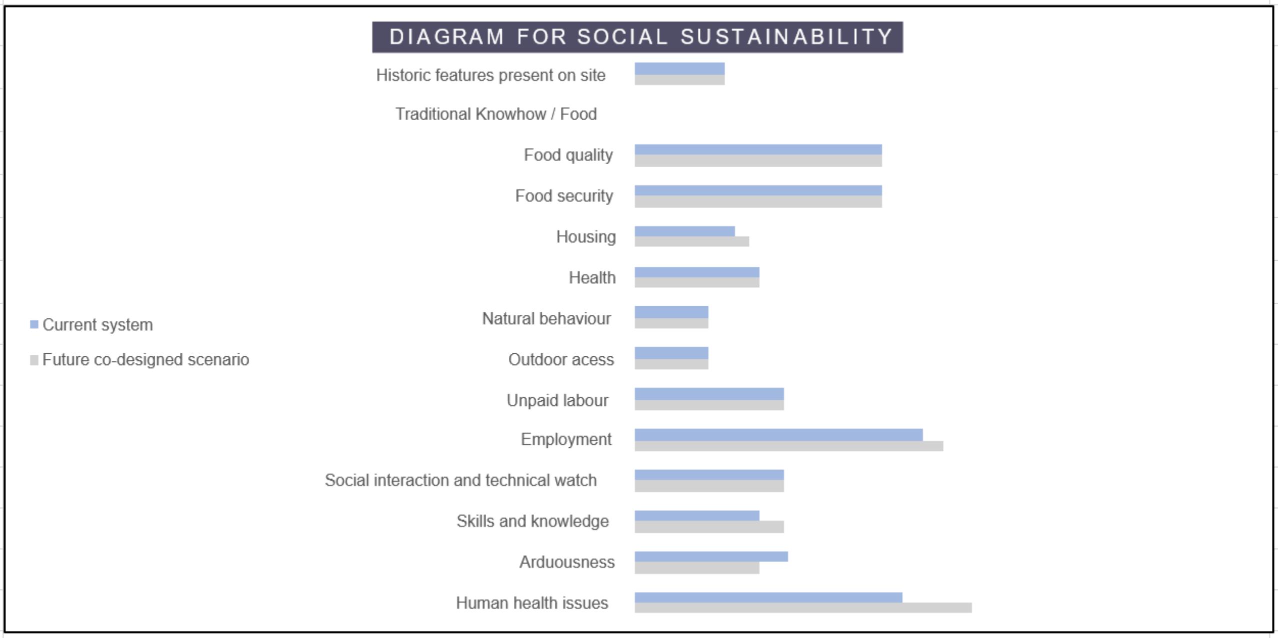

Figure 115 : Scores of the social sustainability indicators, showing the current system and the future co-designed system

In terms of social sustainability indicators, human health issues and the area of employment can be singled out. The agroforestry system may lead to more employment opportunities on the farm. This indicator has a positive effect if there is sufficient income to pay for this additional labour. The pilot team intensively discussed the fact that planting trees is also a societal responsibility and must be rewarded accordingly. However, the work involved in caring for trees also has a health aspect. In an increasingly digitalised world, the population's desire to engage with "living" things is also growing. Here, too, agroforestry systems offer opportunities to contribute to the mental health of parts of the population through active tree care and the associated work (maintenance, fruit harvesting, etc.).

3.9.2.2.4 Economic impacts

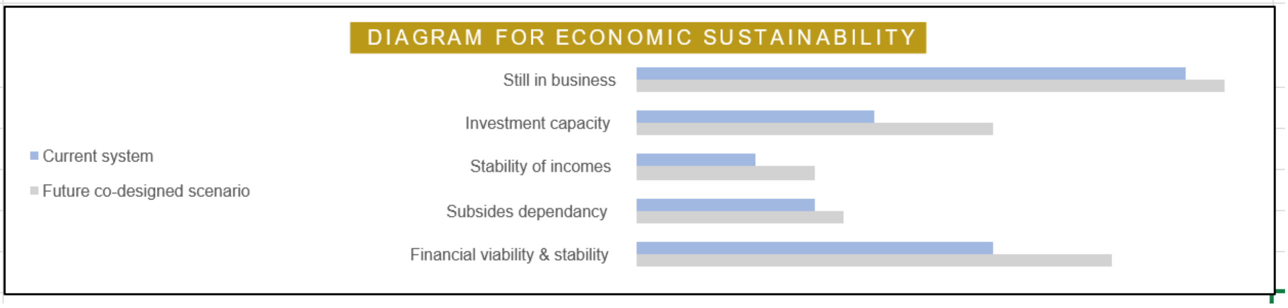

Figure 116 : Scores of the economic sustainability indicators, showing the current system and the future co-designed system

In terms of economic sustainability indicators, the integration of trees is expected to have a positive impact on farm income. In Switzerland, the planting of trees is already very well compensated financially through

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agricultural direct payments. In addition, product diversification is expected to have a positive impact on farm income.

3.9.2.3 Impact of co-design changes on resilience

3.9.2.3.1 Major changes at global scales and comparison with sustainability assessment

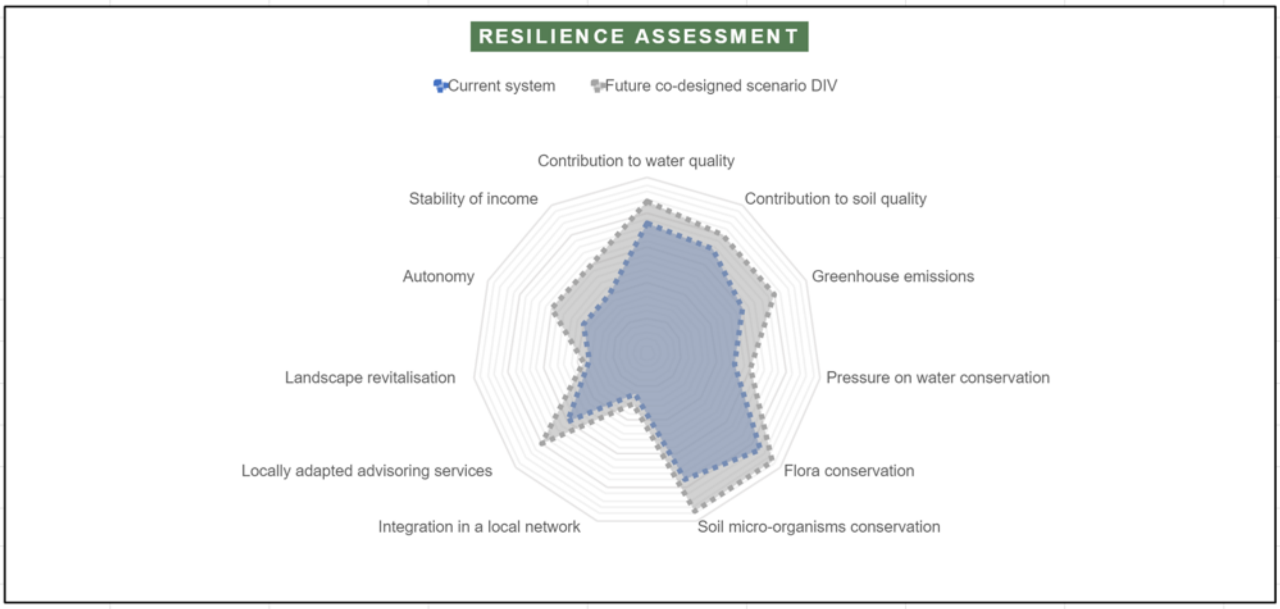

Figure 117 : Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario

If we compare the evaluation of the sustainability assessment with the possible development of the future scenario in terms of resilience, the improvements here are more obvious than in terms of sustainability. However, similar focal points become clear: these lie in economic resilience, certain soil parameters and the reduction of greenhouse gas emissions.

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3.9.2.3.2 Environmental impacts

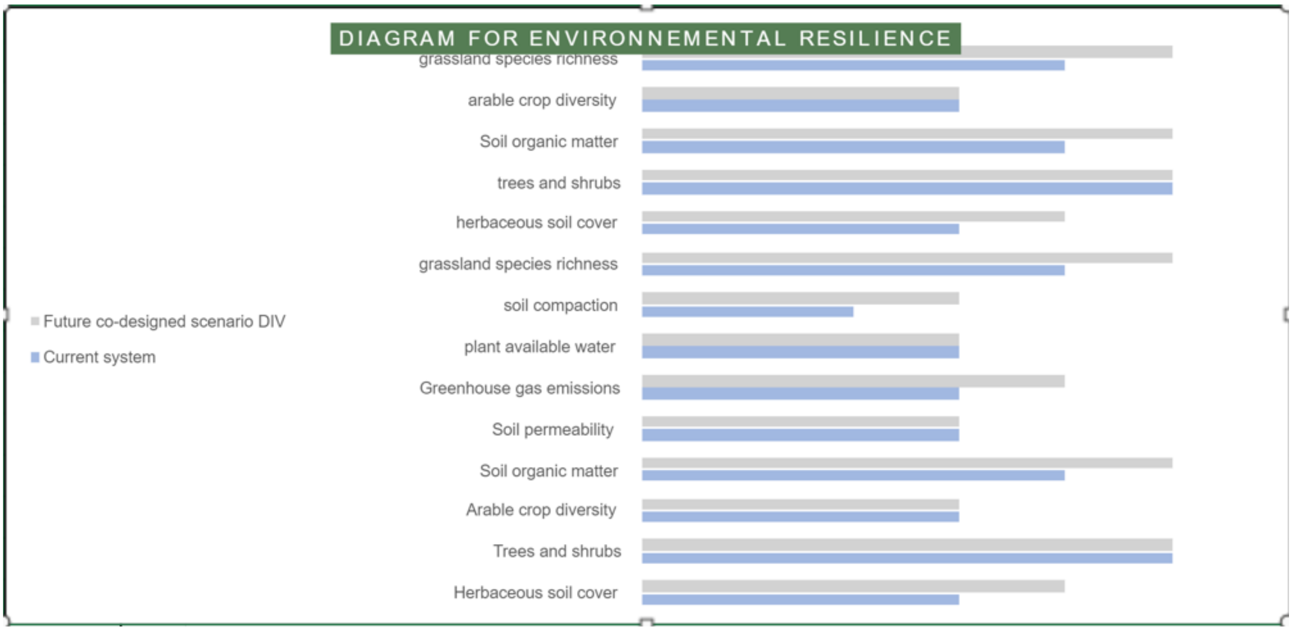

Figure 118 : Scores of the environmental resilience indicators, showing the current system and the future co-designed system

Similar to the sustainability indicators, potential benefits in the area of resilience also lie in an expected increase in soil organic matter, which is reflected in several possible indicators such as soil organic matter and soil compaction. The future scenario assumes significant improvements here. The second area lies in an improvement in biodiversity on the land, which is generally a strong indicator of resilience, as well as in the diversification of cash crops.

3.9.2.3.3 Socials impacts

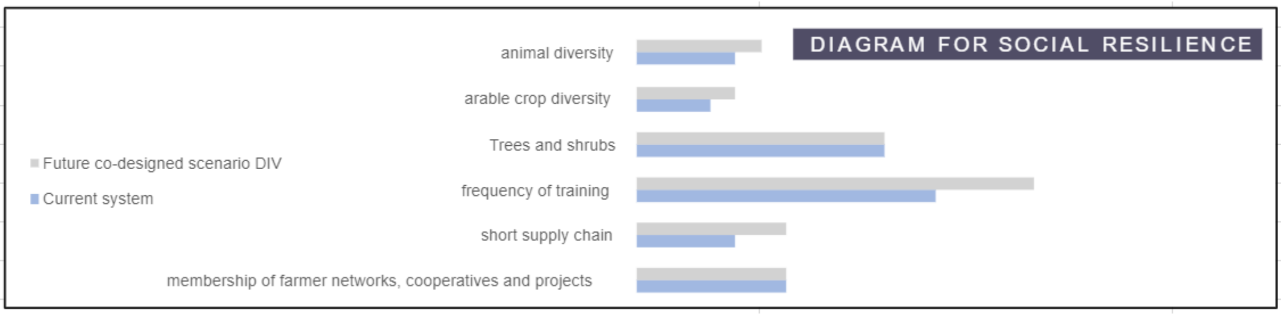

Figure 119 : Scores of the social resilience indicators, showing the current system and the future co-designed system

A possible strong resilience indicator lies in the short marketing channels, as the plan is to market some of the fruit directly from the farm. This reduces dependency on the general market situation. This indicator is also closely linked to crop diversity.

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3.9.2.3.4 Economic impacts

Figure 120 : Scores of the economic resilience indicators, showing the current system and the future co-designed system

As already described in the sustainability indicators, the economic resilience indicators focus on income diversification and increasing independence from external inputs. These possible positive developments have their origin in the additional product value added by the planned agroforestry system.

3.9.3 Tools and methods: feedbacks

Overall, carrying out the assessments together with pilot participants was perceived as valuable, but also challenging. The special situation was also not ideal, as a single farm had to be selected for this assessment. The Swiss co-design pilot is a network of farms. This left uncertainty about whether the selection of the farm was the best choice for the assessment and whether conclusions could be drawn about the Swiss co-design pilot as a whole. Some indicators were difficult to understand or far too specific, as they required a great level of detailed knowledge (such as the question on product-related greenhouse gas emissions). Overall, the environmental indicators were challenging to evaluate.

The tool would have to be simplified for a user group outside the scientific community (practitioners, consultants). Although it helped to better understand the current and future situation, the results were not very surprising.

3.9.4 Take-away messages

The sustainability and resilience assessment enabled an in-depth analysis of the consequences of switching to a diversified agroforestry system at farm level. Certain key areas of change were emphasised, such as effects on soil quality and possible improvements in the income situation. It emphasised benefits already assumed in relation to the planned cultivation system.

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3.10 Rudno Farm – Serbian pilot (NRDS)

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Reviewer	Dejan Zagorac

3.10.1 Pilot site description

3.10.1.1 Pilot site environment

The Serbian pilot site is located in southwestern Serbia, in the Raški district. The pilot area is located in the Nature Park "Golija" and the Biosphere Reservation "Golija-Studenica" protected by UNESCO within the framework of the program "Man and the Biosphere". The nature park covers the territory of 5 municipalities, and the Biosphere Reservation covers part of the Nature park and cover the territory of 2 municipalities. The selected farm is located in the village of Rudno, which is 100 km away from the municipal centre of Kraljevo. The village of Rudno is about 20 km from the main road Kraljevo-Raška. The village is located in a mountainous area at an altitude of about 1100 meters above sea level. In the last 15 years or so, the area has become a popular tourist destination for rural tourism.

The farm of the Andrić family fully reflects the typicality of farms, which were developed in accordance with the landscape characteristics of the area and the geological-pedological characteristics of the soil in the area of PP "Golija". Given the relief, climate, hydrographic and vegetation conditions, the diversity of the geological substrate and the influence of man, Golia has developed soils that belong to different taxonomic units due to their morphological appearance, physical and chemical properties. They are represented by the following lines:

- automorphic soil,
- hydromorphic soil,
- subhydric soils.

Golija lands are primarily forest lands with low production capacity, threatened by erosion.

Shallow soils belonging to lithosols and regosols have the lowest productivity. They appear on almost all substrates, mainly due to the negative influence of man, cutting down the forest on steep slopes, opening new and abandoning old roads, destroying pastures and growing potatoes, all of which potentiates the removal of soil by erosion, water, and wind.

Soils of less productive value can also include calcomelanosol, browned, and even district cambisols, although they are slightly deeper soils, subject to erosion as soon as their protective plant cover is destroyed.

District cambisols, widely distributed in this area, with certain conditions, represent an exceptional potential. It is necessary to prevent the loss of soil with preventive measures, which is noticeable on the slopes that are destroyed for the cultivation of potatoes and some stubble.

Eutric cambisols and calcocambisols are of higher productive value. They occupy significant areas. Eutric cambisols (fertilisers) are soils on which agricultural production takes place to a significant extent. Chalcocambisol has a favourable structure. So, if these two types of soil are properly cultivated, fertilised and maintained, and not degraded, they have a significant potential for agricultural production. Both types of soil

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are subject to erosion, if they are under arable land, so the so-called protective utilisation, including contour processing, isohypse processing, introduction of grasses in the crop rotation, fertilising with manure and mineral fertilisers containing calcium, etc.

Rankers on different substrates have the largest expanse and great potential, although they are included in the VII rating class, because they are more than 20 cm deep, are very humus, and are mostly found under lawns.

As the farm is located within a protected area protected as a natural zone of high ecological, faunal and floristic value. The farm plots that extend to the west border one of the Molitva mountain peaks, which is characterised by a high level of forestation and is a habitat for endangered species of fauna such as: grey fluff (*Myoxis glis*), fluffy hazelnut (*Muscardinus avellanarius*), Eagle kite (*Circaetus gallicus*), Forest owl (S*trix aluco*), Mountain woodpecker (*Dendrocopos leucotos*) etc.

In addition to the mentioned species of fauna, it is important to note that all plots of the Stefan Andrić farm are largely surrounded by forest habitats, groups of trees, meadows and pastures with their biodiversity. In the surroundings of the farm you can find: wild cherry (*Prunus avium*), wild apple (Malus sylvestris), Margrafie's jaundice (*Allysum markgrafi*), Janchen's jaundice (*Alyssum jancheni*), Violet (*Viola elegantula*), Adamović's divism (*Verbascum adamovicii*) etc.

The farm is mostly luvisol soil and is characterised by being acidic, with a reduced amount of humus and poorly supplied with phosphorus. All plots are on a slight slope, so there is moderate to weak soil erosion. Farmers take care according to their possibilities to enrich the soil with organic matter and limit mineral deficiencies.

3.10.1.2 Current system

Filip Andrić's farm deals with mixed agricultural production of vegetables, grains, fruits and animal husbandry. The farm cultivates a total of 10 hectares of its land, leases and cultivates 3 hectares, while about 2 hectares of their land is under forest. Family members are mostly employed on the farm, with occasional employment of seasonal workers in potato production, especially during harvest.

On the 13 hectares he cultivates, the main production is potatoes (seed and commercial), and in addition, cereals are grown in order to maintain the crop rotation.

On average, potatoes are produced annually on about 7 hectares of their own land, while cereals (wheat, oats, barley, buckwheat) are grown on the remaining 3 hectares of land.

Each year, seed and mercantile potatoes are produced in cooperation with Agromobil. Agromobil provides complete raw materials for production, as well as technical support in production. Seed potatoes are produced according to the assortment for different purposes and groups of producers, from hobby production in gardens to professional producers of different sizes and categories. Production takes place under controlled conditions; all fields are monitored from planting to harvesting. As the production itself takes place at higher altitudes, a smaller number of treatments with protective agents is sufficient. Great attention is paid to product safety, so that end consumers can consume a healthy and tasty product. A field book is kept for each parcel, in which all important parameters are entered during production. The aforementioned approach to production ensures complete product traceability, in accordance with all standards and food safety certificates required by the subcontractor company Agromobil.

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When it comes to grain production, one part of production is organic buckwheat production (about 0.5 ha), while wheat, barley, oats and rye are conventionally produced on the remaining area. The purpose of these cereals is, except for buckwheat, for their own needs and for the needs of livestock production. A smaller part of the grain is sold on the local market.

The farm has its own machinery and cultivates its land independently.

After the harvest, manure is poured onto the plots. The amount of manure applied is managed according to the requirements of the main crop. Then it is ploughed for manure before planting. When sowing, seeders are used, depending on the culture that is grown on the plot. None of the plots are irrigated. The farm occasionally has difficulties with reduced yields due to drought, which was also the case in 2022.

