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MIXED
EFFICIENT AND RESILIENT
MIXED FARMING & AGROFORESTRY

MIXED

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Executive Summary

Deliverable D4.3 provided an overview to all partners involved in the MIXED project on the selected MiFAS (Mixed Farming and Agroforestry Systems) and related value chains as a prerequisite for a more comprehensive value chain governance analysis. This constituted the foundation for the preparation of D4.4: Guideline on data collection and analysis. The present deliverable D4.5 provides the results related to the governance of value chains in mixed versus non-mixed or less mixed farming systems and associated value chains.

A case-study approach was used, representing 5 different MiFAS across Europe that focus on a diversity of farming systems and associated value chains as well as different types of related innovations or practices. They also represent a certain diversity of agro-climatic conditions in Europe. This approach was developed and undertaken in order to analyse the social resilience (governance) of mixed related value chain networks (associated to the MiFAS), as opposed to less or not mixed networks. The concept of value chain network is understood from a broad definition that also includes the farm level and any organisations (e.g. farming association, advisers) that may have a direct or more indirect effect through the lens of actors' collaborations. This analysis was performed both in a qualitative and semi-quantitative manner.

In this report, we first provide a short theoretical background for evaluating the social resilience of value chain related systems in terms of their governance. Then, we present the overall approach that was followed for conducting the case-studies both in terms of the network analysis as such and of the 'Goals and Conflicts' study. We also show how the data was analysed in the different cases. Due to the diversity of cases and their own specifics and constraints, the amount of data available differed between cases and the data analysis was thus performed in different ways depending on the case. Results are then presented for all cases except for the specific case of the Netherlands which is presented separately in a subsequent section with both the particular approach undertaken and the ensuing results.

Overall, results show that it is difficult to conclude whether "more mixed" or "less mixed" farming systems and associated value chains are more socially resilient, rather, that there are pros and cons to each type of system that need to be considered in their specific context. Nonetheless, "more mixed" appear to exhibit more social resilience at farm-level while "less mixed" may contribute to a more resilient value chain. These suggest that more diversified farming systems would benefit from a higher diversification of their outlet channels.

In addition, the study finds that semi-quantitative indicators alone are not sufficient to assess the social resilience and thus need to be placed in the qualitative context. The insights gained qualitatively proved instrumental in qualifying the numbers.

Despite limitations, the research allowed for observations to be made on the specificities associated to more and less mixed systems across Europe and their implications for social resilience. In order to ease a reliable comparison between "more mixed" and "less mixed", follow-up studies should focus strongly on the definition of a clear baseline, ideally by implementing controlled and/or rather large trial experiments in order to both increase the spectrum of possible relevant analyses and ensure a higher robustness of the results.

Abbreviations

AF	Agroforestry
AKIS	Agricultural Knowledge and Innovation Systems
AT	Austria
CH	Switzerland
Conv	Conventional
D	Deliverable
DK	Denmark
EC	European Commission
EU	European Union
LM	Less Mixed
MiFAS	Mixed Farming and Agroforestry Systems
MM	More Mixed
N	Nitrogen
NL	Netherlands
Org	Organic
PT	Portugal
R&D	Research and Development
SNA	Social Network Analysis
SSCG	Sustainable Supply Chain Governance
WP	Work Package

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Introduction

Deliverable D4.3 provided an overview to all partners involved in the MIXED project on the selected MiFAS (Mixed Farming and Agroforestry Systems) and related value chains as a prerequisite for a more comprehensive value chain governance analysis. This constituted the foundation for the preparation of D4.4: Guideline on data collection and analysis. The present deliverable D4.5 provides the results related to the governance of value chains in “more mixed” versus “less mixed” systems. The terminologies of “more mixed” and “less mixed” are used only for comparative reasons, meaning there is no clear-cut absolute values between the two systems, rather we want to assess their performance in relative terms.

The MIXED project substantially relies on participatory approaches and involves networks of farmers that practice or are in the process of transforming to MiFAS. Systems such as different forms of organic and non-organic agroforestry, land/manure/nutrients as well as grazing exchange between arable and livestock farmers, (re)wetting of arable land, land exchange and agro-tourism are all represented in the MIXED networks.

In this task 4.4 and Deliverable D4.5, we focus on a range of 5 MiFAS networks. These MiFAS networks selected are located in Switzerland (CH), Netherlands (NL), Denmark (DK), Austria (AT) and Portugal (PT); and focus on a wide range of farming systems that includes one or more of the following: Fruits and oak trees, shrubs, dairy and beef production, poultry and eggs production, and crops and pastures.

More specifically, the Swiss network comprises high stem fruit trees within cattle livestock systems. The Dutch network focuses on a rising cooperation between dairy and arable farmers in the northeast Veenkoloniën region. The Danish network focuses on trees and shrubs in combination with crops, cattle or pigs. The Austrian network focuses on apples and organic egg production. Finally, the Portuguese network is focused on an Agroforestry System (agrosilvopastoral system) called ‘Montado’, dominated by scattered oak trees in combination with native pastures (cattle and pigs), foraging, or feed crops.

The following section offers more context to the report by providing details on the MIXED project, the approach followed, the case studies involved, as well as the outline on the core sections.

1 Context of this report

1.1 MIXED project

MIXED is a project funded by the EU Horizon2020 programme. MIXED explores the benefits and constraints of mixed farming and agroforestry systems (MiFAS) to climate, environment and society in general and supports the further development of such systems. MIXED explores different types of MiFAS. The assumption is that MiFAS have the potential to be both efficient and resilient while providing eco-system services for the benefit of society and the environment. Networks of organic and conventional farmers are the backbone of the project. The different networks have different knowledge and experience that others can benefit from. In MIXED, we create the opportunity for farmers to learn from each other and for researchers to learn and generate new knowledge from undertaking research together with farmers. The project works with groups of farmers and develop networks across Europe covering a wide range of different mixed agricultural and agroforestry systems. This enables farmer-to-farmer knowledge exchange.

The MIXED project is composed of 8 work packages (WP). The present deliverable (D) deals with WP4, assessing the environmental and socio-economic impacts in value chains of increased integration of crops, trees and livestock as well as their role in climate change mitigation and adaptation. Specific objectives of WP4 are as follows: (1) Adapting LCA methodology for MiFAS, especially with regard to carbon sequestration (T4.1); (2) assessing the environmental impacts of the products in the value chain (T4.2); (3) evaluating the impacts of MiFAS on costs along value chains (T4.3) and; (4) assessing the importance of governance structure in the value chains (T4.4). This deliverable specifically focuses on the task T4.4.

Inclusive participatory approaches are embedded across WPs, and include structured and continuous consultation on strategy and prioritization with farmers and other stakeholders, including farming associations, policy makers or experts and value chain actors, using focus groups, workshops and case-study related approaches. In task 4.4, collaboration among actors is considered to be a key factor contributing to the level of social resilience, taking a systemic vision to sustainability reflecting the performance of the value chain governance.

A case-study approach was used, representing the five different MiFAS mentioned above, which focus on a diversity of farming systems and associated value chains. They also represent a certain diversity of agro-climatic conditions in Europe.

1.2 Case-study approach

A case-study approach was developed and undertaken in order to analyse the social related resilience (governance) of "more mixed" value chain networks (associated to the MiFAS), as opposed to "less mixed" networks. The concept of value chain network is understood from a broad definition that also includes the farm level and any organisations (e.g. farming association, advisers) that may have either a direct or more indirect effect on the system through the lens of actors' collaborations. This analysis was performed using both a qualitative and semi-quantitative approach.

The final objectives of the case-studies and governance exploration as a whole are as follow:

- To evaluate the social resilience in terms of their governance of mixed related value chain systems, compared to less or not mixed systems;
- To identify the main points that could support the improvement of social resilience of mixed related value chain systems in terms of their governance;
- To discuss the opportunity of transitioning towards "more mixed" related value chain systems when considering their social resilience in relation to governance aspects;
- To discuss the opportunity of implementing the proposed indicators to monitor and evaluate "more mixed" versus "less mixed" related value chain systems in the future.

1.3 Overview of the selected MiFAS networks

The key characteristics of the selected MiFAS networks are specified in Table 1, with further details on each MiFAS provided thereafter. This information is based on D4.3.