The owner of the farm regularly conducts soil analysis and the results obtained indicate problems with soil acidity and lack of phosphorus, there is a decrease in humus, and due to the configuration of the terrain there is also soil erosion. When we talk about soil erosion, we are not only talking about surface erosion, but there is also leaching of nutrients from the depth of the soil, leaching of basic cations Ca+2, Mg+2, which leads to acidification and soil degradation. This phenomenon of leaching of nutrients from the soil is conditioned by high amounts of precipitation and climatic conditions.

Until now, the farm has not undertaken any agroforestry measures, more precisely the planting of trees, but has been based on already existing trees on the edges of the plots that have grown spontaneously or been planted by previous generations. Some plots border the forest (e.g. plot 2429 in the Molitva locality is completely leaning against the forest on the eastern side).

Existing owned forests (about 2 ha) are used to provide firewood for their own needs, and a very small part is for sale on the local market.

Livestock production is extensive in nature and mainly serves for own production of meat, dairy products and production of manure used in vegetable production and grain production. Livestock includes dairy cows (the number varies from 2 to 5 head), sheep (7-10 heads), pigs (2-3 heads) and a certain number of small poultry.

Cows and sheep are outdoors during the growing season (May-November), while the rest of the year they are mostly in the stable.

Figure 121 : Filip Andrić Farm – Parcel with mix crop production potato, pasture and trees

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3.10.1.3 New co-designed system

The new co-design system is based on the set goals to reduce negative trends in the decline of soil quality (decreasing humus, increasing acidity and lack of phosphorus) and the occurrence of soil erosion, as well as to improve farm operations by diversifying economic activities.

The Co-design system foresees 3 groups of measures, one is related to the improvement of soil quality, the second is measures to reduce erosive processes of arable land, and the third group of measures is related to the diversification of economic activities of the farm.

Measures to improve soil quality include:

- Soil humification with calcification in accordance with needs, all with the aim of better absorption of nutrients and higher yields.

- Controlled use of mineral fertilisers. The application of nitrogen fertilisers should be in accordance with the carbon content in the soil, with the most favourable ratio of carbon and nitrogen in the soil, in order for the microbiological processes in the soil to take place smoothly. On the more developed soils of this area, due to the mountain climate, the decomposition of organic matter is slower and lower quality humus is formed, with a higher proportion of fulvic acid than humic acid. On soils with a shallower humus-accumulative horizon, the possibility of forming high-quality humus is also reduced, so on all types of soil it is necessary to add burnt manure, with a favourable ratio of carbon and nitrogen, and the introduction into the soil should be done immediately after spreading. If the plots are on a slope, immediately sow plants (grasses, cereals) in order to prevent erosion.

- Increasing the percentage of use of organic fertilisers (manure, compost, vermicompost, green manure...) and microbiological fertilisers, which would contribute to the activation of biological processes in the soil and the availability of nutrients.

Increased use of manure is the basis for increasing humus in the soil, because it is a material from which, under favourable conditions and undisturbed work of beneficial microorganisms, humus can be created.

Green fertilisation (sideration) through the production of fresh organic matter (above-ground and root mass of cultivated plants - siderate) and ploughing it into the soil improves its physical, chemical and biological properties, i.e. increases the fertility of the soil and the yield of cultivated crops. Since buckwheat is one of the suitable plants for green fertilisation, and it is grown on Rudna, it can be used to a significant extent for this type of fertilisation.

- Controlled use of fungicides and herbicides, because it negatively affects the development of microflora, especially mycorrhizal fungi. Pay special attention to the choice of preparations, so it is recommended to choose those that cause less damage to the eco system or to use bio preparations.

- In order to achieve a balanced balance of humus in the soil, it is recommended in the crop rotation to alternate crops that impoverish the soil with crops that enrich the soil in humus. Maintaining the level of humus in the soil is possible by increasing the proportion of perennial legumes and grasses or their mixtures in the crop rotation.

- From the point of view of the balance of humus in the soil, it is also important how long the field has been under crops. It is recommended to try to extend the time when the field is under the vegetation period, because organic matter in the soil accumulates and breaks down at the same time, in contrast to the period when there is no vegetation and only mineralisation processes of organic matter take place in the soil.

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Measures to reduce erosive processes of arable land defined in the co-design system are divided into two groups: anti-erosion agrotechnical measures and biological anti-erosion measures.

Anti-erosion agrotechnical measures that are recommended are:

- Contour cultivation that is adapted to the needs of the farm because the plots are located on slopes with slopes that are greater than 2%, and within it, cultivation with rotary ploughs is carried out according to isohypses. The contour cultivation of the soil prevents the runoff of water down the slope and enables the accumulation of water necessary for the development of plants. The negative side of this measure is the possible occurrence of landslides, but it can be eliminated by combining it with biological measures.
- Protective crop rotation differs from classic crop rotation in that, in addition to phyto-physiological criteria, a lot of attention is paid to protecting the soil from erosion. There are several types of these crop rotations, and it is recommended to use a crop rotation in which some agrotechnical measures are limited and a crop rotation that limits the areas under potatoes as fallow.
- Layered sowing consists of sowing different crops on the slope in the form of horizontal strips (plots) of different widths, where grasses must always be present in some layer. The width of the bed depends on the slope of the terrain and can be from 15 to 60 m. If the erosion process is pronounced on the slope, a grassy strip of about 1 m width is formed between the beds.
- Soil mulching is recommended complete mulching. In this way, it is achieved that the soil under the mulch absorbs water better, it is protected from the impact of raindrops, weeds are less successful, and evaporation is weaker.

Biological anti-erosion measures that are recommended are:

- Reclamation of existing meadows and pastures.
- Raising the row of trees on the plots.
- Raising forest belts around the perimeter of the plots.

Diversification of farm economic activities is defined as the third group of measures. It will be implemented through the improvement of the position of the farm in the value chain (with the aim of establishing a short value chain), the improvement of sales and promotion channels and the establishment of tourist services that would serve to diversify income and product placement.

It is estimated that the combination of the mentioned measures will certainly contribute to improving the sustainability and resilience of the farm itself.

3.10.2 Sustainability and resilience assessment

3.10.2.1 Selection of indicators for local assessment

No changes have been made to the weights of the sustainability and resilience assessment indicators.

3.10.2.2 Impact of co-designed changes on sustainability

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3.10.2.2.1 Major changes at global scales

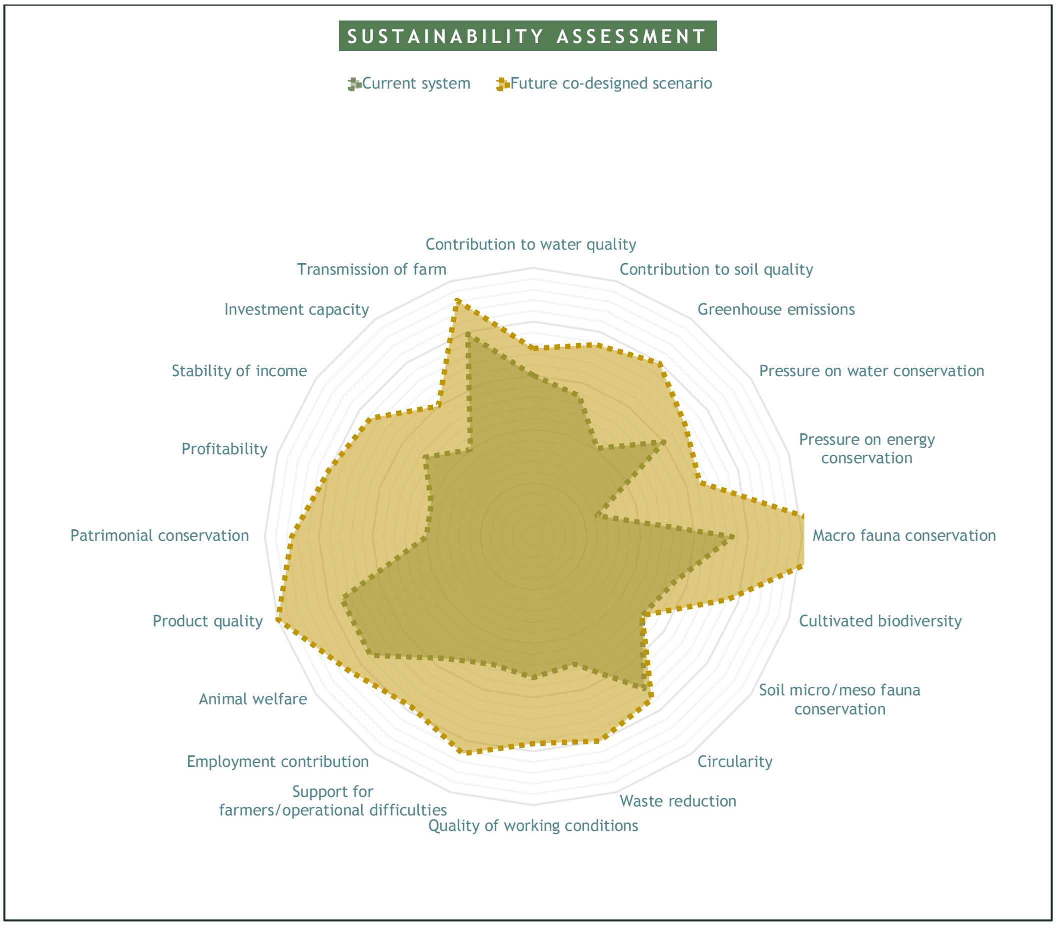

Figure 122 : Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario

The results of the multi-criteria analysis clearly show that the previous system had good sustainability parameters. If we compare the current way of doing business and the co-designed scenario, it is noticeable that the new approach contributes to improving the sustainability of Filip Andrić's farm. Certain indicators (i.e. circularity, soil micro-meso fauna conservation) remain the same as they were in the current system, but the general trend is that there is no negative trend in the social, economic and ecological impacts of the farm. Significant improvements are expected in economic parameters (i.e. income stability, profitability) and social indicators (i.e. patrimonial conservation, employment contribution, quality of working conditions). When taken into account in the environmental criteria, there are also several significant improvements, primarily:

- Contribution to soil quality;
- Greenhouse emissions;
- Pressure on energy conservation;
- Waste reduction.

In the rest of the report, some indicators will be further elaborated.

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3.10.2.2.2 Environmental impacts

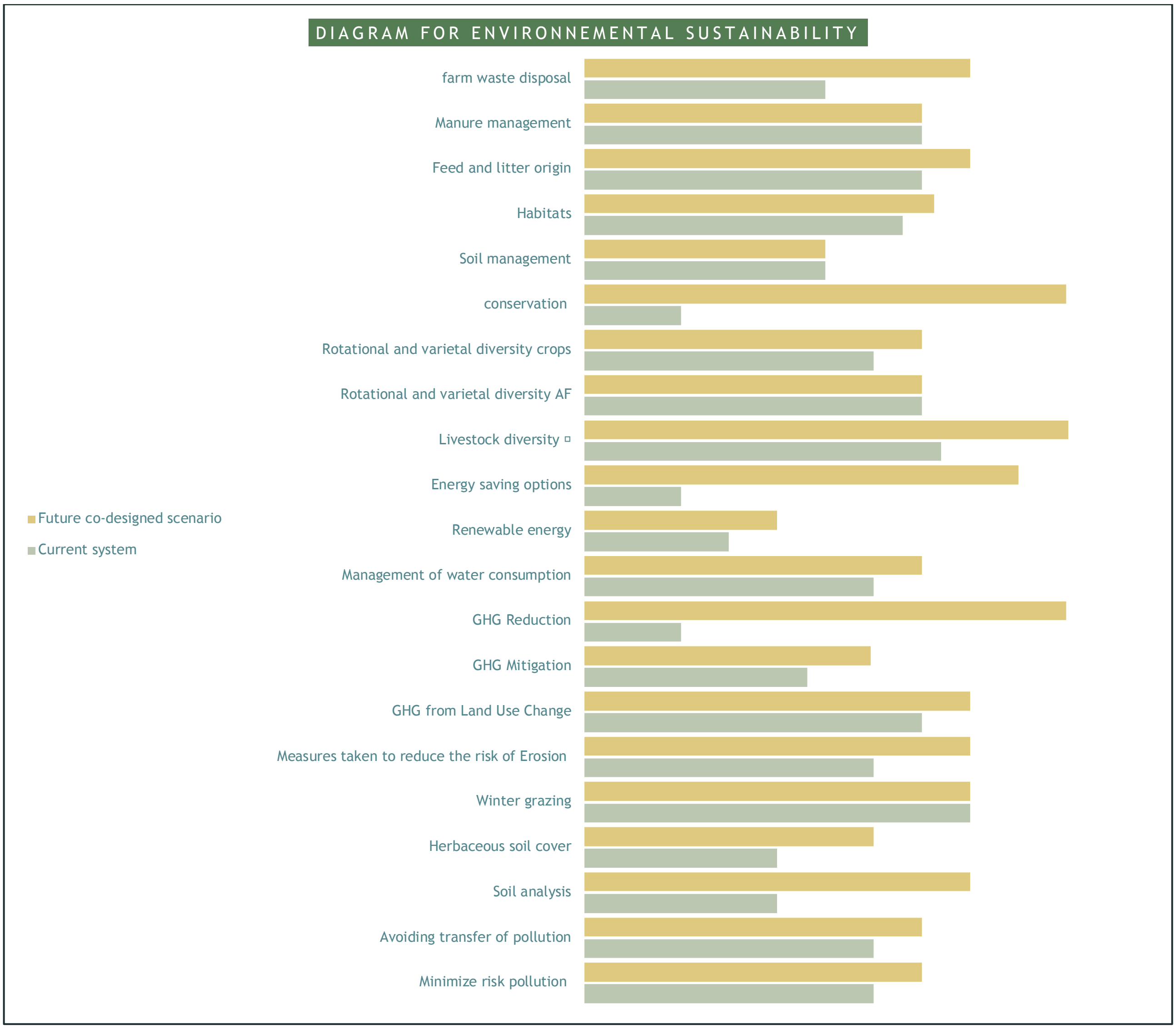

Figure 123 : Scores of the environmental sustainability indicators, showing the current system and the future co-designed system

The findings of this research regarding environmental sustainability are expected, given that the farm is located in a protected natural asset and mountainous area, which conditions that agricultural production is not of an intensive type, but relies to a significant extent on traditional agriculture that is in harmony with the natural environment and limiting factors. which area imposes.

Looking at the environmental assessment of the current system on the farm, indicates that a number of indicators have a significant level already, namely: management of soil, manure, water, risk of pollution, habitat management, crop rotation and diversity, and agroforestry.

In addition to the fairly good condition of the farm in relation to environmental sustainability, there are opportunities for improvement. First of all, the mentioned improvements are possible in reducing the emission of greenhouse gases (GHG), saving energy, using renewable sources on the farm, managing soil quality based on soil analysis, reducing the risk of erosion. The owner of the farm agrees to prepare the

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Energy and Climate Plan of the farm, which will contain a detailed analysis and a plan of next steps in the development of the farm.

Erosion and soil quality are also the main goals in the transformation of the farm, so even in that segment there is agreement that it is necessary to work on the belt of combined agrotechnical and biological measures to reduce the risk of erosion and further degradation of soil quality, specifically humus.

3.10.2.2.3 Socials impacts

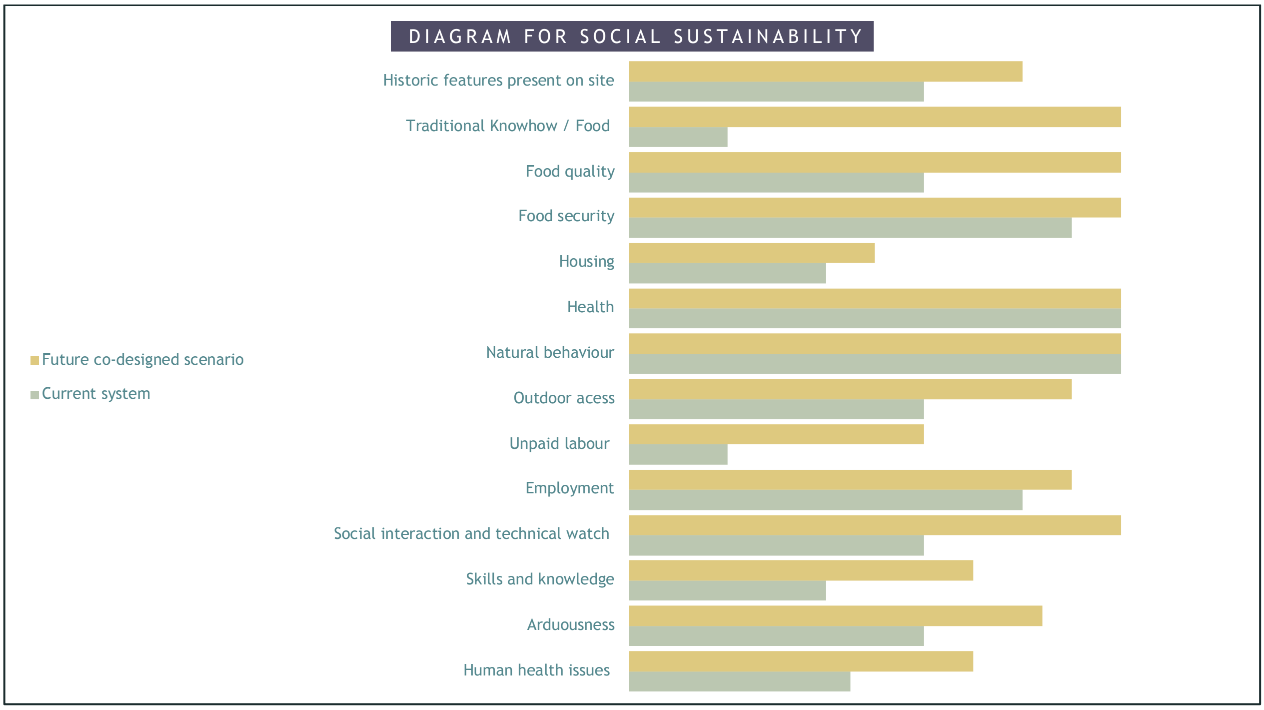

Figure 124 : Scores of the social sustainability indicators, showing the current system and the future co-designed system

Social sustainability is quite good on the farm considering that the farm recently underwent a transition of ownership and two sons took over the family business on the farm. Also, the farm provides 90% of the household's income.

Several indicators should be singled out for opportunities for improvement, primarily the potential for improvement of traditional knowledge and food, quality of food, skills and knowledge, and social interactions.

Traditional knowledge and food exist with the older generation, who left the management of the farm to the younger generation. Traditional knowledge is primarily related to the preparation of traditional dairy products (cheese, cream), as well as the possibility of using forest fruits and medicinal herbs as additional income on the farm. In addition to the knowledge itself, the limiting factor is the limited human resources for diversified farm activities.

In the coming period, it is necessary to further improve skills and knowledge on the farm, primarily related to climate change, organic production and modern market requirements for farm operations.

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Social interaction is partly limited by the distance of the village from the municipal center, but the development of rural tourism opens up new opportunities for the development of social relations and social development of the area, and thus the very interaction of fame with the environment.