Table 1: Characteristics of the five selected MiFAS networks

	Region	**Network partner**	**Main production**	**Associated system**	**Mode**	**Mixedness scale**	**Main type of value chain**	**Main final products**
CH	Basel-Country - St. Gallen - Lucerne (Northern & Central part)	Hochstamm Suisse	Fruits (e.g. apples and pears)	Dairy and Beef cattle	Org & Conv	Within individual farms	Direct market; 'mainstream' and alternative markets	Fresh fruits; juice; transformed products (e.g. yogurt); meat and dairy products
NL	Drenthe and Groningen (Northern provinces from the Veenkoloniën region)		Arable farming	Dairy farming	Conv	Across farms	'Mainstream' channel	Starch, milk, yogurt, cheese, desserts, cream and butter products, pharmaceutical products
DK	Jutland and Zealand	Organic Denmark	Crops, cattle or pigs	Trees & shrubs	Org	Within individual farms Across farms	Direct market; 'mainstream' and alternative markets	Crop based products, meat

AT	Styria (Eastern region)		Apples	Eggs	Org	Within individual farms	Vertical organisa-tion	Eggs, apples
PT	Alentejo (Southern province)	CONSULAI	Scattered cork oak trees	Pastures, forage or feed crops; Beef cattle, sheep, goats and/or pigs	Conv (exten-sive)	Within individual farms		Cork stoppers, other products such as bio absorbents; meat and dairy products

These networks, except the Swiss one, were pre-selected in the MIXED project Grant Agreement with a view to represent a wide range of types of MiFAS. These involve different animal production: dairy farming (NL), pigs (DK), hens (AU) and beef cattle, sheep & goats (PT). These are combined with various systems like arable farming (NL); trees, shrubs and crops (DK); the scattered cork oak trees in Portugal (Montado system); and apples production in Austria. They also represent diverse geographical areas and pedoclimatic conditions.

Furthermore, the scale to which the mixedness occurs is diverse across these MiFAS. In three of the **pre-selected** networks (AT, DK, and PT), the mixedness takes place within individual farms. In the Dutch one, it primarily occurs across farms through specific collaborations between these farms. Furthermore, two of these networks are dealing with conventional production (NL and PT) while the remaining two focus on organic production (DK and AT).

Although the above pre-selected networks were diverse, it was decided to increase the number of networks by also involving the Swiss one, focusing on systems combining fruit trees and dairy & cattle. In this network, the mixedness occurs within individual farms. Moreover, the Swiss MiFAS has the specific characteristic of being established for a long time period.

1.3.1 Switzerland – Fruit Tree & Cattle

The Swiss farming system selected is composed of high stem fruit trees (apples, pears, cherries, mirabelle, plums, and quinces) associated with cattle livestock systems (dairy and/or beef). The case concentrates on North and Central Switzerland

The main focus is on fruit juice and transformed products from fruits. Fresh fruits represent only a small share of the market. ‘Mainstream’ retailers have a lack of interest in fresh products as such products do not always look ‘beautiful’ enough for customers. Such fresh products also pose challenges in terms of harvesting (specific techniques required) and storage (sensitive products).

The Swiss network partner in MIXED is Hochstamm Suisse, which is a farming producer association committed to the promotion and marketing of standard orchards in Switzerland. Hochstamm Suisse owns a label known as “Hochstamm Suisse” for their Swiss orchards products.

In Switzerland, there are more than 2’000 fruit-growers, and 60% of the apple and pear orchards are cultivated by fruit-growers with more than 5 ha. This includes around 1’300 producers who are members of the Hochstamm Suisse association, including 10% of organic farmers. This corresponds to around 2’200’000 fruit trees managed by Hochstamm Suisse members, including 9% organic.

The main role of Hochstamm Suisse is to promote their label by making a clear distinction across the range of system from intensive to more extensive production. The Hochstamm Suisse label requires farmers to meet certain production requirements, so market prices are higher than the average fruit prices. In 2019, 54 processors, 11 brand users, and 123 ’marketers’ were members of Hochstamm Suisse. The ’marketers’ are farmers who sell directly to the public such as farmers’ markets. Most of the apples and pears produced in Switzerland are grown in the Eastern part of the country. A typical Swiss tree production system includes about 100 fruit trees per hectare. More extensive fruit tree production also exists, with e.g. 15 to 20 trees per hectare.

The Swiss MiFAS is essentially focused on fruit juice and transformed products based on fruits, which involve extensive processing.

1.3.2 The Netherlands – Dairy & Arable Farming

The Dutch MiFAS focuses on an emerging cooperation between dairy and arable farmers in the northeast of the Netherlands, i.e. the Veenkoloniën region. Historically, the region predominantly hosted arable farms but some dairy farming has recently commenced. The Veenkoloniën is located across two Northern provinces in NL, namely Drenthe and Groningen. The region ranks amongst the least profitable in NL (Diogo et al., 2017), which is why the cooperation between arable and dairy farms is promising and is the reason for which this MiFAS was selected. The activities of the network include mainly starch potato production, which is rotated every second or third year, mostly with sugar beet and wheat; as well as dairy production.

The Veenkoloniën area, or Peat District, refers to an area in Drenthe and Groningen in which colonies of labourers were once established to mine the raised bog for peat. Nowadays, the term Veenkoloniën simply indicates the district, which has an area of about 80’000 hectares and about 200’000 inhabitants. The history of land reclamation in the peat district was followed by widespread agricultural development, including the associated processing industries, which is still recognizable in the current landscape. The main production in the area includes basic products such as sugar beet, starch potato, and cereals.

Much of the peat has been extracted or decomposed by oxidation and the share of organic matter in the soil highly varies, with a large share of organic matter (i.e. without a state of decomposition), which leads to low water reserve capacity of the soil, high vulnerability to wind erosion, and lowering levels of land. These issues make the region unsuitable for cultivation of many crops and vegetables. Consequently, the region largely relies on starch potato production in a 1:2 or 1:3 rotation, with starch potato being rotated every second or third year with mainly sugar beet and wheat.

1.3.3 Denmark – Organic Agroforestry Livestock Systems

The Danish farming system is composed of trees and shrubs in combination with crops, cattle, or pigs. The network involves four milk producers (selling to “Them” and “Thiese Organic Dairy”) and four pork producers located in the Jutland and Zealand regions.

In the past years, an increasing interest in planting trees has grown among large-scale organic pig farmers and also recently among cattle farmers and many organic farmers are taking into consideration their potential contribution to enhancing public goods such as biodiversity, carbon sequestration, animal welfare, and the environment. Integration of trees and shrubs with agricultural crops and animal husbandry is, however, not a common practice in organic agricultural systems in Denmark.

The Danish network partner in MIXED is Organic Denmark, which is an association of companies, organic farmers and consumers in Denmark. They are the largest representative of the organic food industry in Denmark.

Several of the organic farmers are part of a larger agroforestry network that was established by Organic Denmark. The network involves, among other farmers, four milk producers and four pork producers located in Jutland and Zealand.

The company ‘Them Dairy’ participates in the Danish research project “Agroforestry – a sustainable farming system for crop and milk production” (ROBUST), which is coordinated by Organic Denmark. One objective of ROBUST is to develop an ‘Agroforestry cheese’ in cooperation with ‘Them Dairy’ and two organic milk producers.

The organic pork producers vary largely in farm size (a few sows -> 1000+ sows), pig breeds (modern fast-growing crossbreeds and traditional slow-growing breeds), and value chains. The pig farm value chains varies from pork sold by local farm gate sales, to pork branded as ‘Poplar pig from [XXZ]’ sold in COOP supermarkets, and ‘mainstream’ organic pork that is slaughtered and distributed through ‘Friland A/S’, which is the largest supplier of organic meat in DK and part of Danish Crown; a major player within the conventional pig industry. This means that overall the organic value chain is similar to the conventional one in terms of the actors involved and of the length of that value chain.

Examples of farms

The farm [XXY] produces about 175 fattening pigs per year from 14 sows. Their sow herd is based on two traditional breeds: the Danish Black-spotted pig and the Mangalitsa pig, which is a Hungarian breed also known as the wool pig. In addition to pigs, they have nine sheep and two geese. The farm includes 18 ha farmland with grass clover mainly used as pasture for the pigs and production of silage for the pigs and sheep in the winter season. After one year of ‘pig grazing’, the pastures have one year of recovery (no presence of animals). Contrary to the large-scale organic pig producers, they do not include the pig pastures in a two-year-rotation with barley or other cereal crops. All sow pastures are partly covered with trees mainly to provide shade. Currently, 60% of the pig feed is based on by- and waste products from local food production, e.g. brewers grain from a local beer brewery, bran from a local mill and bread from a local bakery. They are working on including whey (valuable protein source) from a local cheese producer. The by- and waste products are supplemented with compound feed based on Danish produced organic feed sources.