3.10.2.2.4 Economic impacts

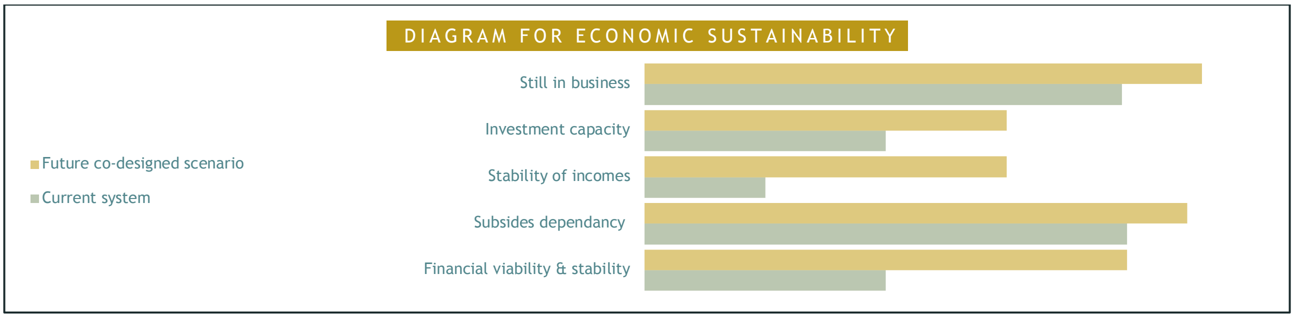

Figure 125 : Scores of the economic sustainability indicators, showing the current system and the future co-designed system

When looking at the assessment of economic sustainability, it is noticeable that at the present moment 3 indicators are somewhat lower and that there is significant potential for their improvement. The mentioned indicators are: Financial viability and stability, Stability of income and Investment capacities.

The new co-designed system is also aimed at joint activities of local producers' associations, as well as companies that organise production cooperatively to improve product placement and diversify economic activities.

Improvement of product placement is directed in several directions: growth of direct sales on the local market and placement through growing demand due to the development of tourism; possibilities of joint placement through newly opened trade chains (eg Lidl); better marketing promotion, based on the quality of the product and its origin from the protected area.

Finding and developing new markets and marketing channels for promotion requires significantly more time, establishing new contacts and developing communication tools to present the advantages of the farm's products and other farms in the area. During the meetings held so far, the idea is that better market positioning can work together for all chrome producers in the area, because the production conditions are identical, and they all cooperate cooperatively with 3 companies that provide them with inputs for production, and then the placement of part of the production. The upcoming co-design workshop will additionally consider the possibilities of joint placement and improvement of product marketing. One of the marketing possibilities is to use the good reputation of the Golija protected area and potentially develop a promotional package (label, slogan...).

One of the possibilities in the coming period is the potential of using funds from the IPARD III fund or the national fund for rural development to establish the processing of a certain amount of chromium into products that allow flexibility in sales.

Rural tourism, which has been in strong expansion for the last 15 years or so in Golija, and in Rudno, has led to the fact that the village itself already has around 200 beds and annually this area achieves around 45,000 overnight stays, which certainly brings the possibility for local farmers to market significant amounts of their products through the local tourist offer.

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New tourist facilities are also being developed in the immediate vicinity (ski center at Golija, more precisely at the location of Odvraćenica, reconstruction of hotels in Matarushka and Bogutovachka banja.

Definitely, the development of tourism and the increase in the number of tourists, and thus the number of customers on the "doorstep", brings a new chance for marketing the products of Filip Andrić's farm and other Rudno farms.

3.10.2.3 Impact of co-designed changes on resilience

3.10.2.3.1 Major changes at global scales and comparison with sustainability assessment

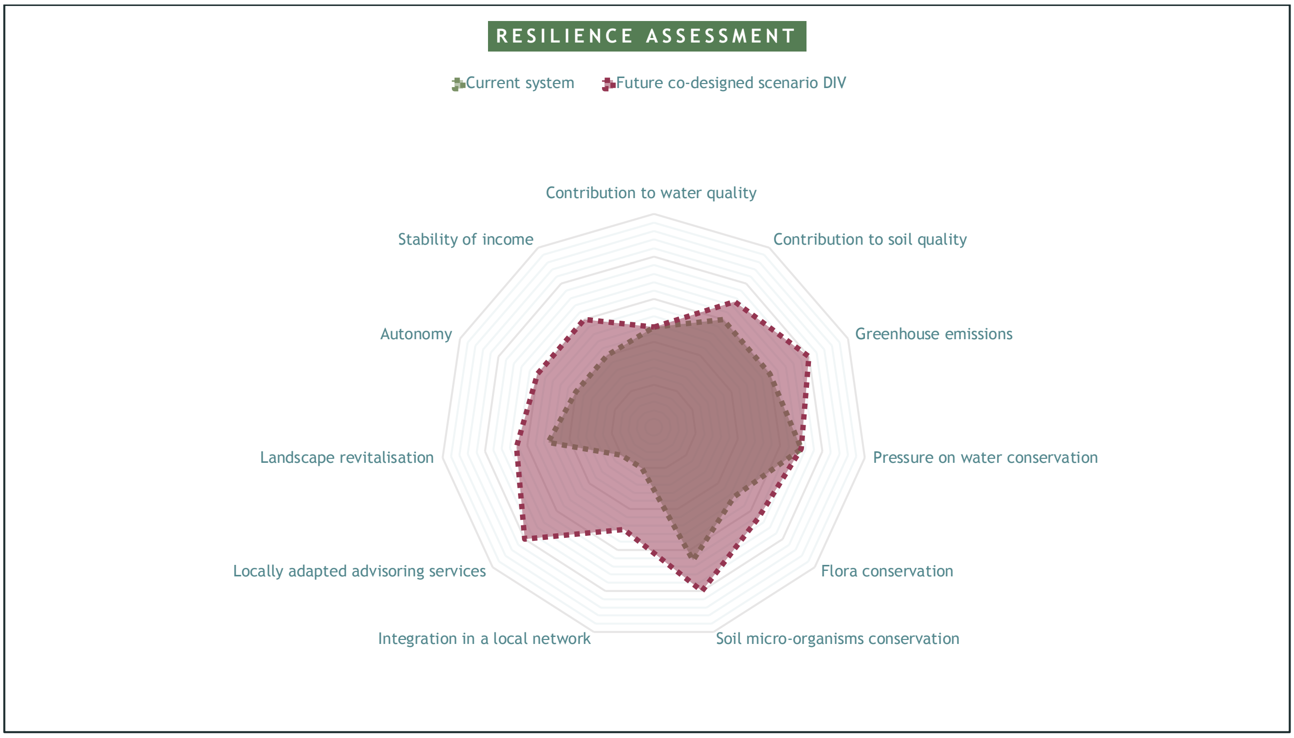

Figure 126 : Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario

Assessment the multicriteria analysis globally shows that 9 out of 11 indicators improve with the implementation of the newly co-designed scenario. The only two indicators that remain unchanged are Contribution to water quality and Pressure on water conservation. The most significant improvements are achieved in the area of the social dimension, according to all three criteria: Integration in a local network; Locally adapted advisory services and landscape revitalisation.

A slightly lower level of improvement than in the social dimension is achieved in the environment dimension. The most significant changes relate to GHG emissions, Flora conservation and Soil micro-organisms conservation.

The obtained results are partly expected, because the indicators of the social dimension are currently at a slightly lower level compared to the indicators of the other two dimensions, and also the change of these indicators is most directly related to the changes that the designed system brings.

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3.10.2.3.2 Environmental impacts

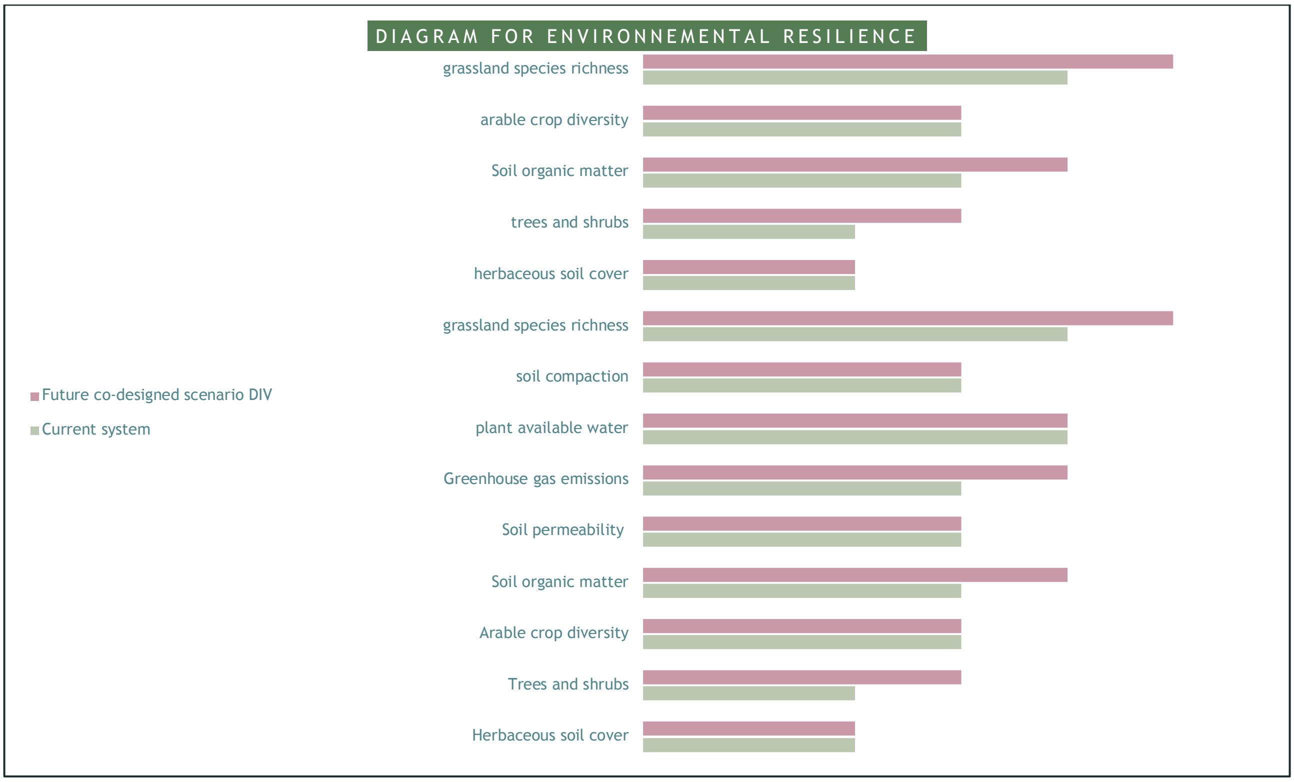

Figure 127 : Scores of the environmental resilience indicators, showing the current system and the future co-designed system

Regarding the environmental impacts on the pilot resilience, the indicators show a moderate improvement over the current and co-designed system, as 4 out of 9 indicators increase. These are the following indicators:

1. Grassland species richness will increase to over 10 per hectare, by planting trees and shrubs, as well as grassing part of the cultivated areas.

2. Soil organic matter is currently on average at the farm level of 2.4%, and the co-designed system by reducing tillage, extending crop rotation, using organic fertilisers, reducing the use of mineral fertilisers and chemical agents will help the percentage of organic matter in the soil to 0-30 cm rise above 2.5%.

3. Trees and shrubs indicator will be improved, because due to the reduction of erosive processes, trees and bushes will be planted, which will contribute to the improvement of this indicator.

4. Greenhouse gas emission indicator will be reduced because CO2 equivalent emission per ton of product will be reduced. The reduction will be achieved by combining measures to reduce the emission of three key GHGs:

- Carbon dioxide emissions will be reduced by planting additional crops outside the primary growing season (known as cover crops). Using cultivation methods that cause less soil disturbance will also reduce carbon dioxide emissions.

- The formation of nitrogen oxides will be limited by reducing the amount of applied fertiliser and avoiding application when the conditions are more favourable for the formation of nitrogen oxides.

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- Methane emissions from manure will be reduced by adopting manure management that allows collection and use in the most optimal way.

3.10.2.3.3 Socials impacts

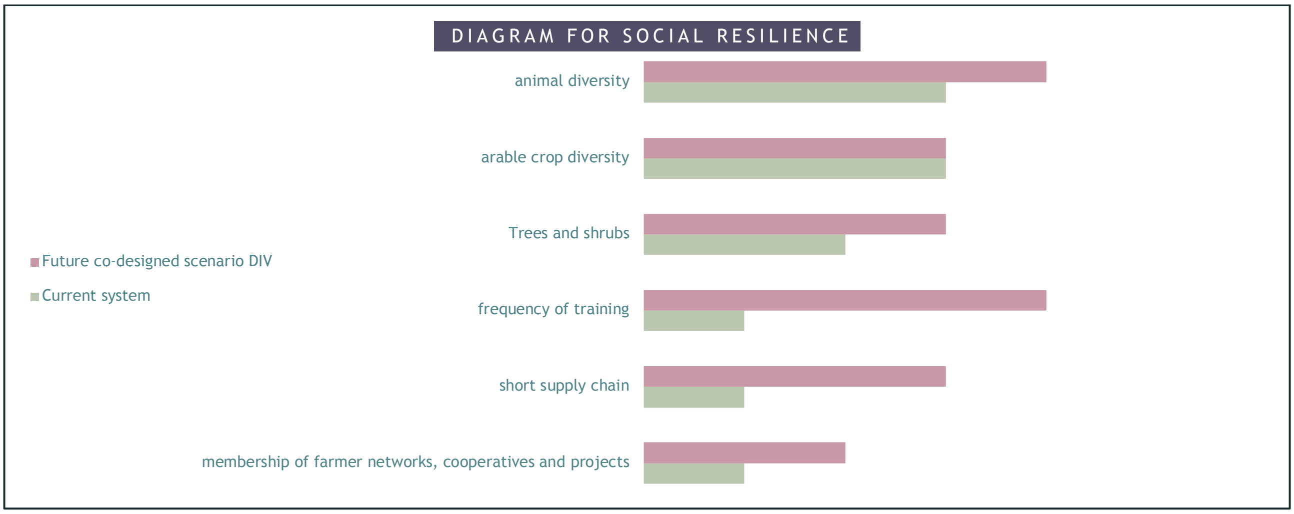

Figure 128 : Scores of the social resilience indicators, showing the current system and the future co-designed system

The assessment showed that in terms of social resilience, 2 indicators were singled out in order of importance for improvement in relation to the current situation. These are the need for locally adapted advisory services and the need for integration in a local network through the development of a short supply chain and membership of farmer networks, cooperatives and projects. In addition, improvements are possible in the Landscape revitalisation category by increasing the number of trees and bushes and animal diversity.

The demands of modern production mean that farmers face significant challenges (climate changes, labour force fluctuations, disruption in the input market), as well as the co-designed scenario for the transformation of the farm means the need to improve knowledge on the farm and use the services of advisors. Training will be provided in the required areas for the farmer as well as for other members of the local association.

The farmer is already involved in the local association and cooperative network coordinated by the Agromobil company, but this is insufficient to establish a short supply chain. The farmer and other farms from the local association will be provided with professional support in defining the direction of short supply chain development and new sales channels.

3.10.2.3.4 Economic impacts

An assessment of the economic indicators for the existing system and the co-designed system was also prepared for Filip Andrić's farm. The indicators are related to income stability and farm autonomy from external inputs. The research showed that both indicators will be improved with the co-design system.
Income stability will be improved by diversifying sales channels, better promotion channels, as well as by diversifying the farm's economic activities.
When we talk about the autonomy of the farm in relation to external inputs, despite the fact that the co-design system will reduce the dependence on external inputs (mineral fertilisers, protection agents and some energy sources), the farm will still have limited autonomy caused by the need to procure planting material, fuel for machines and the need for seasonal random power during the harvest period.

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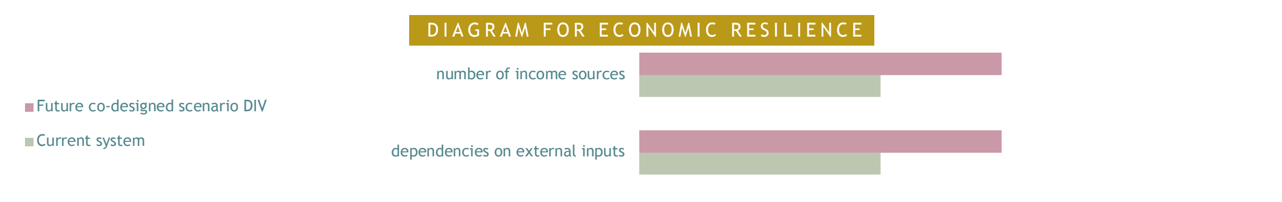

Figure 129 : Scores of the social resilience indicators, showing the current system and the future co-designed system

3.10.2.4 Perspectives on this assessment

The new co-design system of Filip Andrić's farm is based on the set goals to reduce negative trends in the decline of soil quality (decreasing humus, increasing acidity and lack of phosphorus) and the occurrence of soil erosion, as well as to improve the farm's operations by diversifying economic activities.

The co-design system envisages three groups of measures.

<u>Measures to improve soil quality</u> include:

- Controlled use of mineral fertilisers, especially reduction of excessive use of nitrogen fertilisers, which leads to degradation of humus.
- Increasing the percentage of organic fertiliser use (manure, compost, vermicompost humus, green fertilisation...).
- Controlled use of fungicides and herbicides, because it negatively affects the development of microflora, especially mycorrhizal fungi.
- In order to achieve a balanced balance of humus in the soil, it is recommended in the crop rotation to alternate crops that impoverish the soil with crops that enrich the soil in humus.
- From the point of view of the balance of humus in the soil, it is also important how long the field has been under crops. It is recommended to try to extend the time when the field is under the vegetation period, because organic matter in the soil accumulates and breaks down at the same time, unlike the period when there is no vegetation and only mineralisation processes of organic matter take place in the soil.

<u>Measures to reduce erosive processes of arable land</u> defined in the co-design system are divided into two groups: anti-erosion agrotechnical measures and biological anti-erosion measures.

<u>Anti-erosion agrotechnical measures</u> that are recommended are:

- Contour cultivation that is adapted to the needs of the farm because the plots are located on slopes with slopes that are greater than 2%, and within it, cultivation with rotary ploughs is carried out according to isohypses. The contour cultivation of the soil prevents the runoff of water down the slope and enables the accumulation of water necessary for the development of plants. The negative side of this measure is the possible occurrence of landslides, but it can be eliminated by combining it with biological measures.
- Protective crop rotation differs from classic crop rotation in that, in addition to phyto-physiological criteria, a lot of attention is paid to protecting the soil from erosion. There are several types of these crop rotations, and it is recommended to use a crop rotation in which some agrotechnical measures are limited and a crop rotation that limits the areas under potatoes as fallow.
- Layered sowing consists of sowing different crops on the slope in the form of horizontal strips (plots) of different widths, where grasses must always be present in some layer. The width of the bed depends on

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the slope of the terrain and can be from 15 to 60 m. If the erosion process is pronounced on the slope, a grassy strip of about 1 m width is formed between the beds.

- Soil mulching is recommended complete mulching. In this way, it is achieved that the soil under the mulch absorbs water better, it is protected from the impact of raindrops, weeds are less successful and evaporation is weaker.

Biological anti-erosion measures that are recommended are:

- Reclamation of existing meadows and pastures.
- Raising the row of trees on the plots.
- Raising forest belts around the perimeter of the plots.

The third group of measures is related to a set of activities that should ensure the diversification of the farm's economic activities, through the improvement of the farm's position in the value chain (with the aim of establishing a short value chain), the improvement of sales and promotion channels, and the establishment of tourist services that would serve the purpose of diversification income and product placement.

It is estimated that the combination of the mentioned measures will certainly contribute to the improvement of the work of the farm itself.

The co-designed combined system provides better global sustainability assessment results compared to the existing system, in terms of environmental and economic indicators.