Pork from ‘Poplar pigs from [XXZ]’ was launched in 2016 by COOP. [XXZ] were at that time (and still are) Denmark’s largest organic pig production with more than 1’000 sows. [XXZ] separated from the larger company ‘Friland A/S’ (part of Danish Crown) and initiated a cooperation with a private slaughterhouse and the previous CEO of ‘Friland A/S’ to develop the Organic+ concept to be sold/marketed in COOP supermarkets. The life of a Poplar pig from [XXZ] differs from the majority of Danish produced organic pigs because they are born in paddocks with access to poplar trees and a few cherry plums and spruce trees (covering approximately 25-35% of paddock area), weaned later (ten weeks of age), and have access to ‘rooting areas’ in the fattening stage. Poplar pigs from [XXZ] are branded as pigs with improved animal welfare compared to ‘mainstream’ organic pig production (and not branded as an agroforestry system as such). Organic pork from poplar pigs is labelled with four (the highest obtainable number) welfare hearts (signifying ‘the extra good life’) according to COOP’s animal welfare brand scheme.

1.3.4 Austria – Organic Apples-Hen

The Austrian farming system selected is composed of both organic apples and eggs. The network consists of 4 Demeter farmers. The farms are located in the Eastern Styria region, in the climatically preferred apple belt of south-east Austria.

The marketing of the apples is organized by ‘Von Herzen Biobauern GmbH’, which is a leader company in Austria with around 150 participating organic farmers. The ‘Apples-Hen’ project started at the beginning of 2020 with scientific support from the Research Institute for Organic Agriculture (FiBL) in Austria. So far, the two value chains operated independently to each other and both value chains are largely organized vertically.

Membership in the Austrian Demeter association of biodynamic farmers (about 200 members) brought, among other requirements, the obligation to keep animals. Since then, organic laying hens have been using the habitat of the apple orchards in small mobile groups. Due to the absence of similar requirements in conventional apple production, this practice constitutes a significant difference between organic (biodynamic) and conventional farms.

The objectives of the Apple-Hen association include the production of organic eggs by hens, a reduced pest pressure in the orchard, a more even distribution of nutrients, and a positive influence on biodiversity. Furthermore, direct marketing of eggs contributes to the improvement of relations with the neighbourhood and allows for a higher income. The development of the initiative started in 2020 with 4 farmers and was accompanied by the Research Institute for Organic Agriculture (FiBL) in Austria. The initiative started with two flocks of 40 laying hens each and one rooster per group. Two different barn concepts were developed; experiments were carried out at different sites; different concepts against losses through predators, such as foxes, were tried; and initial discussions about a professionalization of the egg marketing were held.

The apple is Austria's primary type of fruit. The per capita consumption is 21 kg/year. In Austria, apple growers produced 476’633 tons of apples in 2019; with 136’906 tons coming from the province of Styria. The organic share is 22% and around 13.5% of all European organic apples are produced in Austria.

Austria has a special position within the EU when it comes to keeping laying hens. The keeping of laying hens in cages, including enriched cages, has been completely abandoned since the beginning of 2020. In comparison, within the EU-28, the enriched cage is still the dominant husbandry system with a share of 50% (FiBL, 2020).

In 2020 the proportion of free-range (including organic) shell eggs purchased in Austria was 45% by quantity and 57% by value (Amainfo, 2020). Table 2 presents key statistics on Austrian egg production.

Table 2: Data and facts on egg production in Austria

Trait	**Quantity / proportion**
Egg producers (>350 hen places)	~ 2’000
Total laying hen places	~ 6.8 millions
Of which:	
- Organic	11 %
- Conventional free range	22 %
- Floor systems	66 %
Eggs produced	~116’000 tons, equivalent to 1.9 billion eggs
Domestic self-sufficiency	87 %
Annual consumption per capita	239 eggs, equivalent to 14.7 kg

Source: ZAG, 2020

So far, the apple and hen value chains have operated independently to each other and both value chains are largely organized vertically. The market requirements only allow for low tolerance and therefore also lead to professional specialization. Producing organic eggs in small mobile houses directly in the orchards is a new concept. In 2020, in the first year of the 'Apples-Hen' initiative, eggs were sold directly from the farms.

Overall and in comparison to the conventional sector, the organic value chain for eggs tends to be shorter as well as involving a broader diversity of actors with supposedly closer relationships among those actors. In the last years, small scale egg production has received much attention from the side of consumer groups who want to purchase eggs directly from small scale producers. Although consumer groups tend to favour organic over conventional egg production, conventional farmers also became interested in selling eggs from small flocks directly to consumers.

1.3.5 Portugal – Agroforestry Montado System

The Portuguese farming system, called 'Montado' (UNESCO protected), focuses on scattered cork and holm oak trees, associated with native pastures, foraging, or feed crops. The livestock includes beef cattle, sheep, goats, and/or pigs.

The network is located in the province of Alentejo in Southern Portugal. Montado is a traditional extensive production system which is being hindered by drought events and inappropriate management practices leading to its abandonment or disappearance due to a lack of natural regeneration. Farmers joined the MIXED network to share experiences and improve their practices. The Portuguese network partner in MIXED is CONSULAI, which is an advisory company in the agribusiness and agroforestry sectors.

The cork material is used for diverse purposes including natural cork stoppers but also new products and applications such as bio absorbents of heavy metals in aqueous solutions (Pereira, 2007). The Montado system contributes to 54% of the annual world production of cork (Ribeiro et al. 2010). Additionally, some areas are also managed for the provision of other services such as biodiversity protection, hunting activities, education, and/or leisure activities.

The type of production in a Montado depends on the farm's characteristics, and these farms are in general very heterogeneous. Cattle breeding is increasing, but many farms still have sheep or goat herds and/or pigs. Some farms have a combination of different livestock. The main significant change that has occurred in the last 5-10 years is the degradation of soil quality, and the effects of the lower precipitation both in rainfall quantity and frequency. In the last years, as a result of soil organic matter decrease and increased erosion, many trees have died, diseases impact has grown, and cork production has been decreasing in quantity and quality. However, many farmers endeavour to adapt to preserve their Montado via individual or combined measures.

The Portuguese cork industry is highly developed and is made up of around 700 companies, which produces around 40-million cork stoppers per day, among other products.

More details on the different networks are provided in Annex.

1.4 Outline of the report

In the next sections, we first provide a short theoretical background to evaluating the social resilience of value chain related systems in terms of their governance. The functional dimension of the concept of "systemic sustainability" was chosen as main methodological framework for conducting the case-studies, assessing the contribution to social resilience in a both qualitative and semi-quantitative manner.

Secondly, we present the overall approach that was followed for conducting the case-studies both in terms of the network analysis as such and of the 'Goals and Conflicts' study.

Thirdly, we show how the data was analysed in the different cases. Due to the diversity of cases and their own specifics and constraints, the amount of data available differed between cases and the data analysis process was thus customized to each case.

Results are then presented for all cases except for the specific case of The Netherlands which is presented separately in a subsequent section with both the particular approach undertaken and the ensuing results. We finish with a discussion and conclusion section.

2 Evaluation Framework

Food value chains can be seen as “systems”. Stringer and Hall (2007) defined food value chains as a set of material flows calling on the involvement of numerous economic actors with complementary and interdependent functions. A sustainable food value chain (SFVC) was defined by Neven (2014) (p. 6) as *“the full range of farms and firms and their successive coordinated value-adding activities that produce particular raw agricultural materials and transform them into particular food products that are sold to final consumers and disposed of after use, in a manner that is profitable throughout, has broad-based benefits for society, and does not permanently deplete natural resources”*.

We refer to ‘systemic sustainability’ as the assessment of how sustainable a given socio-economic system is (in the context of agriculture). A system is deemed to be a delimited entity comprising its own organisation and complying with specific principles and rules. The sustainability of a system depends on its capacity to produce goods and services that fulfil the objectives of the system’s actors without affecting existing resources (Keulen, van Ittersum, & Leffelaar, 2005).

Systemic sustainability refers to system’s resilience and survivability (Fresco, 2009). This approach combines a study of the normative aspects of sustainability (the traditional pillars) with a study of the functional aspects i.e. stakeholders’ interactions in their capacity to ensure the viability of systems. Here we focus only on the functional aspects. Survivability can be measured through the attributes of survival capacity determining how a chain can cope with disturbances, uncertainties and risks (Talamini & Ferreira, 2010; Thadakamalla, Raghavan, Kumara, & Albert, 2004). It can also be informed by attributes of value chain governance (Vurro, Russo, & Perrini, 2010). These attributes can be determined by network analysis indicators.

Value chains are likened to complex networks where information and goods are, respectively, shared and traded through highly diverse linkages involving industrial, organisational and socio-economic constituents (Christopher & Peck, 2004). The study of networks can help in analysing the systemic sustainability of food value chains. The long-term viability of local agri-food systems depends, inter alia, on the effectiveness of collective actions, which are determined by social capital encompassing the notions of trust, reciprocity, norms and sanctions (Jarosz, 2000).

A high network Density, referring to relational thickness or strong ties, is described to favour trust and common norms, even though in certain contexts it can also curb innovation development and assimilation of external knowledge by actors (Lazzarini, Chaddad, & Cook, 2001). The Density of networks can be determined by performing a Social Network Analysis (SNA). In addition, a common property of networks is their division into so-called ‘communities’ within which the actors’ connections are dense but between which they are scarcer. The degree to which a network is made up of such compartments is known as the Modularity. It appears that disturbances tend to spread faster within a compartment than between compartments (Esparon, 2016; Fortuna et al., 2010; May, 1972).

Furthermore, as indicated in Deliverable D6.1[1], “*the concept of MiFAS* [in MIXED] *at the value chain level refers to the capacity of the value chain to promote on the market and add value to the products of MiFAS, making them more competitive with the products of specialised systems*“. Yet, the viability of alternative food value chains requires adaptation to the environment and the development of often radical agricultural innovations (Lamine, Meynard, Perrot, & Bellon, 2009). This implies a need for knowledge brokers to strengthen actors’ relationships (Earl & Scott, 1999; Quiédeville, Barjolle, & Stolze, 2018). The SNA tool makes it possible to identify and determine the role played by knowledge

[1] Report on multi-scale assessment framework for mixed farming systems.

brokers using the indicator of Betweenness centrality, which can be defined as the propensity of a central stakeholder to link unconnected members (Scott, 2000). However, actors with high betweenness may also be sources of vulnerability to the entire network if their removal significantly reduces some of the actors' interconnectivity (Cassidy & Barnes, 2012).

More generally, the importance of information flows, cooperation and financial links within networks of actors, in terms of systems' survivability, has been shown extensively in the field of cluster theory. A cluster is to be understood as a group of companies belonging to the same sector and situated close to each other (Storper & Harrison, 1991). The degree to which actors are clustered together can be measured by the Clustering Coefficient, using the SNA tool. As value chain related mixedness is most likely being obtained with smaller and more distributed infrastructures that allow for the valorisation of local and small-level production (as indicated in D6.1), the importance of those flows and links will most probably be explored within such types of networks.

Moreover, it has been shown that good supply chain flexibility is conducive to a high degree of system survivability (Aspara, Hietanen, & Tikkanen, 2010; Carayannis, 2008). As survivability implies the capacity to react to diverse disruptive events, the Distance between actors must be considered. The Distance can be measured using the SNA tool and equals the average number of actors an actor has to call on in order to reach another actor.

Sustainable Supply Chain Governance (SSCG) models classify value chains based on the measure of Centrality and Density while drawing inferences on the performance of these value chains (Vurro et al., 2010). A highly centralized organization can be either very negative or positive, depending on the level of Density. By contrast, a high Density is considered positive, regardless of the power of the central organization.

Moreover, to ensure a good survival capacity, a network must be able to adapt to the vagaries of its environment. This presupposes that actors within a network can cope with disruptions and be both flexible and highly reactive. The indicators of Robustness, Responsiveness, Flexibility and Adaptivity were proposed by Thadakamalla et al. (2004) to take account of the survival capacity of value chains.

In T4.4, we only considered the functional aspects of 'systemic sustainability'. As shown, the SNA can be particularly useful to that purpose. In parallel, SNA can be particularly useful for studying the dynamics in terms of network development, diffusion of related innovation and learning processes: A dynamic SNA can provide important insights into the diffusion/learning process by analysing the evolution of relationships among actors.

Whenever studying the dynamics is insufficient or impossible, one may evaluate the difference between the current state of the network with a counterfactual situation. The latter is a situation where, all other things being equal, the system studied would be less or not mixed at all. According to the counterfactual approach, an event X is thought to cause Y if X occurred and; if X had not occurred, Y would not have occurred. Thus, the counterfactual lies in the comparison of the factual observation (X causing Y) with the hypothetical situation where X had not occurred. Here, we would study the difference between two situations, one in which the farming system is not mixed or to a little extent, and the other where the farm has become more mixed, or the other way around.

3 Overall approach in CH, DK, AT, PT

First of all, it must be specified that the NL case was treated separately due to its specific nature. It was not justified nor feasible to follow the same approach as for the other cases-studies (CS). In this section, we present the overall approach that was undertaken in the other networks, i.e. in CH, AT, PT and DK. The approach is composed of 4 steps that are outlined in Table 3.

Table 3: The four steps of the overall approach undertaken in CH, DK, AT, PT.

	Activities	**Output**
Step 1:	Getting familiar with the approach	Background knowledge and planning
Step 2:	Preparation of the SNA & SSCG Survey	Surveys ready to be addressed to farmers
Step 3:	SNA related Data collection	Surveys' responses and overall understanding on actors' relationships
Step 4:	Workshop on Goals and Conflicts	Identified goals and conflicts, including in comparison to more specialised systems

3.1 Step 1: Getting familiar with the approach

Step 1 aimed at getting every MIXED project partner on board as to the approach to be undertaken to tackle Task 4.4 and analyse the social resilience of value chain systems in terms of their governance. This was important in order to empower the partners and better understand the relevance of the SNA related survey and workshop on 'Goals and Conflicts'.

3.2 Step 2: Preparation of the Social Network Analysis & Sustainable Supply Chain Governance Survey

Based on the framework, it was decided to design an SNA (Social Network Analysis) and SSCG (Sustainable Supply Chain Governance) type of survey to be addressed to farmers. The survey covered actors' relationships from a general perspective, meaning that we did not account for any specific type of actors' relationships. In order to compare (more) mixed with less or not mixed systems, the survey was designed in a way that would make this comparison possible. That is why, where possible, the survey encompassed two periods of time, including the current one (year: 2022) and either a past or possible future period (forecast based on scenario building). It must be emphasized that due to the diversity of cases and activities implemented by farmers, the periods considered were specific to each case based on the context and feasibility. A possible future period was only considered when no or little change had occurred in the previous years, meaning that no comparison could be made based only on real data. Such a forecast or scenario building was also highly dependent on whether and to what extent farmers could or felt comfortable to imagine a fictional future. In addition to the SNA & SSCG stricto sensu, a few questions focused on the capacity of farmers to withstand 'shocks', which can also be translated into the concept of Robustness.

The questions that were dedicated to farmers are specified in the next two pages. The specific SNA indicators that were computed based on responses from the questionnaire are mentioned in the next section.

Questions addressed to farmers

The texts appearing in the following brackets [ ] are explanations about the questions where necessary. The questions addressed directly to farmers start with a "q", while the questions starting with # had to be answered by the interviewer based on inputs provided by the interviewee. The # questions were important in order to define which period and/or scenario had to be considered in the subsequent questions. Depending on the responses given to the # questions, the subsequent questions were adjusted automatically in the Excel file.

q1. Did you experience any significant changes in your farm over the course of the last 10-15 years? YES/NO

q1.1. If yes, please explain briefly how.

q2. Do you sell some of your products directly to consumers? YES/NO

q2.1. If yes, which products (max. 5 main ones) and what percentage of those products are sold directly to consumer?