The combined co-designed system follows a long-standing approach of mixed agricultural production and diversification of both activities and income:

- preservation and gradual mild growth of livestock production, adapted to the available labour force;
- plant production with the cultivation of plants and fruits for human consumption (potatoes, cereals) as well as additional crops for livestock (cereals);
- processing part of the products from the farm into final products, e.g. dairy products, flour products, which have the potential for direct sales to tourists and visitors to the area;
- development of products and services related to tourism, including accommodation and food services.

As the farm is located in the Nature Park, it should be noted that the importance of the selected co-design system improves the preservation of macrofauna and cultivated biodiversity.

The scenario plans to increase the production of manure with a slight increase in livestock production, which farms need to improve the quality of the soil by increasing the percentage of humus, and on the other hand, it would make it possible to increase the production capacity of traditional dairy products that would be marketed through the tourist offer.

The scenario also envisages an optional consideration of the possibility of opening a small potato processing plant, which would serve all producers, while giving flexibility to farmers to solve periodic problems with placement and low price of the product. In this way, it would contribute to rounding off the production cycle and obtain a competitive product for the market.

In addition to the improvements that are foreseen in the production and processing phase, planned activities to improve the role of farms in the value chain (establishment of the short value chain, direct sales,

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development of new products on the farm), it is estimated that in this way the stability of income on the farm will be improved.

When it comes to the labour force, it is estimated that there will be no need for additional workers, more family members will be able to perform work on the farm as before. Only in the event that capacities for accommodation services in tourism are developed, there would be a need either to hire 1-2 workers or to contract other companies to perform cleaning, laundry and other similar services.

As for the resilience assessment, the main improvements of the combined system scenario compared to the previous system relate to all three segments, social, environmental and economic.

In the social segment, the scenario increases the number of trees and bushes, improves the diversity of livestock and agricultural crops, and all of this together contributes to the revitalisation of the landscape.

In addition, in the social segment, the new system contributes to the improvement of all 3 indicators related to the Support to farmers' category. This is primarily about indicators of integration into the local network and short supply chain, which is achieved by the development of new relationships between farmers and the establishment and development of local networks and the development of projects that contribute both to the integration of farmers and to the improvement of production and processing.

Improving income and autonomy directly contributes to the improvement of economic parameters.

Improving the capacity of farmers and other stakeholders is key to the planned improvements. Without adequate capacities, it is not possible to implement transformation on the farm and establish new and improve existing relationships in the value chain and on the market. In Serbia, there is a training program for the application of protective agents and a list of permitted agents for plant protection, which is harmonised with the EU. There are also support and education programs implemented by the public professional advisory service, as well as private advisory services.

3.10.3 Tools and methods: feedbacks

The assessment of possible farm development systems from the aspect of sustainability and resilience is greatly facilitated by the development of this method and accompanying tools. It is of particular importance that several system variants can be considered and that in different time periods.

In the case of Serbia, the approach itself proved to be useful, namely we chose one farm that is a typical farm for the entire area of Rudno and a good part of Naura Park "Golija", so by evaluating the development system on one farm, we helped other farms to better understand their position and possible directions of development.

Some indicators were difficult to understand or far too specific, as they required a great level of detailed knowledge, and also, it's not so easy to work with farmers and to validate all data.

The tool has the potential to be simplified for a user group outside the scientific community (practitioners, consultants).

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3.10.4 Take-away messages

An in-depth analysis based on the assessment of sustainability and resilience made it possible to see the consequences and results of applying the principles of agroforestry on one farm. Certain key areas of change were considered, such as effects on soil quality, improvement of income, the need to build relationships between the farm and actors in the environment, and especially the impact of the farm on the environment.

Our analysis shows a general improvement in the sustainability and resilience of the combined co-designed system compared to the current system applied on a typical farm for the NP "Golija" area, as well as for other mountainous areas in Serbia.

The general conclusion is that the chosen design will support the implementation of the pilot goals and support the sustainability and resilience of the farm, and thus the sustainable development of Nature Park "Golija", as a protected area.

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3.11 Curralões – Portuguese pilot (MVARC)

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Reviewer	Ulrich Schmutz

3.11.1 Pilot site description

3.11.2 Pilot site environment

The MVArc farm, Curralões, covers 240 hectares near Mértola in Baixo Alentejo, in south-east Portugal. It is in a landscape dominated by game management and extensive livestock/arable production on marginal land. The climate is characterised by an average annual rainfall of 548mm (although in the last 15 years, the average has dropped to 273mm) falling in the winter months and hot, dry summers. As elsewhere, climate change impacts are a concern with drought a frequent issue in recent years. The soils are lithosols/leptosols (subgroup Eutric), which are shallow soils over hard rock and comprise of very gravelly material, with a pH between 5.6 and 6.5. With a poorly developed structure and weakly expressed horizons, they are characteristic of undulating lands and steep slopes and are also found in areas where the soil is highly eroded. In 1994, over 130,000 *Pinus pinea* trees were planted on 160 hectares of the farm under an afforestation measure in the CAP Pillar 2, with the aims of increasing carbon storage, to fight greenhouse gas effects, contribute to "more compatible management of the natural environment", and improve forestry resources. Planted in lines 7m apart, the alleys between lines were, until recently, used by a neighbouring farmer, for alternating woody vegetation for game protection with extensive arable (cereals) cropping to be directly grazed by game. The non-agroforestry area is occasionally grazed by sheep. The pines do not produce commercially viable yields of pine nuts in this semi-arid climate and have very slow growth (4 meters high, 15cm diameter after 25 years). Hunting (rabbits, partridges, hares, wild boar, deer) is very important in this region, with the local town, Mértola, being known as the capital of hunting and hosting a popular annual hunting festival in October. Wildlife in this area is very diverse and the farm is near the boundary of the Parque Natural do Vale do Guadiana, valued for its birds, fish, vegetation and mammals, being home to a growing population of Iberian lynx (spotted twice in the farm in 2022).

Figure 130 : Aerial view of the Pinus pinea orchards

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3.11.2.1 Current system

Currently, the farm does not produce anything for sale. The afforestation management plan that was in place for 20 years restricted agricultural production beneath the trees, in accordance with the measure. In accordance with the management plan, initial tree densities of 816 trees/hectares were thinned in 2009 to 653 trees/ha, with pruning carried out in 2016/17. Around 30 hectares were thinned again in 2016/17 to 326 trees/ha.

The afforestation agreement finished in 2015; since then, the land area with pines was reclassified as an orchard (for pine nuts) and therefore eligible for direct payments under CAP Pillar 1. Like most of the farms in this area (and across Europe), the farm is reliant on CAP payments. As part of maintaining eligibility, the tree understorey (the alleys between tree rows) must be kept clear of shrubs (maximum 20% cover above 0.5m in height). Like other farmers in this area, this has been carried out using an offset disc harrow every four to five years (Figure 131). This leaves the alleys between tree rows clear of vegetation, with natural regeneration of grasses, forbs and within a year or two, re-emergence of shrubs. As well as being costly for farmers, harrowing destroys soil structure, releases soil carbon and leads to soil erosion. In addition to this harrowing every 4-5 years, 10m-wide firebreaks around each parcel and along track and roadsides is cleared annually to reduce risks of wildfires.

Figure 131 : Left: disc harrowing to clear the tree understorey of shrubs. Right: before clearance the tree understorey is dominated by the shrub Cistus ladanifer.

3.11.2.2 New co-design system

There have been two scenarios produced through the co-design process. The first was initiated and developed at the early stages of the co-design process and then implemented by the pilot farmer during the project period with contributions by the pilot participants. The second scenario has been developed during the co-design workshops as a joint output of the co-design process with pilot participants.

3.11.2.2.1 Co-design scenario #1 Essential oil from understorey shrubs

Triggered by concerns about the level of soil degradation being caused by regular harrowing of the tree understorey to remove shrubs, a new approach to shrub management was proposed by the farmer. The shrub community is dominated by *Cistus ladanifer* – or rock rose (Figure 132). This abundant species is highly resistant to drought and heatwaves. It is also an aromatic shrub, producing a valuable, although low yielding

(~0.01%) essential oil as well as a sticky residue called labdanum. Local artisanal essential oil producers wild harvest by hand to produce small amounts of the oil. The farmer's idea was to initiate a shrub management plan in the alleys between the trees to produce essential oil – but to scale the process through mechanisation. With the support of the pilot team, a search for an appropriate machine that would cut and collect the shrub was successful. This mulcher cuts the plant at 30-50cm above ground, thus encouraging bushy re-growth with a higher proportion of oil-containing leaves, while maintaining eligibility for CAP payments by keeping the shrubs below 50cm in height, at least for the first year.

The essential oil is extracted from shrub biomass by steam distillation, and a 2 x 1000 litre still was installed in 2021. Water is heated using woodfuel harvested from pine tree prunings and thinnings and the potential for using the post-distillation shrub biomass for feeding the boiler was suggested by the pilot participants. Other uses of the biomass including as a soil improver and weed control mulch were also proposed. Water is recycled through the system, with the only water leaving the system being the 'floral water' or hydrolate from the condensation process while recovering the essential oil. This hydrolate also has a value in its own right as a product from the process. Therefore, in comparison with the current system, this co-design scenario is proposed to increase farm productivity (essential oil and hydrolate) and income (sale of EO and hydrolate, maintenance of direct payments without cost of disc harrowing), and improve soil health (reduce cultivation, addition of organic matter via post-distilled biomass).

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Figure 132 : Top left: Coppicing the shrub. Top right: The shrub harvester/mulcher in action. Bottom left: Re-growth from coppiced shrub. Bottom right: packing the shrub biomass into the still.

3.11.2.2.2 Co-design scenario #2 Water conservation using keylines and introduction of resilient tree crops

Water management was identified by pilot participants as crucial for improving the resilience of the farm (and all farms in this area) to the impacts of climate change. Of the various ideas proposed for water storage and conservation, a keyline approach was identified by the group as potentially the most effective. Keyline was developed in the 1950s by an Australian mining engineer, Percival Alfred Yeomans, who was investigating the rehabilitation of degraded agricultural land, dry and seasonally subject to forest fires. A special plough, the Yeoman's plough, creates small tunnels below ground to aerate the soil and encourage water distribution across the land area. The tunnels are along keylines, lines that are 1-2 degrees off the contours. Infiltration rates are increased and surface runoff and evaporation are reduced, enabling a significant improvement in soil fertility and structure. By improving the distribution of moisture in the soil, biological activity is promoted by significantly increasing the total organic matter content. Farmers in the area have been using this approach in pastures (Figure 133), and there was interest by those in the pilot group in seeing if this approach could also be used successfully in tree-based systems, with potential benefits to tree growth and ultimately, pine nut productivity.

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Complementary to the water management idea, the group also identified a need to diversify the tree component of the system, by introducing other fruiting tree species. There are instances of pest damage in the pine orchards, from the processionary moth and diseases caused by nematodes. While there has been a strong promotion of the establishment of irrigated tree crop plantations (olives, almonds, vines, avocado) in southern Portugal, the group recognised the short-sightedness of this approach, as evidenced by recent summers where severe droughts have reduced the capacity for irrigation due to depleted reservoirs. A recent visit to the **Alvelal project** in Andalusia, southern Spain (Figure 133), had inspired the group; climatic conditions in that part of Spain are even more extreme than in Mértola, but rain-fed high-value almonds were being successfully produced, using adapted varieties and a regenerative approach. Building on this idea, the proposal is to introduce a number of productive tree species, adapted to this climate, such as almonds, carobs, olives and pistachios, into the pine tree rows, to reduce pest and diseases in the pines while diversifying production, and potentially, with benefits for wild biodiversity. Compared with the current system, this co-design scenario is proposed to increase farm productivity (tree crops) and income, spread production risk (by diversifying crop production) while improving soil health and water conservation (through keyline), and potentially increasing biodiversity (tree diversity).

Figure 133 : Left: keyline implementation on a neighbouring livestock farm. Right: rain-fed almond production at Alvelal, Andalusia.

3.11.3 Sustainability and resilience assessment

3.11.3.1 Selection of indicators for local assessment

3.11.3.1.1 Relevant/non relevant indicators regarding Pilot site specificity

Through discussions of the indicators within the pilot group, irrelevant indicators were identified in order to be excluded from the assessment. These were indicators related to livestock and arable crops (including water consumption for irrigation) as the pilot farm does not include either of these. However, it was decided to retain 'Arable crop diversity' and use this as a proxy to represent the tree/shrub crops as this was missing from the assessments, despite it being an important component of agroforestry systems. Indicators relating to grassland were retained; while there are no livestock on the farm, there is natural grassland (80ha) and this has been occasionally grazed by sheep by neighbouring farmers.

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3.11.3.1.2 Weighting indicators

In terms of allocating weights to indicators, the default was to weight indicators within a 'Leaf' equally apart from following cases:

Resilience assessment
Environmental. Within the Flora Conservation leaf of the Biodiversity Conservation category, we assigned greater weighting to the trees and shrubs (50%) compared with grassland species richness (25%) and herbaceous soil cover (25%) as trees and shrubs are the dominant vegetation on the farm.

Sustainability assessment
Environmental. Within the GHG emissions leaf, we gave a lower weighting to the indicator GHG from land use change (20%) compared with Mitigation (40%) and GHG reduction (40%). The farm changed from extensive livestock to forestry (and now classified as an orchard) in mid-1990s and the vision going forward is to retain the trees and avoid LUC, so this indicator was given a lower weighting compared to the other two indicators in this section (GHG mitigation and reduction).
Social. Within the Employment contribution leaf, the indicator Unpaid labour was given lower weighting (40%) compared with Employment (60%) as providing paid positions was viewed as more important to focus on.

3.11.3.2 Impact of co design changes on sustainability

3.11.3.2.1 Major changes at global scales

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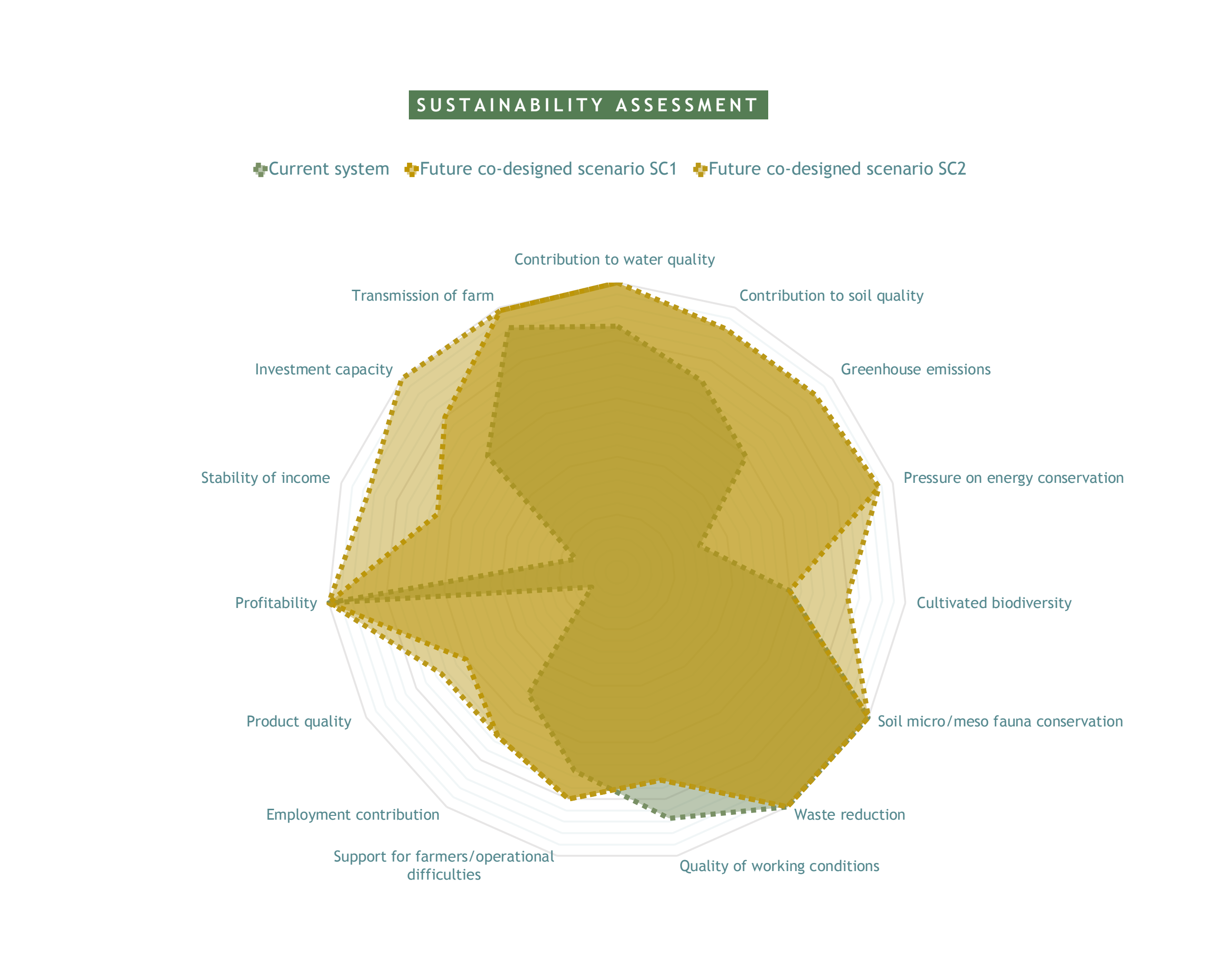

Figure 134 : Radar diagram of the results of the sustainability assessment, showing the current system, scenario 1 (essential oil from understorey shrubs) and scenario 2 (keyline and resilient tree crops)

The radar diagram in Figure 134 highlights the global changes to sustainability predicted by the co-design scenarios; in most categories, sustainability improved or stayed the same, with only the category 'Quality of working conditions' remaining higher in the current system. There are a number of environmental indicators positively impacted by the co-design scenarios, particularly water and soil quality, GHG emissions and energy conservation. Impacts were more moderate in the social dimension, apart from for product quality which increased notably from a very low level in the current system. In the economics dimension, although the profitability indicator didn't change, stability of income showed a considerable increase. More detailed analysis of these changes will be presented in the following sections.