[In relation to q3, discuss with farmers to define periods of time corresponding to different state of farm diversity. For instance, one period could represent a high farm diversity and the other one a lower farm diversity. Each single period should be quite stable (no major change in terms of farm diversity). 'Period 2' refers to the current period, which should include the year 2022 (e.g. 2020-2022). Such a period, however, should not have experienced significant changes. Depending on the situation, 'Period 2' could also refer to a single year, which in this case would be the year 2022. In the same vein, where possible, 'Period 1' refers to a homogenous previous period, which is significantly different to 'Period 2' and not overlapping with it (e.g. 2010-2015)].

q3. Please specify time periods: Period 1 and Period 2 where your farm experienced/ operated with significant differences in operational diversity. Please briefly explain the differences in your operations/ farming diversification during these time periods.

q3.1. On average, how often do you interact with each of these actors, currently/ today? Please briefly explain your responses. [Document responses according to scale of 0 to 4, where 0=never, 1=infrequently (1x per 3 months), 2=sometimes (>1-3x per 3 months), 3=frequently (>1-3x monthly), 4=very frequently (>3x monthly)].

q3.2. On a scale of 0 to 5, where 0=none and 5=very high, what is the relevance of your interactions with each of these actors, currently/ today. [The relevance refers to the relevance for the system in place in the Period considered]. Please briefly explain your responses. [Document responses according to scale of 0 to 5, where 0=none, 1=very little, 2=little, 3=medium, 4=high, 5=very high]. [Please note: frequency of interactions does not need to be related to the relevance].

[Interviewer to assess in collaboration with the interviewee whether Period 1 and Period 2 exhibit significant differences, based on assessment questions]:

Is there a significant difference between Period 1 and Period 2? YES/NO

Is the farm currently well diversified? YES/NO

Is it possible, to diversify further? YES/NO

[If differences between Period 1 and Period 2 are not significant, pose scenario e.g. of adding trees (for currently more specialized farms) or e.g. abandon tree production (for currently more diversified farms)].

q4. Considering today's situation (Period 2), please reflect whether current relationships would be different if you would [add/develop or abandon] e.g. tree production (case dependent).

Specify how different current relations would be. Please mention any new relationships/ actors that you do not currently have.

[Repeat q3.1. and q3.2. for this scenario].

q5. What are your top three financially most important products sold?

q6. To whom do you sell each of these products?

q7. Now please imagine a current situation where each of these companies or outlet channels disappeared and/ or you could no longer sell to them.

q7.1. For each outlet channel, how easy or difficult would it be to change/ replace that outlet company? Please briefly explain your answer. [Document responses according to scale of 0 to 4, where 0=very easy, 1=easy, 2=difficult, 3=very difficult, 4=impossible].

q7.2. For each outlet channel, what would be the economic impacts on your business? Please briefly explain your answer. [Document responses according to scale of 0 to 5, where 0=none, 1=very little, 2=little, 3=medium, 4=high, 5=very high].

q8. Now let's imagine back again to [Period 1, or where applicable, scenario of e.g. adding trees or removing trees].

q8.1. Are there differences to the current time period with regard to whom/ where you sold (/would sell) each of the aforementioned top three financially most important products?

q8.2. For each product/ outlet channel this situation, are there differences to the aforementioned difficulty of changing the outlet channel, if it were to disappear and you could no longer sell your products there? Please briefly explain your answer.

q8.3. For each product/ outlet channel this situation, are there differences to the aforementioned economic impact on your business, if this channel were to disappear and you could no longer sell your products there? Please briefly explain your answer.

q10. Did you experience any significant issue (e.g. contracts, relationships, product refusal, etc.) in the last 10 years?

q10.1. Which decisions did you take? What were the consequences of those decisions on your farm?

q10.2. Do you think you recovered from the disruption? How long (approximately) did it take to recover from the disruption?

q10.3. If yes, how could your farm be improved/changed to avoid or better deal with such issues? Do you feel the diversification of your farm plays any major role here? Why?

3.3 Step 3: Social Network Analysis & Sustainable Supply Chain Governance data collection

The research includes structured, face-to-face or telephone interviews with farmers to collect qualitative insights around social resilience and semi-quantitative data to support a Social Network Analysis (SNA), a Sustainable Supply Chain Governance (SSCG) study, as well as an exploration into Robustness.

We planned to use SNA to measure the following indicators: network Density, network Centrality, Betweenness centrality and relationship strength, with qualitative questioning serving to rationalize quantitative results. As inputs to the SNA, and as shown by the questions specified in the previous section, farmers were asked to assess the frequency and relevance of interactions with actors they deemed important in their network at the time period considered. The SNA indicators are defined in Table 4. The indicator of Robustness, using inputs from "q10" questions block, was also considered. Robustness is defined as the capacity or strength to withstand stresses, disturbances and 'shocks' without loss of function.

Table 4: Social Network Analysis indicators and their definitions & implications

Indicator	Definition	How measured	Implications for resilience
Network Density	Relational thickness or strength of ties, thus cohesion[1]	SNA: total number of ties divided by the total number of possible ties[11] Qualitative context	High = usually positive; favors trust, common norms & information flow Can be negative, as it can also inhibit innovation because of uniformization of values and inhibit assimilation of external knowledge by actors[1,2]
Network Centrality	Power of a central organization	SNA: degree centrality of each vertex, which is number of vertices adjacent to a given vertex[11] Qualitative context	High = positive or negative based on density High centralization facilitates coordination among actors, but impedes learning[3]; Removal of central actors exposes network to vulnerabilities
Betweenness Centrality	Centrality of actors in the network[11]; How often an actor links otherwise unconnected actors[2]	SNA: betweenness between two vertices, which is number of times a vertex occurs on a geodesic[11]	High = greater influence in disruption[4]; however, average betweenness centrality suggested to have no correlated influence on reislience[7]
Relationship strength	Likelihood of relationship persisting over time[2]	Average frequency x relevance of interactions Specific qualitative questions	High = positive, as able to maintain relationships over time[2]
Robustness	Capacity/ strength to withstand stresses, disturbances and (un)anticipated shocks without loss of function[5,8]	Specific qualitative questions	High = positive; can sustain loss of some of its structures and functions Robustness a component of resilience and similar to buffer capacity[6]

Sources: [1] Lazzarini, Chaddad, & Cook, 2001; [2] Therrien et al., 2019; [3] Bodin & Crona, 2009; [4] Choudhary et al., 2021; [5] Meuwissen et al., 2019; [6] Stone & Rahimifard, 2017; [7] Kim et al., 2015; [8] McDaniels et al., 2008; [9] FAO, 2019; [10] FAO, 2018; [11] Freeman, 1979.

In addition, the SSCG questions were designed to assess farmers' ability to change outlet companies, thus indicating their level of adaptability. This ability to change was assessed by asking farmers to semi-quantitatively estimate the difficulty of changing outlet companies and the financial impact of changing outlet companies for their top three financially most important products sold in an imaginary scenario where their current outlet companies disappeared.

Both the SNA and SSCG exercises were done across "more mixed" and "less mixed" environments within the same farm, so that comparison analyses could be conducted. As such, the SNA questionnaire was designed in a way that more and less mixed environments could be determined by asking the interviewed farmers to describe a past time where they operated at a different level of mixedness or hypothetical future period where they would operate with a different level of diversification through the addition or removal of a certain production (e.g. fruit trees) depending on the specifics of the case.

Given that operating in a mixed way is rather new in most of the different networks, it was highly difficult to assess the current status. It must be emphasized that in the Swiss case there has been a long-standing mixedness in farming. Most of the Swiss farms interviewed always operated in their current way and thus could not compare to a time on their farm when they actually operated with a different level of mixedness. This means that for the Swiss farms, their current period had to be compared with a hypothesized future period where they would be more or less mixed depending on what made more sense in terms of feasibility in each farm considered. Furthermore, due to the long-standing mixedness of Swiss farms and specifically Hochstamm Suisse network farms, the SNA and SSCG comparisons were also made at an additional level of analysis: The present-day level of mixedness. Farmers were categorized as being **currently** “more mixed” if their management of high-stem trees included the integration of crops and/ or livestock, or **currently** “less mixed” if they specialized on the production and sale of agricultural products from the high-stem trees that they manage; of the 22 Swiss farms involved in the study, 11 were classified as “more mixed” whilst the remaining 11 were considered “less mixed”. More details are provided in Table 17 in Annex.

Table 5: Number of farmers interviewed in each network for the governance study

Network	CH	AT	DK	PT	Total
# Core farmers	6	6	5	6	**23**
# Additional farmers	16	*n/a*	*n/a*	4	**20**
# Total	22	6	5	10	**43**

3.4 Step 4: Goals and ‘Conflicts’ Analysis

It was decided to perform a goals and ‘conflicts’ analysis in order to complement the SNA & SSCG research. To do so a workshop was organized with stakeholders in CH, AT, and PT. In DK, an individual farmers’ survey, tackling the same matters, was circulated instead due to a lack of time from participants.