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3.11.3.2.2 Environmental impacts

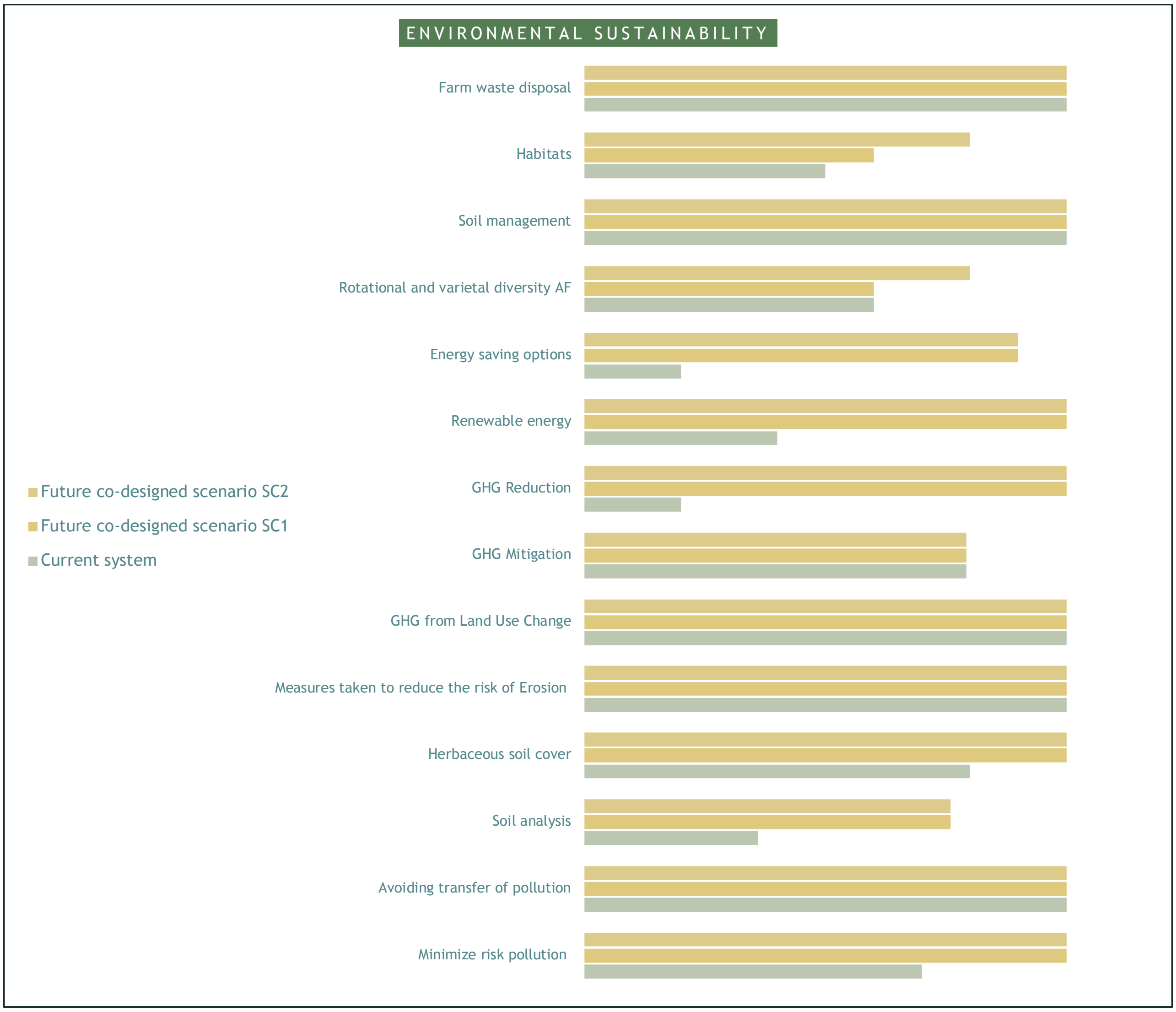

Figure 135 : Scores of the environmental sustainability indicators, showing the current system and future co-designed systems SC1 and SC2

The main driver behind the increase in score for the **habitat** indicator is the introduction of productive species. Starting from the current system where there is no commercial production, scenario 1 would initiate cultivation of the existing understorey shrub to produce essential oil and hydrolate, while in scenario 2, new tree species would be planted to produce tree crops including almonds, pistachios, olives and carobs. This same increase in crop diversity also accounts for the increase in the indicator **rotational and variety diversity of agroforestry**.

The farm is aiming to increase its self-sufficiency in energy, and this is reflected in the higher scores for the **Renewable energy** indicator. While in the current system, wood is used for heating the farmhouse, this comes from external sources. Moving forward, the plan is to use wood from the pine tree thinnings and prunings, and biomass from the post-distilled *Cistus* for heating. Additionally, PV panels have recently been installed to produce electricity, with export to the grid on most days (there are around 330 days of sun a year).

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With the new scenarios, a **reduction in GHG emissions** is expected; this would be primarily due to avoiding the cultivation of the understorey, thus retaining carbon in the soil. Subsequently, overall soil quality is expected to improve under the new scenarios, by maintaining the shrub cover through coppicing instead of disc harrowing to remove the shrub and expose the soil, **herbaceous soil cover** will increase, thus also leading to higher **soil organic matter** levels.

3.11.3.2.3 Social impacts

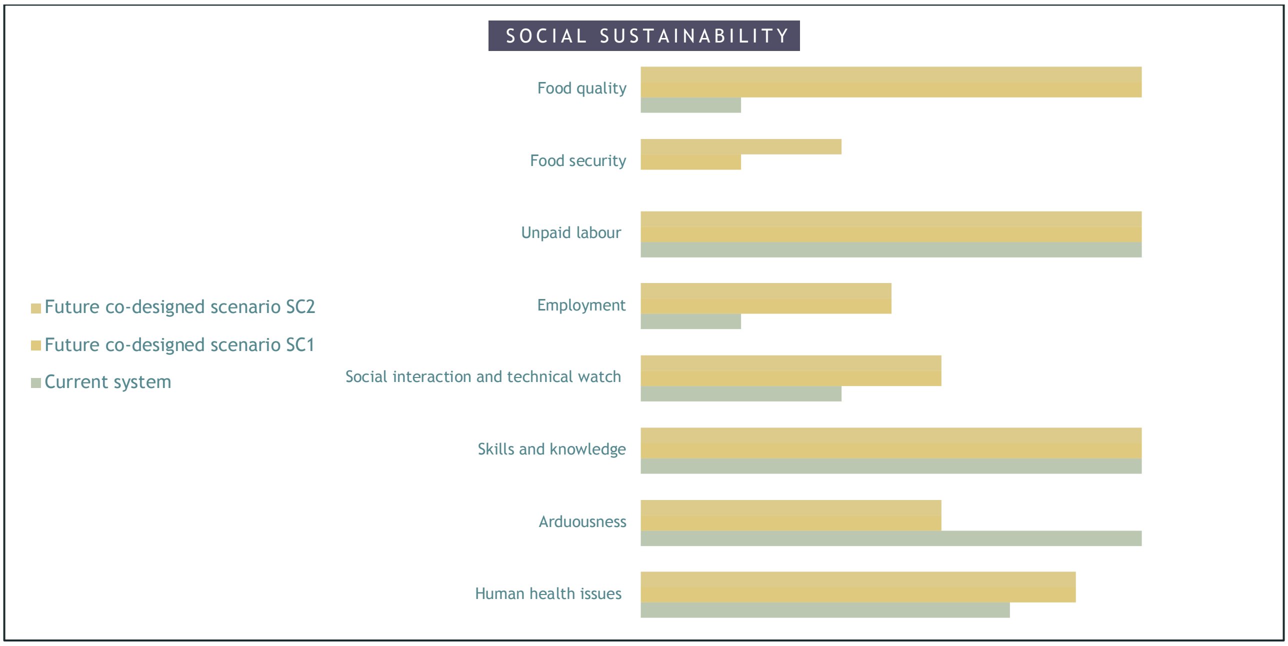

Figure 136 : Scores of the social sustainability indicators, showing the current system and future co-designed systems SC1 and SC2

Regarding the product quality indicators, the driver behind higher scores for **food quality** for both new scenarios is due to the farm undergoing Organic certification. This is important for ensuring the highest quality and premium prices for both the essential oil/hydrolate and future tree crops. For **food security**, from a starting point of no commercial production in the current system, the introduction new products in the new scenarios leads to slightly higher scores, although as it is foreseen that most of the products will be marketed internationally rather than the limited regional marketplace.

Employment levels are predicted to increase under the new scenarios; currently the farm employs no staff while it is estimated at least 3 new positions will be generated. However, there is a trade-off with the **arduousness** indicator with the new scenarios relying on considerable manual work, managing the trees and shrubs, carrying out distillations and maintaining machinery.

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3.11.3.2.4 Economic impacts

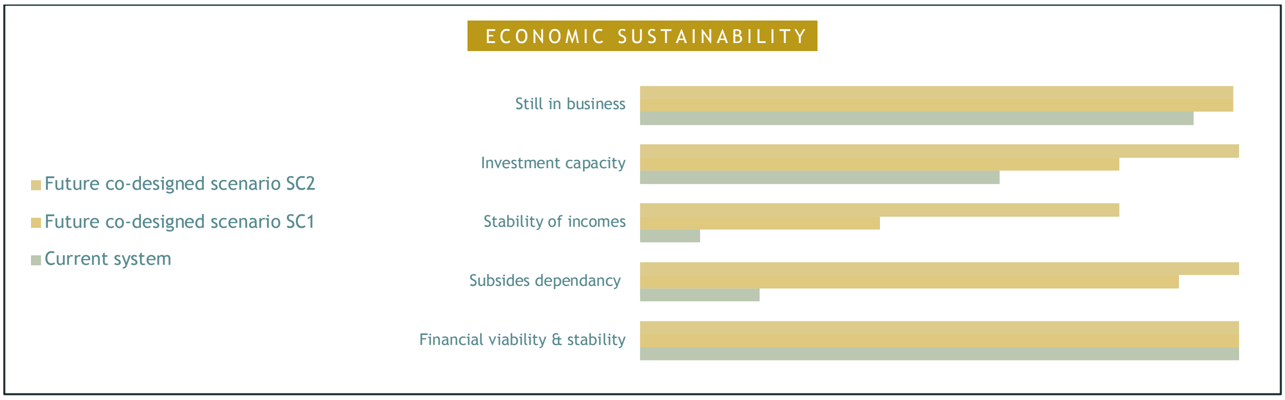

Figure 137 : Scores of the economic sustainability indicators, showing the current system and future co-designed systems SC1 and SC2

Several of the economic indicators are predicted to increase in the new scenarios, thanks to the introduction of new products. The current system is reliant on subsidies for income; **dependency on subsidies** should decrease when new income streams are created from the essential oils/hydrolate and new tree crops. By diversifying production and ensuring that cultivated species are resilient to current and future climates (i.e. harvesting essential oil from well-adapted *Cistus ladanifer*, and choosing resilient tree species such as pistachio and carob), it is assumed that there will be better **stability of income**, while overall increase in profits should allow for increased **investment capacity**.

3.11.3.3 Impact of co design changes on resilience

3.11.3.3.1 Major changes at global scales and comparison with sustainability assessment

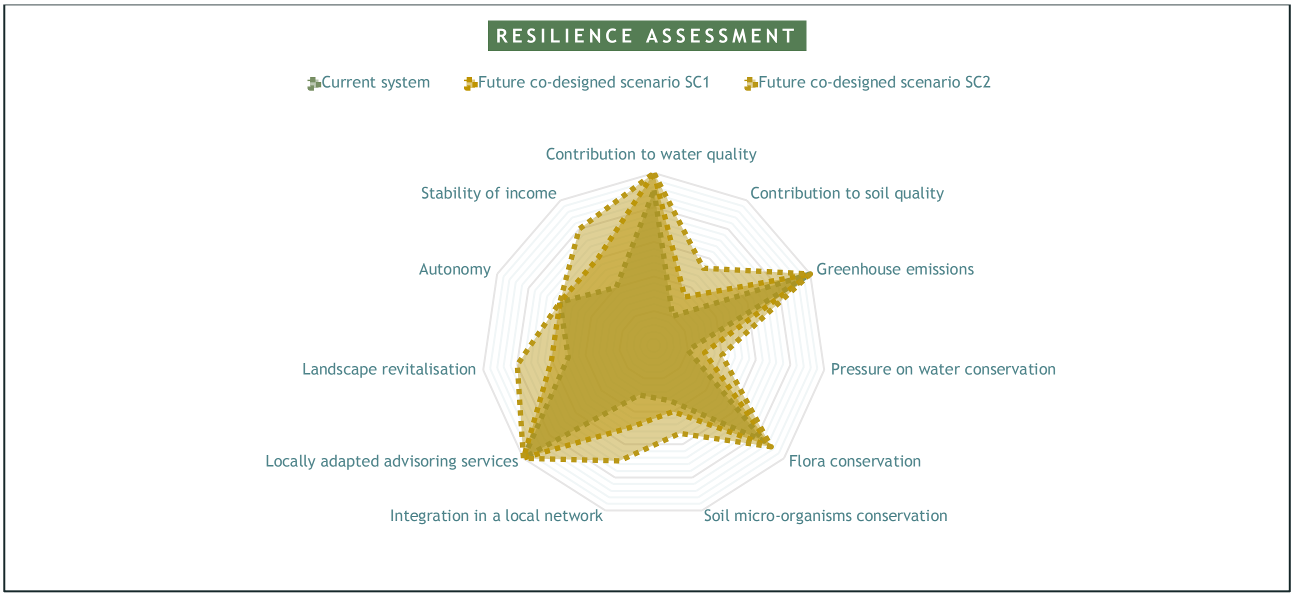

Figure 138 : Radar diagram of the results of the resilience assessment, showing the current system, scenario 1 (essential oil from understorey shrubs) and scenario 2 (keyline and resilient tree crops)

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Regarding global resilience, the impacts of the new scenarios are less obvious than in the sustainability assessment, although again we can note improvements in specific indicators within each dimension. Main improvements are within the economic dimension for stability of income, in the environmental dimension for soil quality and in the social dimension for landscape revitalisation.

3.11.3.3.2 Environmental impacts

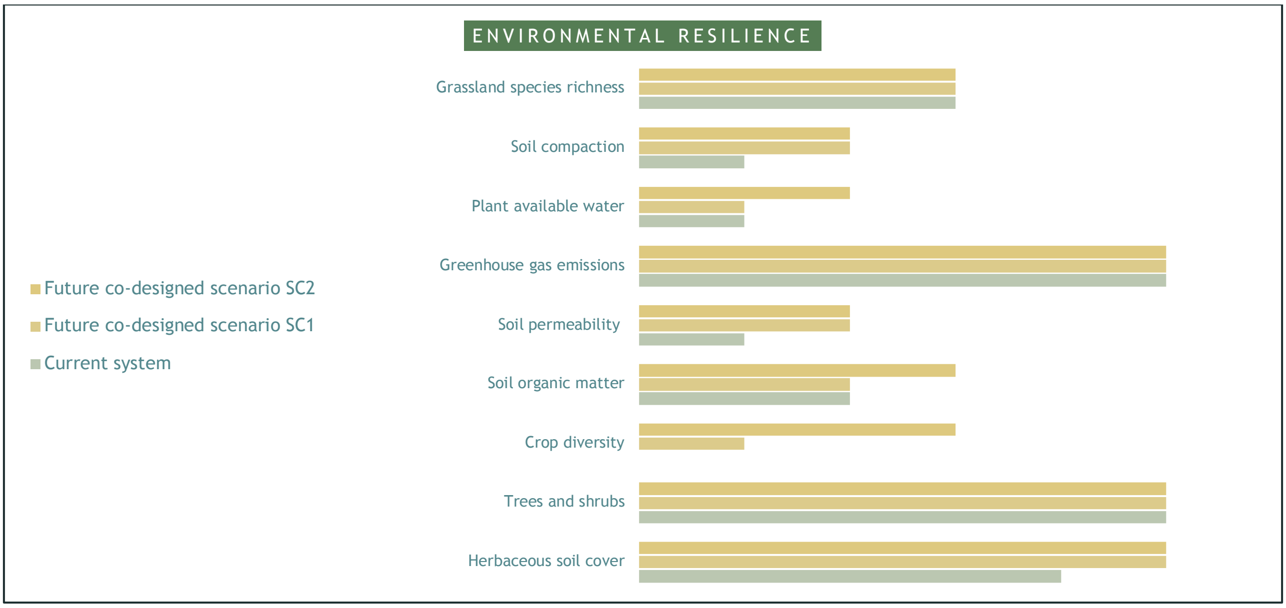

Figure 139 : Scores of the environmental resilience indicators, showing the current system and future co-designed systems SC1 and SC2

Similar to the changes discussed in the sustainability assessment section, we see potential improvements to several soil-related indicators within the environmental resilience dimension, primarily due to the replacement of destructive harrowing practices with maintenance of **herbaceous soil cover** and coppicing of the understorey for essential oil production. Thus, soil health indicators such as **soil compaction, soil permeability** and **soil organic matter** levels are predicted to improve under the new scenarios. As scenario 2 involves keyline management to improve water retention in the soil, it is assumed that **plant available water** will be positively impacted. Similar to the driver behind improvement to the habitat indicator in the sustainability assessment, the introduction of productive species in the two scenarios are reflected in the increase in the **crop diversity** indicator.

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3.11.3.3.3 Social impacts

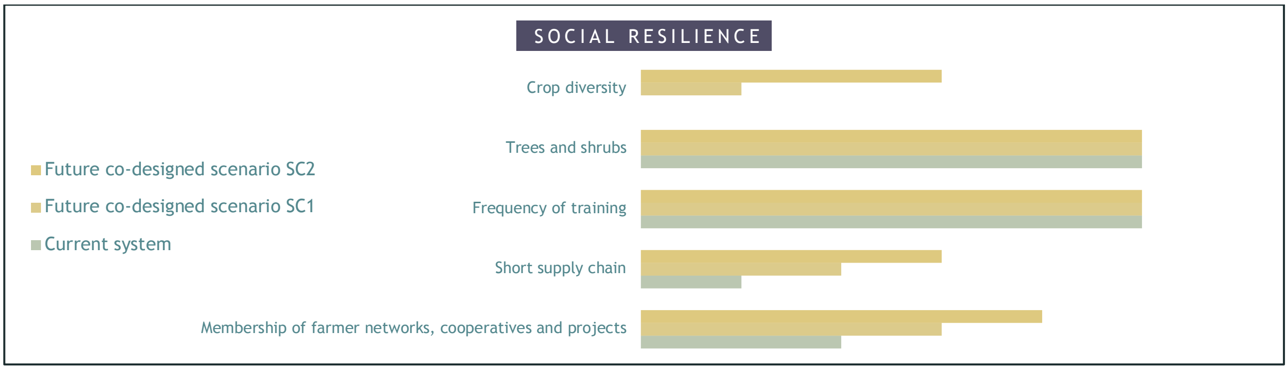

Figure 140 : Scores of the social resilience indicators, showing the current system and future co-designed systems SC1 and SC2

In addition to the positive impact on **crop diversity**, the introduction of new products would allow for the development of **short supply chains**, and by opening up innovative approaches such as keyline, sustainable management of the understorey for essential oil, and diverse resilient tree crops, it is likely that opportunities for **involvement in networks and cooperatives and new research projects** would increase.

3.11.3.3.4 Economic impacts

Figure 141 : Scores of the economic resilience indicators, showing the current system and future co-designed systems SC1 and SC2

Aligning with the sustainability assessment, the new scenarios should improve economic resilience primarily through the introduction of new products and therefore, diversifying **income sources**. It is expected that there would be no impact on dependency on external inputs.

3.11.4 Tools and methods: feedbacks

Feedback from the pilot participants regarding the resilience assessment was positive, particularly the environmental domain. However, some of the indicators were too difficult to measure and instead were estimated. These were: soil organic matter, soil permeability, GHG emissions and plant available water. It would be good to have alternative data/metrics available, particularly to encourage use of the assessments by non-researchers. The Social and Economic indicators were easier to complete, although it would be good to see a more balanced assessment with similar numbers of indicators in each domain.

The sustainability assessment took longer to complete, with more data points per indicator, but most were straightforward to complete. Several of the indicators weren't relevant to the pilot site, particularly those

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relating to arable crops and livestock, as neither component is present on the farm. Perhaps having the ability to choose alternative indicators to replace these would be beneficial, for example, indicators relating to tree crops. In the Economics dimension, the data point relating to financial viability (net assets) was difficult to understand, and it was proposed that a better measure may be variation in profit (or loss) over a 5-year period.

Overall, the flexibility to adjust the assessments to better reflect the pilot site and its context was seen as a positive aspect, rather than assuming a 'one-size fits all' approach. Discussion of the appropriate weighting was also a good opportunity to consider what elements of sustainability and resilience are most important to different actors of the pilot group.

3.11.5 Take-away messages

The assessments highlighted how the two co-designed scenarios would potentially improve multiple dimensions of sustainability and resiliency. Better management of the tree understorey, by replacing heavy cultivations to remove shrubs with management of the shrubs for essential oil and hydrolate production, was shown to have potentially positive impacts on several environmental indicators, particularly relating to soil quality. Adding in new tree species and implementing keyline cultivations is likely to improve water retention and increase diversity. Positive social impacts highlighted include more employment opportunities and the production of new outputs from the farm, produced in a sustainable way. The primary driver for designing the new scenarios, to reduce dependencies on subsidies, was recognised in the Economics indicators, as well as the positive impact of product diversification on buffering the farm from impacts of climate change or market fluctuations, with subsequent increased stability of income.

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3.12 Winthagen – Dutch pilot

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Reviewer	Daniel de Jong

3.12.1 Pilot site description

3.12.1.1 Pilot site environment

Winthagen is a region covering 200 hectares in the southern region of the Netherlands (see Figure 1). The landscape is typical of this region, with gently undulating hills, hedgerows and various agricultural activities including livestock, fruit, vineyard and arable farming. Arable farming is the most common land use in this region with a crop rotation that often contains cereals, sugar beet and potato. The soil is loamy to silty-loam and sits upon limestone bedrock which is sometimes quarried in this region.
In recent years, Winthagen has experienced an increase in flooding and soil erosion due to the intensification of arable farming, the loss of hedgerows, and the disappearance of dairy farms and the grassland that had helped mitigate these issues. Many locals have been impacted by these issues, from the farmers whose crops and soil can be lost in the extreme weather events, to local villagers whose houses can be flooded.

3.12.1.2 Current system

The pilot Winthagen takes place in this landscape and is a multi-stakeholder landscape co-design involving multiple landowners and interested parties. These included the municipality Voerendaal, the Limburgse Land en Tuinbouw Bond (LLTB = Farmers Union in the province of Limburg) local farmers, landowners, the waterboard, and other relevant stakeholders.

Figure 142 : Pilot region of Winthagen

Figure 143 : Location of Winthagen in Netherland

Currently, very few farmers in Winthagen practice mixed farming or agroforestry methods, although some have utilised subsidies to plant fruit trees in their meadows. Other measures have been implemented to mitigate flooding and soil erosion, including the augmentation of soil organic matter through the cultivation of green manures, the installation of runoff barriers between potato ridges, direct seeding in grain stubble or green manure, and non-inversion tillage on hilly plots. Government-mandated non-inversion tillage is enforced, while the other methods are adopted voluntarily.

Farmers assert that their investments in soil organic matter, green manures, and other regenerative techniques have contributed to the reduction of flooding and soil erosion in their region. However, there is a recognition that these efforts may not be adequate in the face of a changing climate, as evidenced by extreme weather events, such as the flooding experienced in the previous year. This susceptibility is particularly heightened by the timing of rainfall and the developmental stage of the crops in the field. Heavy rainfall in the spring before the establishment of potato or sugarbeet crops can result in significant runoff.
Moreover, the current infrastructure, especially roads, is situated in the lowest points of the landscape, exacerbating water-related challenges downstream in the valley.

Figure 144 : Pictures of the pilot site

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3.12.1.3 New co-design system

The core goals of the pilot are to support adaption to climate change, improve water management, improve landscape aesthetics, strengthen biodiversity, improve living quality and ensure economically viability. During the co-design process four concrete designs were developed to achieve these goals. These concerned cultivation and rotation, landscape infrastructure, infiltration, and water storage. These are described in more detail in the following paragraphs.

3.12.1.3.1 Cultivation and rotation

Figure 145 : Artists impression of the design cultivation and rotation

The design for cultivation and rotation concerns the spatial distribution of different crops in the area. The crop rotation and cropping plan of different farmers in the area is currently not discussed between landowners. This can lead to large areas of the same crop in erosion-prone areas and areas vulnerable to water run-off. By making agreements between landowners on the crop rotation for the area, it can be ensured that there is sufficient variation between erosion-sensitive and less erosion-sensitive crops (for instance: potato, sugar beet, maize versus winter cereals and grass), thus reducing the erosion risks. Such agreements require cooperation and consultation between different landowners and possibly a mediator (area coordinator). Financial support during the transition period would also be necessary.

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3.12.1.3.2 Landscape infrastructure

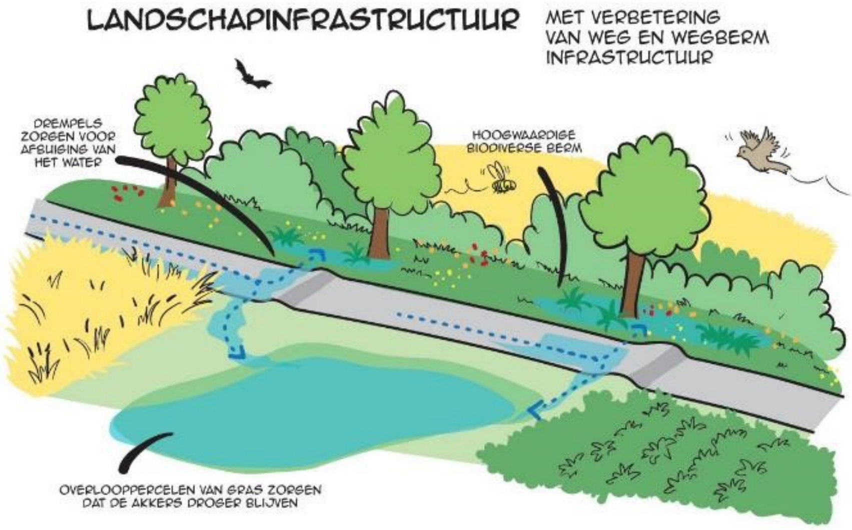

Figure 146 : Artists impression of the design for landscape infrastructure

The design for landscape infrastructure involves improving road and verge infrastructure in combination with spillways and floodable areas. The current road and verge infrastructure channels water together and creates a highway of flowing water directly to the built-up area thus increasing the risk of flooding. By changing this infrastructure, it is possible to slow down and redistribute the water into buffer zones. By creating small mounds, or low spots in the road, water can be diverted into buffers before it accumulates and reaches built up areas. This water can be diverted into verges and floodable plots, which act as buffers. Besides water collection, these newly created verges can also provide opportunities to support biodiversity and connect habitats in the landscape.

3.12.1.3.3 Water infiltration

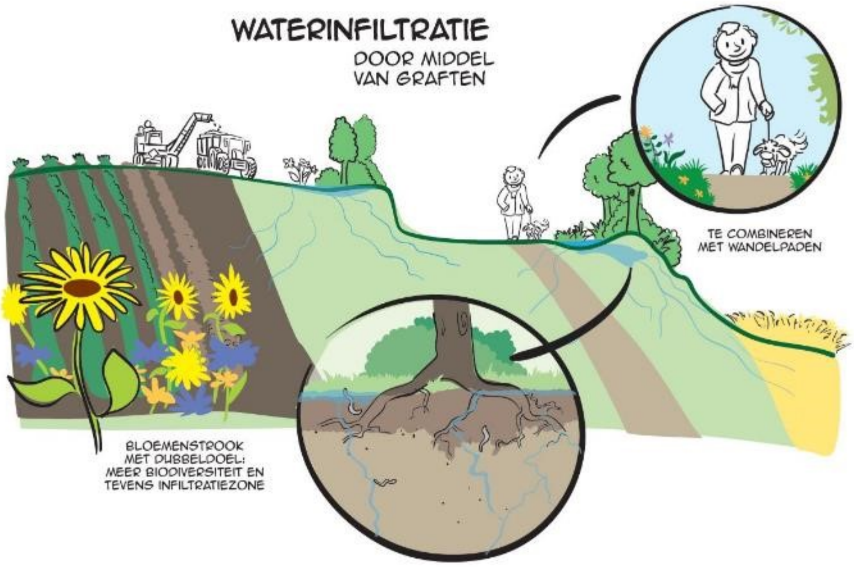

Figure 147 : Artists impression of the water infiltration design

The Water Infiltration design involves the creation of multi-purpose swales and berms. The swales and berms lie across the hillside on contour, which slows down or stops runoff water and gives it more time to infiltrate into the soil. Hedges can be planted on the berms for various purposes, including for flowers, fruit, nuts, biomass, and building materials. This can support both biodiversity and provide local self-harvesting opportunities for unique products. The berms can also be combined with paths for walkers. In this way, walkers have good access to the landscape for recreational purposes, while the hedges act as a barrier to prevent unwanted behaviour of these walkers on farmland. Berms can also be combined with other landscape elements such as ponds and flower strips to further contribute to different objectives.

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3.12.1.3.4 Water storage

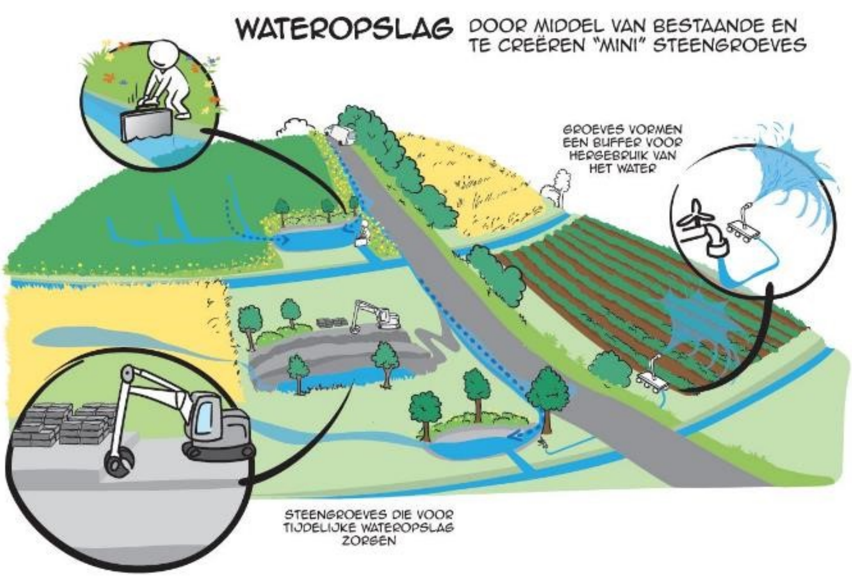

Figure 148 : Artists impression of the design for water storage

The Water Storage design involves the creation of mini quarries (for mining limestone) through the landscape. These quarries operate commercially, however, when needed they provide the additional service of temporary water storage. During heavy rainfall, water is diverted to the quarry through canals, swales and berms to be temporarily stored in the quarry basin. When the risk is over, the water can be redistributed through the landscape with pumps, or by gravity. In this way, the risk of flooding is reduced and water is not lost from the area. This is expected to make the area more resilient to climate change by making it more resistant to heavy rainfall and better able to retain water to cover longer dry periods. As the quarries are a commercial business, the cost of the additional service is expected to be limited and it will also generate employment in the local area. A major concern, however, is the licensing to operate these quarries and potential impact on water quality. As the legal feasibility of the quarries was not known at the time of the assessment they were not included in the comparison.

3.12.2 Sustainability and resilience assessment

3.12.2.1 Selection of indicators for local assessment

Given that it was a system design to improve the whole system with multiple goals almost all the indicators for sustainability were relevant. The only indicator that was removed was the GHG (greenhouse gas) reduction indicator as this is not something that we could quantify in the project and was also not a direct goal of the group. Other relevant indicators of GHG based on "*GHG mitigation*" and "*GHG from Land Use Change*" were retained. The weight of various sustainability indicators was altered to coincide better with the goals and relevance to the pilot. For instance, "*soil cover and measures to reduce erosion*" were given a

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higher weight than "*winter grazing*" and "*soil analysis*" as this was more relevant the desired developments of the pilot. Additionally, "*Buffer strips*" were also given a higher weight.

For the indicators of resilience there was a similar approach. Indicators that were relevant to the goals of the pilot were given a higher weight and indicators that were not relevant, or not quantifiable, within the pilot were excluded. This led to the Greenhous gas indicator being excluded as we didn't measure this. Various indicators were given different weighting, in particular we gave a higher weighting to "*herbaceous cover*" more equal weighting to "*grassland, soil cover and trees and shrubs*" and additionally we gave a higher weighting to "farm membership" and "short supply chain" as these were seen as important indicators for the development of collaborative locally focused developments.

3.12.2.2 Impact of co design changes on sustainability

3.12.2.2.1 Major changes at global scales

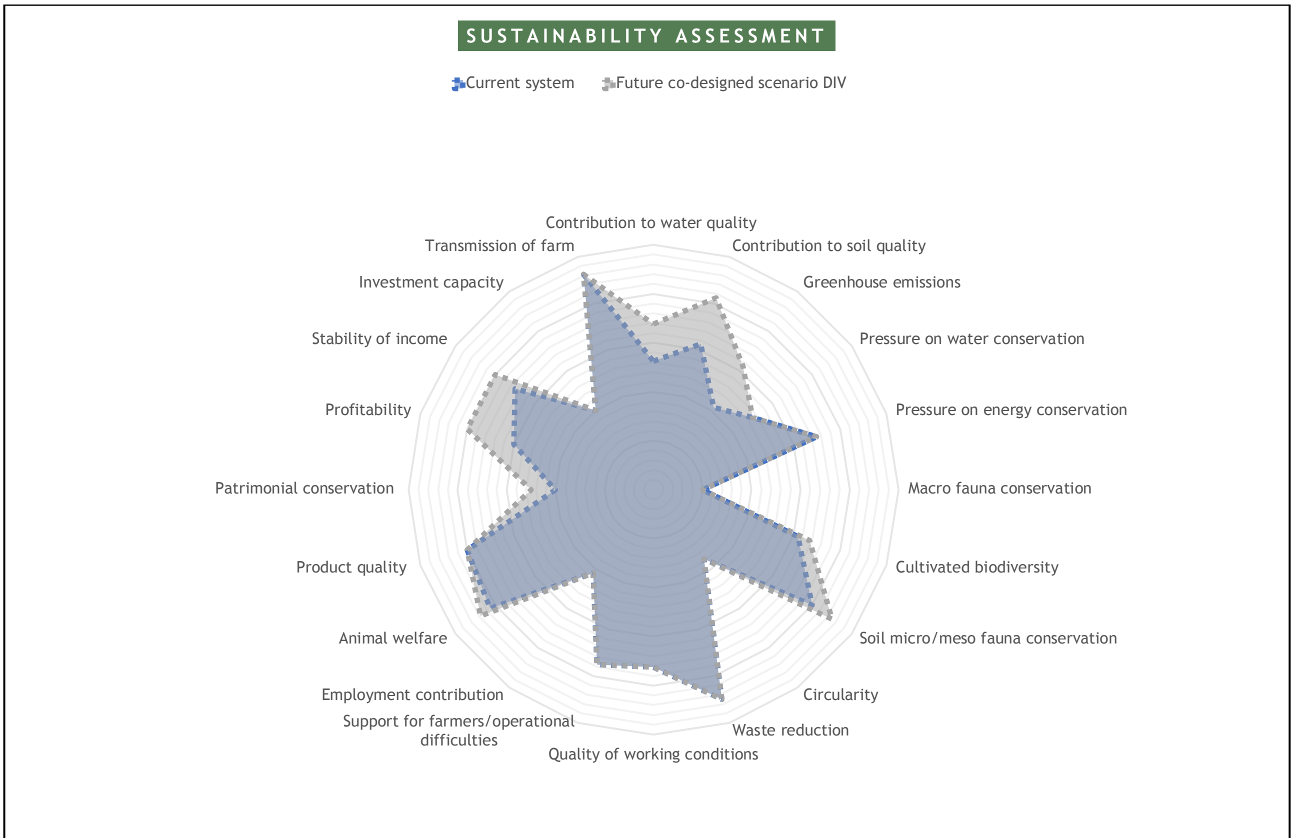

Figure 149 : Radar diagram of the results of the sustainability assessment, showing the current system and the future co-designed scenario

Globally, this multicriteria analysis shows that the new co-designed scenario provides improvements to several of the indicators when compared to the current pilot region. In particular the environmental dimension shows large differences, and to a lesser degree the economic dimension. The social dimension shows the smallest changes between the current and future scenario, which is to be expected given the nature of several of the changes. Many of the greatest improvements are in areas that were key goals of the pilot. Suggesting that the pilot design has successfully worked towards achieving these goals.

3.12.2.2.2 Environmental impacts

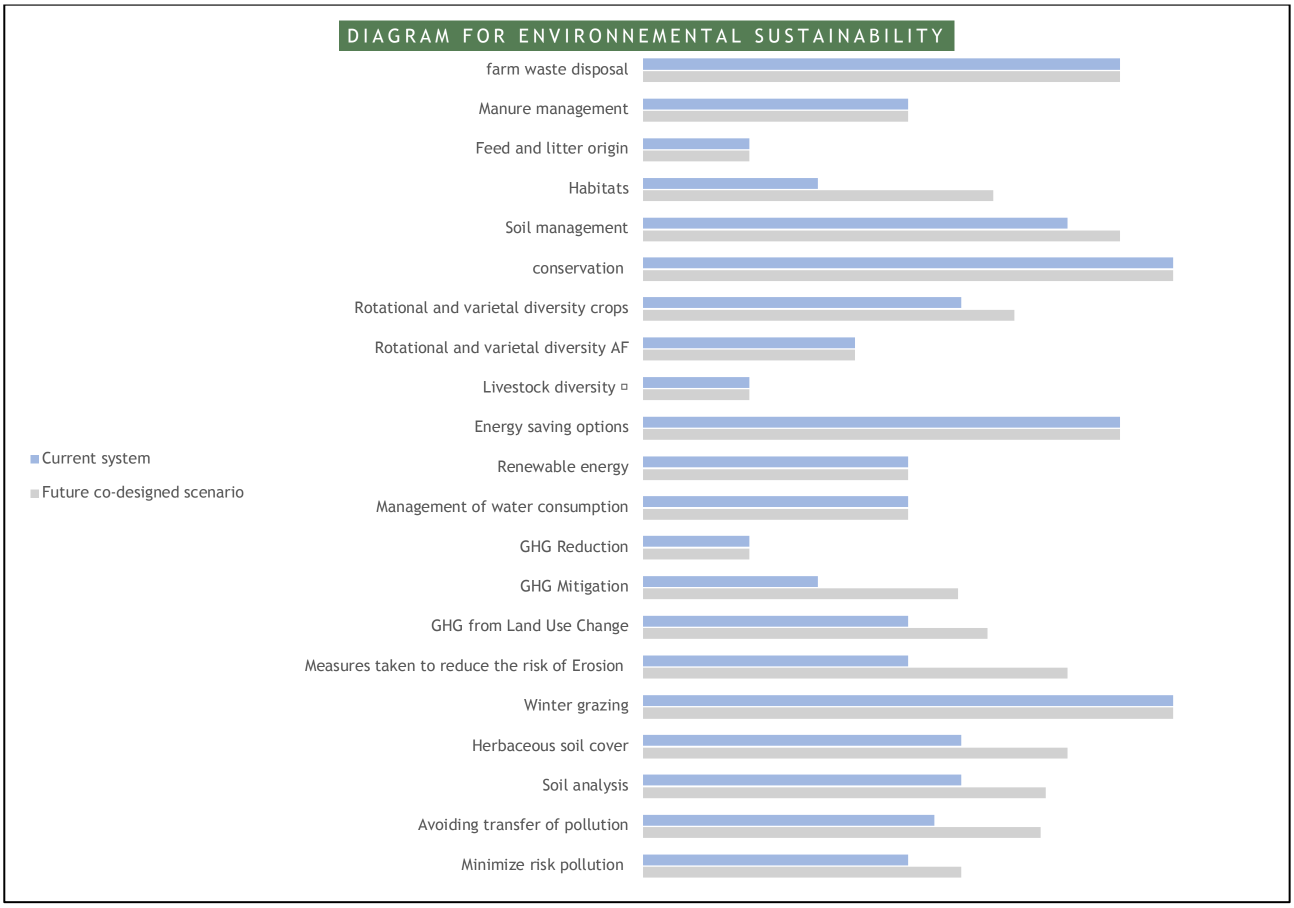

Figure 150 : Scores of the environmental sustainability indicators, showing the current system and the future co-designed system

The Diagram for the environmental sustainability assessment shows many differences between the current and future system for a range of different indicators. The major improvements are seen for the Indicators: Habitats, Measures taken to reduce the risk of erosion and GHG mitigation. Given the goal of the pilot to reduce erosion and support biodiversity this is a positive indication that the new design will help to achieve these goals. Many of the design elements were specifically designed to reduce erosion, through improving infiltration and providing storage. Many of these elements were also designed to support biodiversity and result in habitat creation. For instance, hedgerows on contour to improve infiltration can also provide various habitats to flora and fauna.