The approach used for the workshop was inspired from the Structured Decision Making (SDM) approach (Conroy et al., 2008; Fatorić & Seekamp, 2017; Gregory et al., 2012; Gregory & Keeney, 1994; Ogden & Innes, 2009). The latter allows the identification of stakeholders’ objectives as well as the analysis of these objectives against the background of opportunities, uncertainties and constraints. The different stages constituting the developed approach are specified in the subsequent sections.

The approach aimed at identifying the common goals, the known or potential issues not already acknowledged, as well as observing how stakeholders manage to find collective solutions or whether significant disagreements occur. To make observations possible on whether and how stakeholders are able to find collective solutions, the workshop endeavoured to identify such potential solutions according to stakeholders’ views while gathering insights on what could be their effects. This also implied that a diversity of views on problems and solutions had to be reached in order to allow participants to critically assess different opinions. The workshop (ca. 2 hours) involves some farmers and experts & value chain actors.

Table 6: Number of participants for the Goals and 'Conflicts' analysis in each network

Network	CH	AT	DK	PT	Total
# Farmers	12	3	8	8	**31**
# Value chain actors / experts	6	3	*n/a*	9	**18**
# Total	18	6	8	17	**49**

3.4.1 Stage 1: Rationale and objectives of the workshop

This first stage consisted of a presentation by the organisers of the workshop in three stages:

a. Outline the interest to participants themselves:
   - To identify solutions on problems related to actors' relationships along the value chain (incl. farmers);
   - To assess the effects of the solutions on the different dimensions of sustainability and in relation to the goals of the participants.
b. Outline expected outcomes for participants:
   - To develop and also contribute knowledge on possible solutions to such existing or potential problems related to actors' relationships along the value chain;
   - To be better prepared for possible future problems related to actors' relationships along the value chain.
c. Ask for feedback:
   - To ask participants to feedback and comment;
   - To get approval from participants on the design of the workshop.

3.4.2 Stage 2: Stakeholders' objectives

This second stage aimed at defining what "matters" to stakeholders in relation to their business and the mixed system being considered. In other words, stakeholders were asked here to formulate what their objectives are. These could be for instance to maximise their incomes or to be particularly cautious on some aspects of sustainability. The following possible categories of objectives were considered when reflecting upon objectives: Social, Economic, Environmental, Political and Technical. However, there was no need to come up with objectives for each of those categories. Two sub-stages were completed:

a. Examples of objectives were presented and explained to participants;
b. Participants then reflected individually on what "matters" for them. The main objectives were communicated to the whole audience and written down by the organizers.

3.4.3 Stage 3: Problems related to actors' relationships

This stage consisted of identifying problems related to actors' relationships along the value chain. Where applicable, it was based on the results of the SNA and SSCG questionnaire. In some cases, existing relevant results from the already completed WP1 workshops were utilized as basis as well.

Each CS Team presented the main already identified issues to the attendance. The attendants were then asked whether there are any other key problems, including potential ones that could occur.

3.4.4 Stage 4: Identification of solutions

This fourth stage aimed at identifying potential solutions to the key identified problems. It consisted of asking participants to identify solutions to the key identified problems. Where possible, the likely effect of the key identified solutions was discussed. It must be emphasized here that we were less interested by the effects themselves than by how stakeholders, agree or disagree on (possible) solutions.

3.4.5 Stage 5: Summary and feedback

This last stage of the workshop itself addressed the following points:

a. To make a summary on the outcomes of the workshop;
b. To ask participants to react to that summary, with the opportunity to add other points;
c. To ask participants to give any other feedback.

4 Data Analysis in CH, DK, AT, PT

4.1 Overview

In the Swiss case, SNA data scores for frequency and relevance of interactions with network actors in both more and less mixed environments / scenarios were analysed using UCINET 6.0 by Analytic Technologies.

The other cases (except NL) were considered differently since (1) it was more challenging to compare two different situations in terms of mixedness on each farm, and (2) recruiting more farmers (in addition to the MIXED "core farmers") either did not make sense due to a lack of mixed farmers, or was restricted by financial resources already used for the considerable core data collection in WP2. In many situations, it was highly difficult for farmers to imagine a scenario where they would be more or less mixed compared to the current state of mixedness on their farm. Given the limited data, it was therefore decided not to conduct a traditional SNA analysis for those cases but to compare the scores on frequency and relevance of relationships between mixed and less mixed situations using statistical tests. Depending on the distribution of data, we used a paired t-test and/or a Kruskal-Wallis test to determine whether there are any significant differences between the two environments (mixed vs. less mixed), and used qualitative insights to try to explain the underlying reasons.

In all cases (except NL), data from semi-quantitative interviews was transferred into summary tables in Microsoft Excel, cleaned and transformed into matrices required as input format, for the statistical (all cases) or UCINET analysis (Swiss case). Separate matrices were created for frequency of interactions (scale of 0 to 4), relevance of interactions (scale of 0 to 5) and frequency multiplied by relevance of interactions (scale of 0 to 20) in both more and less mixed environments.

In every networks (except NL), SSCG data for ease of changing outlet company and financial impact of changing outlet company for farmers in both more and less mixed environments / scenarios was compiled in Microsoft Excel and analysed in Stata17. Additional analyses were conducted, splitting the data by farmers assessed by current management method in the Swiss case, comparing organic with conventional.

The SNA and SSCG results then served as inputs and discussion starters in the workshop in each network except for NL. Outputs of the workshop, in turn, served to bolster and rationalize interview findings. An assessment of how and how well the actors worked together during the workshop to create solutions to problems served as qualitative insight into conflict and collaboration in the value chain and to create recommendations on how actors in the value chain can operate with greater social resilience in the future. Perceived conflict or collaboration between specific actors or groups of actors was also documented for analysis purposes.

4.2 Descriptive Sustainable Supply Chain Governance in the Swiss case

As already mentioned, the ability to change outlet companies was assessed by asking farmers to semi-quantitatively estimate the difficulty of changing outlet companies and the financial impact of changing outlet companies taking an imaginary scenario where their current outlet companies disappeared. Given the relatively large size of the sample that was made possible in Switzerland, this was not only analysed statistically (see result section) but also in a more comprehensive manner. In fact, the openness of farmers and diversity of farms involved as well as the split between organic versus non-organic made this possible.

4.3 Statistical tests on farmers' relationships and Sustainable Supply Chain Governance

4.3.1 Sustainable Supply Chain Governance

Statistical paired t-tests and Kruskal-Wallis tests were done using Stata17 in order to compare the easiness of changing outlet (score of 1 to 5, with 5 being the highest possible difficulty) and the ensuing possible economic impacts (score of 0 to 5, with 5 being the highest possible negative impact) between a "more mixed" (MM) and "less mixed" (LM) environment. The rationale for also conducting Kruskal-Wallis tests is that the normality of data distribution is questionable. Such tests were also done to compare the multiplied score of easiness of change by the economic impacts (score of 0 to 25) in MM versus LM environment. For each item, the lower the score the better, but it only makes sense to determine whether values are relatively different between MM and LM and not to assess the absolute values because each farm and network is different.

Overall, these tests were done by pooling all the networks together as well as for each single network. The rationale for also running the tests in each individual network is that networks are quite specific in terms of the assessed system within its own context and also that the number of observations deviates substantially between networks.

4.3.2 Actors' relationships: Frequency & Relevance (based on SNA data)

In terms of the frequency and relevance of actors' relationships, the same procedure as for SSCG was followed except that only Kruskal-Wallis tests were conducted. The rationale is that data are not normally distributed.

5 Results in CH, DK, AT, PT

5.1 Social Network Analysis and descriptive Sustainable Supply Chain Governance in the Swiss case

5.1.1 Social Network Analysis in the Swiss case

5.1.1.1 Network Density (Swiss case)

Using the data collected from the 22 farmers interviewed, the network Density was calculated, showing a difference of 12.5% greater network Density in a more mixed environment. However, this higher Density means that in a more mixed environment, farmers are mentioning, i.e. reliant on, more of the same actors. This is reflected in the SNA data, whereby overall greater count of actors is mentioned by all farmers when operating in a less mixed environment than when in a more mixed environment, although the count of unique actors is lower: 139 unique actors in a more mixed environment vs 147 in a less mixed environment. This means that when in a more mixed environment, farmers are mentioning more of the same actors, resulting in a more specific network. The main contributors to this trend are the lower count of unique distributors, news and media channels and suppliers when operating in a more mixed environment. Network drawings in Figure 1 and Figure 2 of both environments help to visualize this.