Additionally, the indicators; herbaceous soil cover, avoiding transfer of pollution and rotational and varietal diversity also show noticeable improvements. These are key elements to support infiltration and provide greater spatial diversity in crops to reduce the risks of exposed soil during the early spring when the soil is bare.

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3.12.2.2.3 Socials impacts

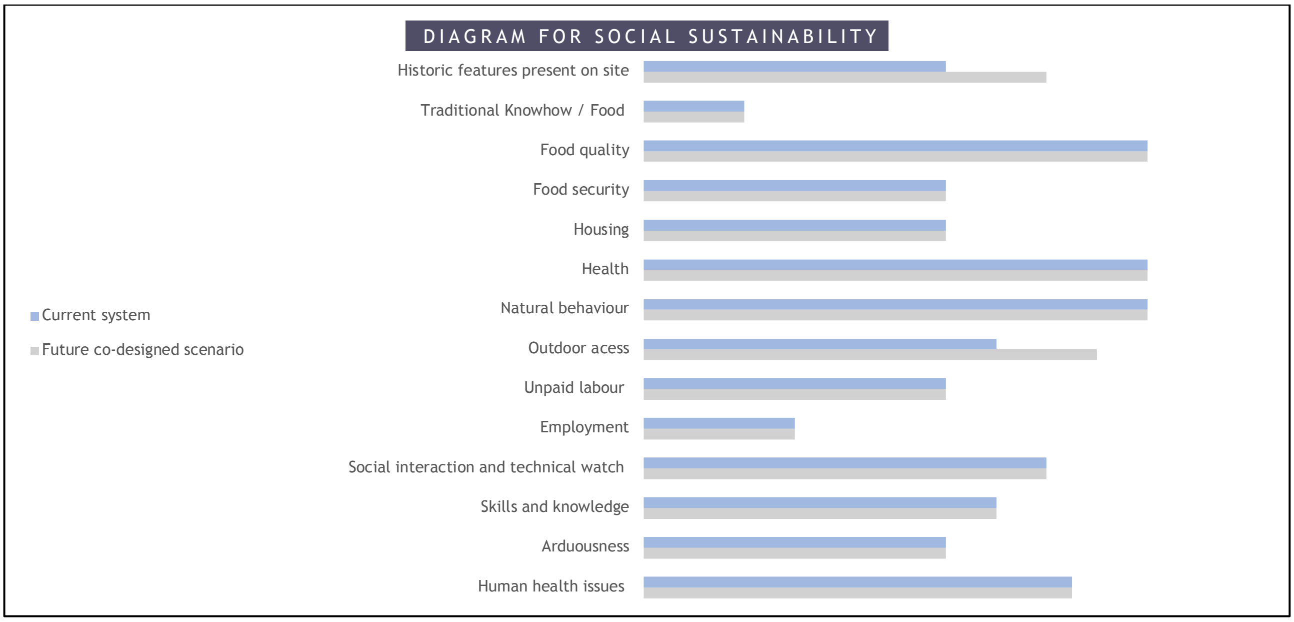

Figure 151 : Scores of the social sustainability indicators, showing the current system and the future co-designed system

The diagram for the social sustainability assessment shows that most of the indicators remain stable between the current and new scenario. Only the indicator for *historic features present on the site* and *outdoor access* showed differences. Both improving in the new scenario. The design for the new scenario included ideas based on historic landscape features "Graften" (berms planted on contour). These features had traditionally reduced the risks of erosion and were largely lost during the land consolidation process. The introduction of more landscape features was also an indicator of the quality of outdoor access which is why this indicator also shows an improvement. Besides these indicators. Several indicators also scored the highest rating in the current scenario leaving no room for improvement. Nevertheless, none of these indicators were reduced in the new scenario which suggest that there were no socially negative consequences of the new design.

3.12.2.2.4 Economic impacts

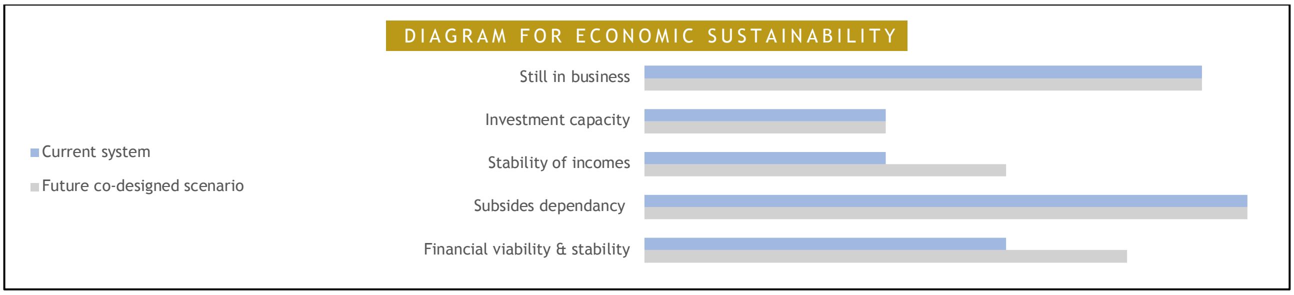

Figure 152 : Scores of the economic sustainability indicators, showing the current system and the future co-designed system

The diagram for the economic sustainability assessment shows two key indicators which are improved in the new design. These are the *stability of incomes* and the *financial viability and stability*. The other indicators

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remained the same as in the current scenario. The new scenario is expected to provide improvements to the sales channels with the potential to market new products and market them in new ways. Improvements to stability are expected due to the reduced risks of losses from erosion and flooding during extreme weather events.

3.12.2.3 Impact of co design changes on resilience

3.12.2.3.1 Major changes at global scales and comparison with sustainability assessment

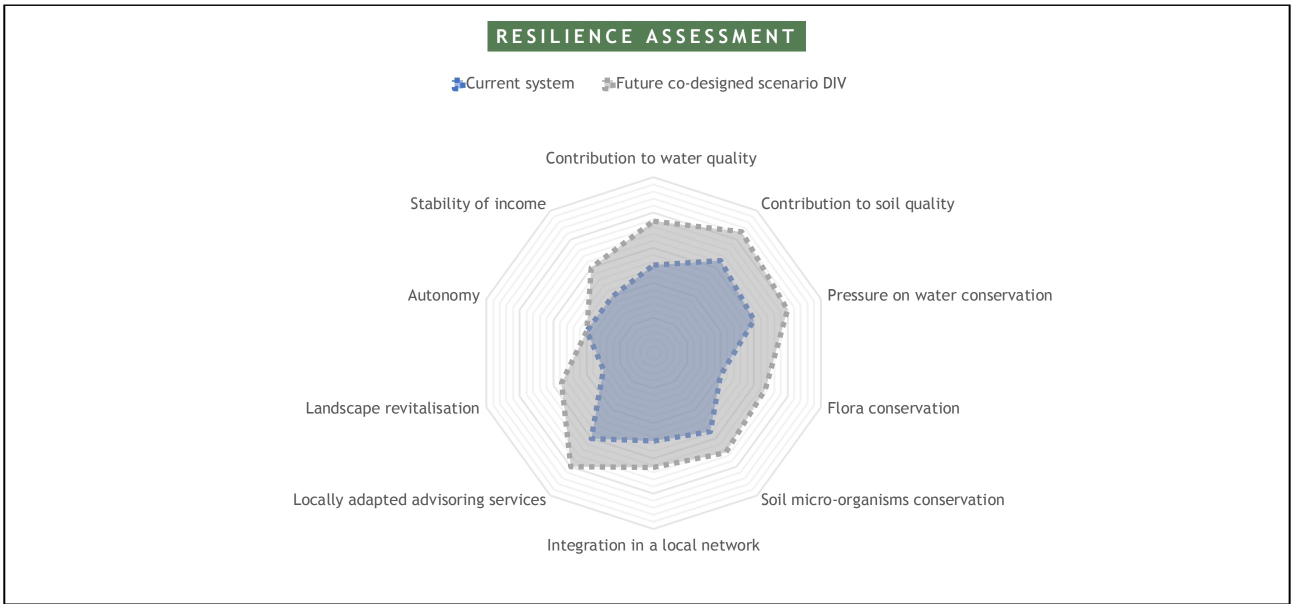

Figure 153 : Radar diagram of the results of the resilience assessment, showing the current system and the future co-designed scenario

The multicriteria assessment of resilience shows several differences between the current scenario and the future designed scenario. For all indicators except *autonomy*, where the performance is equal, the future system is an improvement on the current system. This suggests that the different dimensions of resilience, including social, economic and environment are all supported by the changes made in the new design.

In comparison with the sustainability indicators the resilience indicators show a more consistent positive impact. This suggests that the future co-designed scenario has greater impact on system resilience than on system sustainability as measured in this assessment. Or that the resilience assessment is more sensitive to the changes made in the new design.

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3.12.2.3.2 Environmental impacts

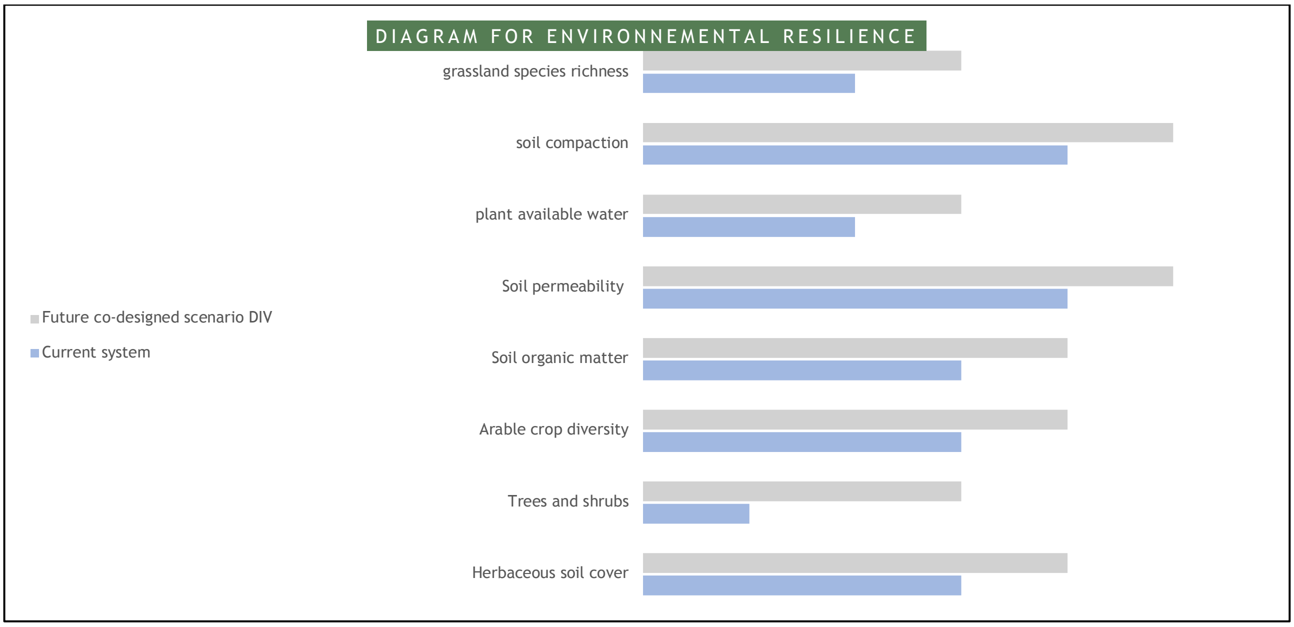

Figure 154 : Scores of the environmental resilience indicators, showing the current system and the future co-designed system

The diagram showing the environmental resilience assessment shows that the new scenario achieves an improvement in all the resilience indicators. Given that one of the key goals was to increase the landscape resilience to climate change it is unsurprising that these improvements are to be expected. Many of the resilience indicators were directly or indirectly discussed during the design process with attention given to how these could be improved on in a future scenario. In the future scenarios there are numerous design elements directly focused on improving infiltration, supporting crop diversity and increasing trees, shrubs, and herbaceous soil cover to support water infiltration, reduce erosion and provide habitat for biodiversity.

3.12.2.3.3 Socials impacts

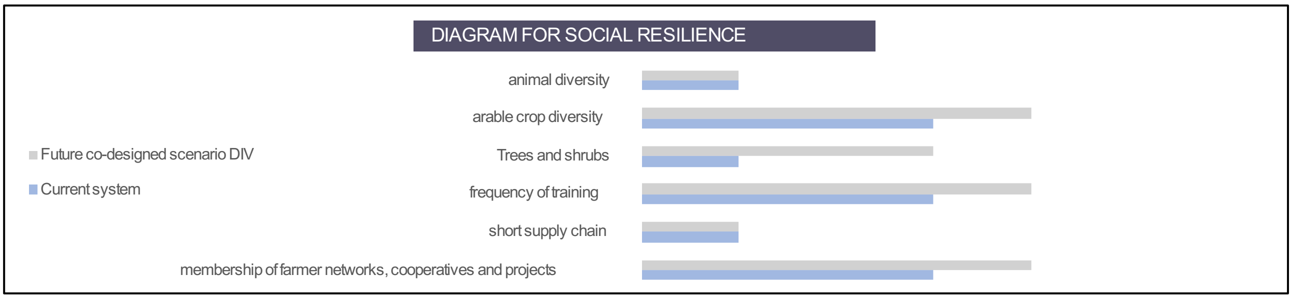

Figure 155 : Scores of the social resilience indicators, showing the current system and the future co-designed system

The diagram showing the social resilience assessment shows an improvement of several indicators in the future scenario. In particular for trees and shrubs, farmer networks, training, and arable crop diversity. The future design involves the development of a collaborative network of farmers who work together to implements crop rotations what support landscape resilience. This will increase farmer networking and also

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may necessitate training, or other means of collaboration. This design is also implemented to work on the spatial diversity of arable crops whose indicator also shows an improvement in the future system.

3.12.2.3.4 Economic impacts

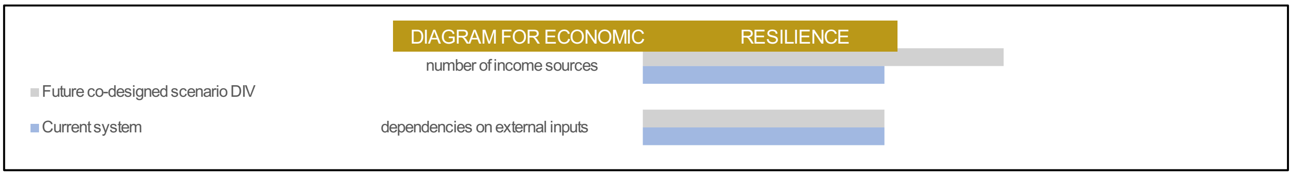

Figure 156 : Scores of the economic resilience indicators, showing the current system and the future co-designed system

The diagram showing the economic resilience assessment shows improvements to the number of income sources but no change in the dependence on external inputs. The diversification of income streams was also an element of the future scenario, with developments to include not only products but also services such as water management, or agricultural nature management. These can provide alternative streams of incomes to landowners. Interestingly the dependence on external inputs was expected to remain the same as the important inputs of seed, manure, and fuel were not addressed in the future design.

3.12.3 Tools and methods: feedbacks

The multicriteria assessment was a useful tool to evaluate the future design and assess if the design decisions were expected to contribute to the overarching goals of the pilot. In this regard it provided the opportunity to assess and redesign elements to see if they could realise the design goals of the pilot. The assessment was flexible and once users are experienced with the contents and how it functioned it was relatively simple to complete and edit based on the pilot's needs. Some of the indicators such as *Greenhouse gas emissions per unit of product, plant available water* and *soil permeability* were highly specific and would require dedicated measurement. Simpler versions of these indicators could be valuable to provide a more approachable tool for without the opportunity to make these measurements. Additionally, in the future it could be interesting to explore if the social and economic resilience could be strengthened with additional indicators to represent the absorptive, adaptive and transformative capacity of resilience more fully. Or if alternative indicators could be found to indicators which are present for both the environmental and social dimensions.

One of the challenges for the Dutch pilot was that the pilot was a landscape level development involving multiple landowners and farms. This made the assessment more difficult for some elements and an assessment more tailored to this approach could be valuable in the future. Nevertheless, many of the indicators were also relevant at different scales and the flexibility of the assessment allows for development for different approaches and scales. As a tool the assessment remained valuable to explore if the design changes would result in the desired changes at landscape level.

Overall, the assessment was able to reflect changes in the design and how these would affect the sustainability and resilience of the system. As a tool it worked well to test assumptions and provide feedback which could trigger changes in design decisions.

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3.12.4 Take-away messages

Our analysis shows that the co-design approach was able to develop a new future scenario where the system was expected the be more sustainable and resilient for multiple different indictors. Furthermore, the assessment gave a clear indication that the proposed design is expected to improve the performance of several of the indicators of particular importance to the pilot, which represent key goals of the pilot and are essential to fulfilling the design requirements. Interestingly the design also improved several indicators, such as emissions, which were not direct goals of the design.

The assessment of the new scenario shows various environmental improvements in the soil, water and plant cover indicators which suggest that our design is likely to achieve the desired improvements that make the landscape more resilient to climate challenge and also support biodiversity in the area. Additionally, the scenario is expected to improve on a number of social dimensions such as cultural elements, outdoor access and social cohesion. There may be additional benefits in the social dimension depending upon how the design would be implemented, this could be re-assessed at a later stage to help guide the implementation process. This reassessment is also relevant for the Economic dimension. For this dimension there are also improvements regarding the expected sources and stability of income. However, the results will be affected by how the designs would be implemented thus reassessment during the implementation process would be valuable. Overall, the conclusion is that the design will support the realisation of the pilot goals and support the sustainability and resilience of the landscape of Winthagen.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 862993.

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5 Annexes

Annex 1: Extract from the tool used to assess the sustainability of pilot sites.

Legend: The column in yellow is editable for each pilot sites, columns in orange (weight and thresholds) are propositions which can be modified for each pilot site with explanations.