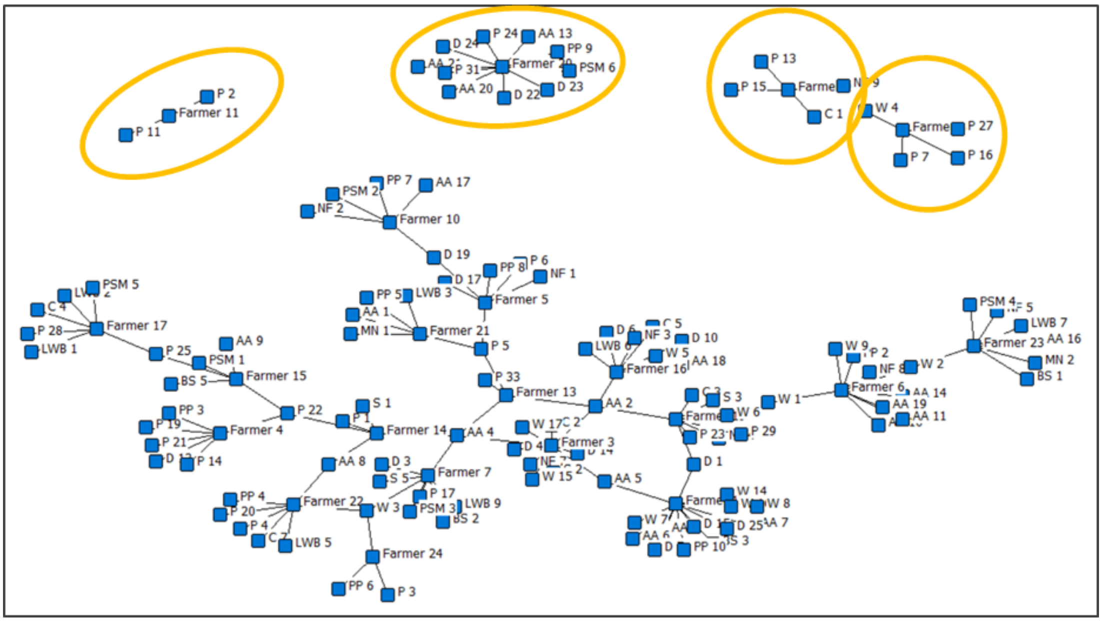

Figure 1: Network drawing of more mixed environment in the Swiss case

Note: Interviewed farmers are listed as "Farmer" with their ID number, and actors in their network that they mention during interviews are labelled with their actor category and ID. AA = Associations and Advisors, B = Farms, C = Direct consumers, D = Distributors, LWB = Agricultural schools, NF = Networked or colleague farmers, MN = News and Media, P = Processors, PSM = Plant protection services, PP = Public policy, W = Retailers, S = Suppliers.

Farmers are connected to the actors they mentioned during interviews. Commonalities in mentioned actors are seen in the lower half of the diagram, whereby nodes are connected into a network. Four farmers, circled in yellow in the upper half of the diagram, appear disconnected from the larger network and from each other, as they do not mention any of the same actors to which they are connected to.

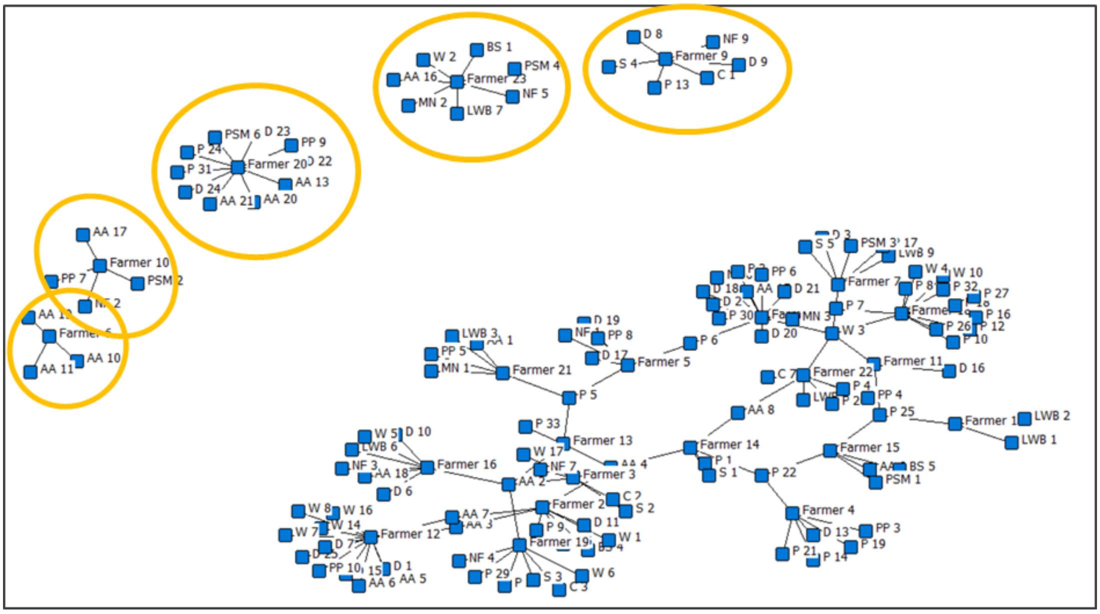

Figure 2: Network drawing of less mixed environment in the Swiss case

Note: Interviewed farmers are listed as “Farmer” with their ID number, and actors in their network that they mention during interviews are labelled with their actor category and ID. AA = Associations and Advisors, B = Farms, C = Direct consumers, D = Distributors, LWB = Agricultural schools, NF = Networked or colleague farmers, MN = News and Media, P = Processors, PSM = Plant protection services, PP = Public policy, W = Retailers, S = Suppliers.

In a less mixed environment, it is seen that 5 farmers appear to be disconnected from the network, meaning these farmers are mentioning unique actors that are not mentioned by other interviewed respondents. However, this does not necessarily mean that additional connections do not exist as not all actors mentioned could be interviewed. Additionally, it must be kept in mind that some farmers’ less mixed environment was a past time period, while other respondents’ less mixed time period is today.

Between the two environments, not only does one additional farmer become disconnected from the broader network, but the composition of those farmers who are mentioning the same actors has changed, given that Farmer 18 and Farmer 11 in their less mixed environment mention importance of network actors that other respondents mention as well.

5.1.1.2 Network Centrality (Swiss case)

Calculated network Centrality from the SNA analysis conveys a difference of 7.7% greater network Centrality in a more mixed environment. In addition to the average Degree of individual connections, we show the average of the weighted Degree for categories of actors (Table 7). Weighted Degree is a count of the number of connections a respondent mentioned, weighted by the frequency and relevance of those interactions. The calculation, provided by the UCINET software, simply takes account of the score that was defined by each respondent in terms of their relationships with the other actors. Alongside the weighted Degree, we calculated the Eigenvector, a specific measure of influence of a node in a network (Zaki and Meira, 2014). It shows distance of actors from centres of power and helps to identify those with wide-reaching influence (Shaw, 2019). Given individual farmers were interviewed, rather than all actors in the network, Eigenvector is actually a measure of how important a particular actor is to the overall network, whereas average Degree is a measure of importance of a particular actor to the individual farmers who mentioned that actor. In this context, we believe that the use of Eigenvector, coupled with average weighted Degree, builds a more robust picture of influential actors.

Table 7: Network Centrality results in the Swiss case

	More Mixed Environment / Scenario				Less Mixed Environment / Scenario			
	Mean FxR Weighted Degree (% of total)	SD of Mean FxR Weighted Degree	Count of Unique Actors	Eigenvector (% of total)	Mean FxR Weighted Degree (% of total)	SD of Mean FxR Weighted Degree	Count of Unique Actors	Eigenvector (% of total)
Assoc. & Foundations	10%	6.686	19	17%	10%	8.501	19	43%
Tree farms	11%	7.141	4	100%	10%	7.000	3	0%
Consumers	8%	5.913	6	1%	7%	3.937	5	2%
Distributors	10%	5.444	15	55%	9%	4.929	21	95%
Agricultural schools	7%	3.958	7	0%	6%	3.039	7	2%
News & Media	6%	1.414	2	0%	6%	1.155	3	71%
Colleague farmer	6%	3.852	8	1%	9%	4.027	8	100%
Processors	9%	5.734	25	1%	10%	5.226	29	62%
Regional govt offices	10%	5.718	9	13%	6%	5.285	8	63%
Plant protection	7%	3.445	6	0%	7%	4.416	5	1%
Suppliers	5%	2.630	4	1%	8%	5.941	5	1%
Retailers	12%	6.685	13	68%	12%	6.468	7	23%

Legend Assoc.=Associations; govt=government; FxR=frequency multiplied by relevance of interactions; SD=Standard deviation; Green=main ideas discussed

Investigating averages of connections to categories of actors, not individual actors, we observe highest weighted Degree for retailers, tree schools, regional government offices and distributors in a more mixed environment. The interviewed farmers mentioned more heavily relying on advice and information from their local or cantonal government advisory offices, as more guidance, confirmation against regulations, or joint projects to further rare species is required specifically when starting new business enterprises.