Dimensions	CATEGORIES	Basic criteria ("leaves")	Sustainability Indicators	Weight	Data/ Information to ' be addressed' measure the indicators	Weight	Thresholds					Source
							1	2	3	4	5	
Environmental	Contribution to resource protection	Contribution to water quality	Minimize risk pollution	50%	What intensity of action(s) is/ are being taken for water resource protection (minimise water pollution and maximize water efficiency?	50%	Heavy loss	No action being taken	Low intensity actions being taken, eg: selecting suitable stock types and levels	Medium intensity actions being taken, eg: non inversion tillage or contour ploughing	High intensity actions being taken, eg: planting and maintaining riparian/ buffer strips	PG tool
					%of untreated land with pesticides ?	50%	0-20%	20-40%	40-60%	60-80%	80-100%	ITAB
			Avoiding transfer of pollution	50%	What %of arable area contains buffer strips?	50%	0%	1-25%	26-50%	51-75%	76-100%	PG tool
					What %of arable land (including permanent meadows) is left as bare ground (e.g: over winter stubble without a cover crop) over the winter?	50%	75-100%	50-75%	25-50%	1-25%	0	PG tool
		Contribution to soil quality	Soil analysis	25%	How often do you undertake soil analysis?	20%	Never	I test every 5+years	I test a few fields every few years	I test some fields every two years, or on grassland test every 5 years	I test some fields every year to monitor long-term change	PG tool
					Are you increasing, decreasing or maintaining Soil Organic Matter levels?	80%	Heavy loss	Slight loss	Maintaining levels	Slight gain	Large gain	PG tool
			Herbaceous soil cover	25%	What is the average yearly %of soil cover ? (visual observation or NDVI value)	100%	<50%(NDVI <0.4)	51-60 (NDVI 0.4-0.5)	61-70 (NDVI 0.51-0.6)	71-80 (NDVI 0.61-0.79)	81> (NDVI 80>)	D1.3
			Winter grazing	25%	Do you out winter cattle?	50%	Yes, pigs	Yes, cattle/ horses	Yes, sheep/ goats	Yes, hens	no	PG tool
					How would you describe area used of cattle during winter ?	50%	no vegetation				mostly cover by vegetation	ITAB
			Measures taken to reduce the risk of Erosion	25%	On what percentage of your land are you either implementing cultivation that reduces risk of erosion on arable land (eg minimum tillage and contour ploughing) or permanent pasture ?	50%	None	0-10%	10-25%	25-50%	50%plus	PG tool
					What is the edge linear in meter per hectare of tree and shrubs ? (Including Agroforestry)	50%	<100m/ ha	>100-200m/ ha	>200-300m/ ha	>300-400m/ ha	>400m/ ha	ITAVI/ D1.3
	Greenhouse emissions	Greenhouse emissions	GHG from Land Use Change	20%	What% of your total woodland/ grassland converted to arable in the last 20 years?	25%	45-60%+	30-45%	15-30%	1-15%	None	PG tool
					What %of your total arable area converted to permanent grassland or woodland in the last 20 years?	25%	None	1-15%	15-30%	30-45%	45-60%+	PG tool
					What %of proteins/ soybean feed food quantity is from abroad ?	50%	other	<30%	<20%	<10%	0%	ITAB
			GHG Mitigation	40%	What %of total area is covered up with permanent meadows ?	33%	0-20%	20-40%	40-60%	60-80%	80-100%	ITAB
					What is the edge linear in meter per hectare of tree and shrubs ? (Including Agroforestry)	33%	<100m/ ha	>100-200m/ ha	>200-300m/ ha	>300-400m/ ha	>400m/ ha	PG Tool
					Are you implementing measures to sequester C in significant way?	33%	none		no till and/ or mainly organic fertilisation	intercropping and/ or temporary meadow	agroforestry	4/ 1000 - Pellerin et al., 2019
			GHG Reduction	40%	Are you measures/ evaluate GHG émissions from a specific tool ?	20%	No				yes	ITAB
					Are you implementing measures to reduce GHG emissions ?	80%	No				yes	ITAVI
	Pression on abiotic resources	Pressure on water conservation	Management of water consumption	100%	Do you have water meters ?	5%	No				yes	ITAVI
					What %of total arable land is irrigated ?	50%	80-100%	60-80%	40-60%	40-20%	0-20%	ITAB
					Where does the water for irrigation come from ?	30%	other system or no period restriction				basin irrigation, filled with winter water pumping or gravitation	ITAB
					Do you use specific material to improve water efficiency ? (drip irrigation, ..).	15%	not specifics practicises and no regulatory restrictions		following regulatory restrictions		better practices than regulatory restrictions	ITAB
		Pressure on energy conservation	Renewable energy	50%	What part of your energy buy is from renewable sources? (This includes 'green tariffs' for electricity consumption)	50%	0	<25%	<50%	<75 %	100	PG tool
					Do you produce any energy on farm or have you considered installing energy generation capacity (e.g: solar, wind, biofuel) or are you planning to install?	50%	Don't produce any energy	Produce energy and cover half own energy needs	Produce energy and cover all own energy needs	Export some energy occasionally	Export energy every day	PG tool
			Energy saving options	50%	Have you completed an energy audit to explore efficiency options ?	50%	No				Yes	PG tool
					Are you acting on it?	50%	No		acting on partialy	acting on mostly	acting on fully	PG tool

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Environmental	Biodiversity improvement / restauration	Macro fauna conservation	Livestock diversity	100%	How diverse is the livestock system on the farm with regard to numbers of species?	20%	Single specie	2 species	3 species	4 species	5 +species	PG tool
					How diverse is the livestock system on the farm with regard to numbers of breeds/ crossbreeds? (Dairy Cattle Beef Cattle Sheep Pigs Poultry Other livestock)	30%	1 breed	2 breeds	3 breeds	4 breeds	5+breeds	PG tool
					How many rare livestock breeds are present on-site ?	50%	0 breed		1 breed		>1 breed	ITAB
		Cultivated biodiversity	Rotational and varietal diversity AF	30%	What % of total area is covered up with agroforestry ?	50%	0%		<20%		>20%	ITAB
					How diverse is the agroforestry system on your farm in terms of numbers of tree types?	50%	0-5	5-10	10-15	15-20	>20	ITAB
			Rotational and varietal diversity crops	50%	Except grassland, What is the part of major crop on total surface area ?	50%	>75%	> 50% and <75%	<50%	>25% and <50%	<25%	PG tool
					How many species/ varieties do you grow in total ? (Arable cereals Arable fodder crops Grain legume and oilseeds Vegetables Forage/ green manures/ leys Other crops)	50%	1-3 crop vars	3-6 crop vars	7-10 crop vars	10-15 crop vars	15+crop vars	PG tool
			conservation	20%	Are you working with rare breeds ?	100%	No				yes	ITAB
		Soil micro/ meso fauna conservation	Soil management	100%	What % of arable land (including permanent meadows) is left as bare ground (e.g: over winter stubble without a cover crop) over the winter?	50%	75-100%	50-75%	25-50%	1-25%	0	PG tool
					How many different crops are cultivated on area ?	50%	1 to 3		from 3 to 5		more than 6	PG tool, Venter et al., 2016 ; Zampieri et al. 2020
		Semi natural habitats	Habitats	100%	What is the amount of land that is woodland consisting of native species (ex. broadleaved, mixed or coniferous, etc) and/ or non-productive areas of ecological interest (such as such as hedges, ponds or fallow land)	33%	<5%	5-10%	10-15%	15-20%	>20%	PG tool
					How many different crops are cultivated on area ?	33%	1 to 3		from 3 to 5		more than 6	PG tool
					Are you maintaining hedges, if so how regularly?	33%	Not monitored	monitored rarely (5+years)	monitored infrequently (3 years) and maintained if	monitored frequently (2 years) and maintained if	monitored regularly (yearly) and maintained if	PG tool
	Circularity	Circularity	Feed and litter origin	50%	What % of livestock feed is produced on farm?	50%	0-20%	20-40%	40-60%	60-80%	>80%	ITAVI
					Concerning feed not produced on-site, which part is from a regional scale ? (Please add a comment to define "regional scale")	50%	0-20%	20-40%	40-60%	60-80%	>80%	ITAB
			Manure management	50%	What % of fertilizers applied is coming from of the site ?	50%	0-20%	20-40%	40-60%	60-80%	>80%	ITAB
					How far is valorised the manure produced on your farm ?	50%	other destinations		Mainly local exchanges		not manure surplus or small volumes	ITAVI
		Waste reduction	farm waste disposal	100%	What percentage of farm waste (e.g: plastics, metals, timber etc) is recycled?	50%	0-15%	15-30%	30-45%	45-60%	60%+	PG tool
					How do you dispose of unused/ unwanted medicines?	50%	Flush down sink, drain or sewer	Landfill site	Return to supplier - unsure how they dispose of the medicine	On-farm incineration	Return to supplier (e.g. vet) - they carry out clinical incineration	PG tool
Economic	Economic performance	Profitability	Financial viability & stability	100%	How have your net assets (total assets less total liabilities) changed, on average per year, in the last 5 years?	100%	decrease of more than 5%	decrease of less than 5%	not much change from previous year	increase of less than 5%	increased by over 5%	PG Tool
		Stability of income	Subsides dependancy	50%	What is the % subsidies represent in your sales revenue/ turnover ?	50%	>50%	50-40%	40-30%	30-20	<20%	ITAB, Agreste, 2022 (data from RICA 2020)
					What % of total incomes is from of external activity ? (in economic value)	50%	>50%	50-40%	40-30%	30-20	<20%	ITAB
			Stability of incomes	50%	How many sale channel do you have ?	50%	1 to 2		3 to 4		more than 4	ITAB
					How many significant sources of farm income (per activity) do you have?	50%	1 to 2		3 to 4		more than 4	PG Tool
	Long-term productive capacity	Investment capacity	Investment capacity	100%	Have you been able to carry out the investment you would like?	100%	none	some	about half	most	all	PG Tool
		Transmission of farm	Still in business	100%	Do you expect to still be in business next year?	33%	No				Yes	PG Tool
					Do you expect your farm to still be farmed in the next decade?	33%	No				Yes	PG Tool
					How is your farm doing?	33%	Struggling	surviving		making a reasonable living	booming	PG Tool

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Social		Quality of working conditions	Human health issues	50%	How exposed are you or your workers to hazardous chemicals ?	25%	Highly exposed		From time to time	Limited expositionon	Not exposed	ITAB
					How rigorously is health and safety enforced on the farm?	25%	Little attention and proper training given		Some attention and proper training given		Full attention and proper training given	PG Tool
					How would you describe the working environment at your farm?	25%	Poor		Average		Positive	PG Tool
					Frequency of of antibiotics use	25%	Systematic treatment	Preventive treatment	1 allopathic treatment for animal with life cycle < 1 yr and 3 allopathic treatment for animal with life cycle > 1yr	Less than 1 allopathic treatment for animal with life cycle < 1 yr and less than 3 allopathic treatment for animal with life cycle > 1yr	none	ITAVI
			Arduousness	50%	Time spent par men work unit ?	40%	current level is not sustainable		sustained level but livable/ manageable		conveinent	ITAB
					Ardousness of tasks	60%	current level is not sustainable		sustained level but livable/ manageable		conveinent	ITAB
		Support for farmers/ operational difficulties	Skills and knowledge	50%	How many training days have each personn/ ind had per year ? (including farmer, casual, family labour)	50%	<1	1	2	3	>=4	PG Tool
					How well qualified are your staff? (by experience and/ or courses/ certification)	50%	Below average		average (e.g. BASIS, telehandler licence)	higher than average (e.g. FACTS/ BASIS)	All staff are very highly qualified/ experienced (e.g. FACTS/ BASIS, agricultural degree, decades of experience)	PG Tool
			Social interaction and technical watch	50%	Are you member of a professionnel network ? (including adv or vet)	50%	Not a member		Working towards such membership		Member of an ethical trade scheme	ITAB
					Do you contribute to production and sharing knowledge ? (social and prof media, technical review, education)	50%	Not involved		Involved when there is a need		Regular and active member	ITAB
		Employment contribution	Employment	60%	How many long term staff do you employ?	50%	<1	1	2	3	>=4	PG Tool
					How many casual staff do you employ?	50%	<1	1	2	3	>=4	PG Tool
			Unpaid labour	40%	Do you depend on unpaid Family labour/ interns / woofer to run your business ?	100%	Essential dependency		Occasional dependency		Non-dependent	PG Tool
		Animal welfare	Outdoor acess	25%	Do you restrict grazing/ outdoor access at certain times of year (for any species)?	25%	Fully kept in	Indoor +access to an exercise yard	Outdoor access whenever conditions allow	Outdoor access whenever conditions allow and access to an exercise yard in severe weather	Permanent Outdoor access	PG Tool
					Is range coverded by vegetation ?	50%	No vegetation		Range mostly covered by vegetation (tree cover, bushes, tall grass..).		Range mostly covered by vegetation (tree cover, bushes, tall grass..).+ Shade/ shelter from elements provided on pasture.	ITAB
					How much access do they have to grazing/ outdoors on a daily basis during times of year when they are not kept in?	25%	No access	access to grazing for shorter periods	kept in overnight	kept in for short periods	24 hour access	PG Tool
			Natural behaviour	25%	How do you judge your animals' ability to perform natural behaviour? (feeding/ resting/ social/ comfort)	100%	unable to do so		somewhat restricted		fully able to	PG Tool
			Health	25%	Mortality rate	100%	>25%		arround 15%		<5%	ITAB
			Housing	25%	Stocking density	50%	> standards		in line with standarts		< standards	ITAB
					How would you describe the housing options available to your livestock? Natural light, floor type, ventilation ...)	50%	Below "freedom foods" standards		according to "freedom foods" standards	higher than "freedom foods" standards	much higher than "freedom foods" standards	PG Tool
		Product quality	Food security	50%	Approximately what percentage of your produce (by weight) is sold to regional sales ?	50%	<20%	> 20 and <39	> 40 and <59	> 60 and < 79	>80%	PG Tool
					Approximately what percentage of your produce (by weight) is sold to international sale ?	50%	>80%	> 60 and < 79	> 40 and <59	> 20 and <39	<20%	PG Tool
			Food quality	50%	What level of food quality certification do you have?	100%	None		Farm assured/ red tractor		Global GAP/ Europe GAP/ Organic certification	PG Tool
		Patrimonial conservation	Traditional Knowhow / Food	50%	What level of food quality certification do you have?	100%	None				PGI / PDO/ TSG	PG Tool
			Historic features present on site	50%	If there are historic features present on the farm (including archaeological features, traditional buildings, listed monuments), how much maintenance/ care do you give them?	100%	None	Little	Some	Non concerned	Much	PG Tool

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Annex 2: Extract from the tool used to assess the resilience of pilot sites.

Legend: Columns in orange (weight and thresholds) are propositions which can be modified for each pilot site with explanations.

CATEGORIES	Basic criteria ("leaves")	Resilience Indicators	Weight	Data/ Information to ' be addressed' measure the indicators	Thresholds					Source
					1	2	3	4	5	
Contribution to resource protection	Contribution to water quality	Herbaceous soil cover	50%	What is the average yearly % of soil cover ? (visual observation or NDVI value)	<50% (NDVI <0.4)	51-60 (NDVI 0.4-0.5)	61-70 (NDVI 0.51-0.6)	71-80 (NDVI 0.61-0.79)	81> (NDVI 80>)	D1.3
		Trees and shrubs	50%	What is the edge linear in meter per hectare of tree and shrubs ?	<100m/ ha	>100-200m/ ha	>200-300m/ ha	>300-400m/ ha	>400m/ ha	D1.3
	Contribution to soil quality	Arable crop diversity	25%	How many crops grown per year ?	1	2 to 3	4 to 5	6 to 8	>8	D1.3
		Soil organic matter	50%	What is the % of soil organic matter in 0-30 cm ?	depending on reference value of the soil type and location.	<2%	2-2.5%	2.5-3%	>3%	D1.3
		Soil permeability	25%	What is the permeabilty of the soil in cm/ h ?	<0.13 or >25.4 cm/ h	0.13-0.5 or >12.7-25.4 cm/ h	>0.5-1.5 or >9.5-12.7 cm/ h	>1.5-2.0 or >6.3-9.5 cm/ h	>2.0-6.3 cm/ h	D1.3
	Greenhouse emissions	Greenhouse gas emissions	100%	How many CO2 equivalents emission are produced per ton of product ?	> 25 t CO2 eq. perton product	25 - >10 t CO2 eq. per ton product	10 - >1 ton t CO2 eq. per ton product	1 – 0 t CO2 eq. perton product	net sequestrationperton product (more sequestration than emission)	D1.3
Pression on abiotic resources	Pressure on water conservation	plant available water	50%	How many mm of water available (difference between field capacity and wilting point) in upper 30cm of soil ?	<30mm	30-<40 mm	40- <50 mm	50- <62.5	62.5 >	D1.3
		soil compaction	50%	see soil permability line 5	<0.13 or >25.4 cm/ h	0.13-0.5 or >12.7-25.4 cm/ h	>0.5-1.5 or >9.5-12.7 cm/ h	>1.5-2.0 or >6.3-9.5 cm/ h	>2.0-6.3 cm/ h	D1.3
Biodiversity conservation	Flora conservation	grassland species richness	25%	how many grass/ plants species per m² ?	1 specie per m2	2 to 3 species per m2	4 to 6 species per m2	7 to 10 species per m2	> 10 species per m2	D1.3
		herbaceous soil cover	25%	What is the average yearly % of soil cover ? (visual observation or NDVI value)	<50% (NDVI <0.4)	51-60 (NDVI 0.4-0.5)	61-70 (NDVI 0.51-0.6)	71-80 (NDVI 0.61-0.79)	81> (NDVI 80>)	D1.3
		trees and shrubs	50%	What is the edge linear in meter per hectare of tree and shrubs ?	<100m/ ha	>100-200m/ ha	>200-300m/ ha	>300-400m/ ha	>400m/ ha	D1.3
	Soil micro-organisms conservation	Soil organic matter	50%	What is the % of soil organic matter in 0-30 cm ?	depending on reference value of the soil type and location.	<2%	2-2.5%	2.5-3%	>3%	D1.3
		arable crop diversity	25%	How many crops grown per year ?	1	2 to 3	4 to 5	6 to 8	>8	D1.3
		grassland species richness	25%	how many grass/ plants species per m² ?	1 plant specie per m²	2-3 plant species per m²	4-6 plant species per m2	7-10 plant species per m²	> 10 plant species per m²	D1.3
Support for farmers	Integration in a local network	membership of farmer networks, cooperatives and projects	50%	How many number of memberships the farm take part of ?	1 or less network	2 networks	3 networks	4 networks	>4 networks	D1.3
		short supply chain	50%	Identify how many short-supply chain activities the farmer undertakes	zero or 1 activity/ characteristic present	2 activities/ characteristic present	3 activities/ characteristic present	4 activities/ characteristic present	5 activities/ characteristic present	D1.3
	Locally adapted advisoring services	frequency of training	100%	How many number of training hours per year ?	< 4 hours per year	4-8 hours per year	8-12 hours per year	12-16 hours per year	> 16 hours	D1.3
Landscape revitalisation	Landscape revitalisation	Trees and shrubs	50%	What is the edge linear in meter per hectare of tree and shrubs ?	<100m/ ha	>100-200m/ ha	>200-300m/ ha	>300-400m/ ha	>400m/ ha	D1.3
		arable crop diversity	25%	How many crops grown per year ?	1	2 to 3	4 to 5	6 to 8	>8	D1.3
		animal diversity	25%	How many species and breeds in a year at farm level ?	only 1 species and 1 breed	2 species, or 1 species with a least 2 breeds	2 species with at least in 1 species 2 breeds	4 or more species or a t least 2 species with at least 2 breeds	3 species or more with at least in 2 species 2 different breeds	D1.3
Autonomy	Autonomy	dependencies on external inputs	100%	Determine kind of inputs used and where they are from	Almost all inputs are external;mainly dependent on externalactors, no local markets.	Inputs are partly external and partly local.	Only parts of the inputs (e.g., some seeds or some special inputs) comes from non local sources.	All inputs are fromlocal markets or internal	Only internal inputs used.	D1.3
Stability of income	Stability of income	number of income sources	100%	Sum up the number of income sources mentioned in the definition of this indicator	1 type of income source or activity	2 type of income source or activity	3 type of income source or activity	4 type of income source or activity	5 or more type of income source or activity	D1.3

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