In a less mixed environment, highest average weighted Degree is assigned to retailers, processors, associations and foundations and then tree farms. The importance of processors here conflicts with qualitative statements, whereby less mixed farms, due to their specialization on their products, are more likely to have in-house, on-farm processing capability. Eleven of 22 farmers interviewed state having in-house processing capabilities of raw products on the farm. The fact of having in-house processing would typically decrease the average importance of external processors, but instead the opposite trend is seen per the SNA data, whereby processors on average exhibit high weighted Degree.

The appearance of retailers as the highest weighted Degree in both environments shows the high prevalence of direct sale and interactions with end retailers, big and small, rather than many intermediaries before reaching final sale. These direct sale interactions between farmers and retailers in Switzerland is also confirmed by value chain stakeholders, whereby one large retailer mentions selling products purchased directly from small, local farms for their regional section of the supermarket. When more intermediaries, like distributors, enter the picture, farmers express concern around lack of control in contracts in terms of quantity and quality requirements and limited control in pricing (4 of 17 farmers who mention challenges in the value chain). This may suggest that due to high-stem fruit trees often serving as a side income for more mixed farmers, they are less likely to diversify their outlet channels and rely on distributors to further sell their fruits to gastronomy business, retailers and sales channels. This suggests that more mixed farmers may be more likely to subject themselves to the mass-market for fruits, which means more intermediaries, less direct sale interactions and thus lower control over prices, which indicates lower social resilience.

The influence of frequency and relevance of interactions as factors on the overall average weighted Degree for each category of actors is displayed in Table 8. No obvious trend is seen, however, actor categories with the greatest difference of weighted average Degree between more and less mixed environments see frequency of interactions more often as the main driver contributing towards that average.

Table 8: Contribution of frequency and relevance to overall average weighted Degree in the Swiss case

	More Mixed Environment		Less Mixed Environment / Scenario		Comparison Calculations		
	Mean F Weighted Degree	Mean FxR Weighted Degree	Mean F Weighted Degree	Mean FxR Weighted Degree	% Diff in F Weighted Degree	% Diff in FxR Weighted Degree	Biggest Driver of Difference
Assoc. & Foundations	2.579	8.47	2.632	8.47	-2%	0%	NA
Tree farms	2.000	9.5	2.000	8	0%	16%	R
Consumers	2.833	6.83	2.400	6	15%	12%	F
Distributors	2.800	8.93	2.429	7.1	13%	20%	F and R
Agricultural schools	2.429	6	1.857	4.71	24%	22%	F
News & Media	3.500	5	3.667	4.67	-5%	7%	R
Colleague farmer	2.125	5.375	2.375	7.25	-12%	-35%	F and R
Processors	2.360	7.72	2.759	8.38	-17%	-9%	F
Regional govt offices	2.556	8.78	1.750	5.25	32%	40%	F
Plant protection	1.833	5.67	1.800	6	2%	-6%	R
Suppliers	1.500	4.25	1.800	6.4	-20%	-51%	F and R
Retailers	3.385	10.23	2.583	9.71	24%	5%	F and R

Legend Assoc.=Associations; govt=government; F=frequency of interactions; R=relevance of interactions; FxR=frequency multiplied by relevance of interactions; Diff=difference; Green=main ideas discussed

Again, analysing averages of a category of actors, in a more mixed environment, farms on average have highest Eigenvector centrality. This means that farms have the widest-reaching influence in a more mixed environment. This is not entirely consistent with qualitative statements, whereby farmers mention that farms become more important for advice and guidance specifically when planting new trees. Though, absolute values for Eigenvector centrality show next highest influence of retailers and then distributors in a more mixed environment. Similar to average weighted Degree, this conveys the direct influence of retailers among farmers' interactions.

5.1.1.3 Betweenness centrality (Swiss case)

According to the SNA analysis, more mixed environment results in 6.5% higher average Betweenness centrality than a less mixed environment. Table 9 provides an overview of Betweenness centrality averaged by actor category and top-ranking individual actors.

Table 9: Average Betweenness centrality by actor category; and top-ranking actors in each environment in the Swiss case

	Average Betweenness Centrality by Actor Category	
	More Mixed Environment	Less Mixed Environment
Assoc. & Foundations	385	365
Tree farms	0	0
Consumers	0	0
Distributors	67	0
Agricultural schools	0	0
News & Media	0	0
Colleague farmer	0	0
Processors	159	146
Regional govt offices	0	0
Plant protection	0	0
Suppliers	0	0
Retailers	225	183

Top-Ranking Actors in each Environment				
Environment	Rank	Actor ID	Actor Details	Betweenness Centrality
More Mixed	1	AA4	Label organization	3285
More Mixed	2	AA2	Research institute	2768
More Mixed	3	P22	Regional cidery	1715
More Mixed	4	P5	Regional cidery	1623
More Mixed	5	R1	Large retailer	1568
More Mixed	6	AA5	Label organization	865
Less Mixed	1	AA4	Label organization	2925
Less Mixed	2	R3	Large retailer	2192
Less Mixed	3	AA2	Research institute	1461
Less Mixed	4	AA8	Cantonal fruit union	1374
Less Mixed	5	P5	Regional cidery	1366
Less Mixed	6	P22	Regional cidery	1104

On average, actors with the highest Betweenness in both more and less mixed environments are associations and foundations. This is well illustrated by an interviewed respondent who farms high-stem nut trees. Due to Swiss-produced nuts being newer to the market and considered a specialty product, the knowledge and expertise is concentrated among a few key actors in the network, like labelling organizations and nut collection/ washing stations.

The above is consistent with the fact that one of the label organizations exhibit the highest Betweenness level in both environments, whereby the label provides the value add that allows higher price or even access to certain retailers and distributors. The highest-ranking label organization is also mentioned as becoming more important upon planting new trees, whereby the organization serves as an advisor and sometimes investor. Next highest average Betweenness by category of actor in both environments are retailers, followed by processors. Interestingly, neither of these mentioned processors are the same as the large cidery who has made significant investments in the high-stem fruit market, showing that interviewed farmers may not specifically recognize the role of this processor in the market, likely because they deliver their cider fruits to third-party collection stations and do not conduct any direct interactions with this actor.

Second highest Betweenness value for an individual actor in a more mixed environment is a research institution, which interviewed farmers use as a lender of machinery and also as an advisor/ supporter in the planting of rare species. This same actor exhibits third highest Betweenness centrality in a less mixed environment.

Second highest value in a less mixed environment is a large agricultural retailer that also serves as a supplier and distributor. The high Betweenness of this actor may be due to its multiple influences throughout the network, as interviewed farmers use this actor as a supplier of their agricultural inputs, as a distributor (collection station) for their fruits and as a retailer for sale of their final products in the regional section of the store. Interestingly, this actor also displays high Betweenness in a more mixed environment, but is the eighth highest value. This may be due to the fact that in a less mixed environment, this retailer is a main source for inputs, specifically pig feed and cereal seeds, and as a collection station for cider apples, which as previously discussed, is more likely to apply to less mixed farmers.

5.1.1.4 Relationship strength (Swiss case)

Using the mathematical average of frequency and relevance of interactions with actors in the network as a proxy for relationship strength, shows minimal difference in relationship strength between the two environments, with a more mixed environment average 2.4% higher frequency and relevance of interactions. This could mean slightly higher frequency of interactions with actors in the network and higher relevance of information exchanged during those interactions when operating in a more mixed environment.

Qualitative statements provide a more obvious result, whereby of the ten farmers interviewed who have diversified more compared to their past, six claimed (out of 6 providing comments) that relationships have become more important and tighter compared to their less mixed past, or would become more important in a scenario of more diversification. Though this could be due to present day requiring stronger relationships and more frequent interactions compared to the past, the fact that interviewed farmers who have moved in a direction of specialization do not agree on whether relationships have become more or less important, conveys that it is not necessarily a time period difference. This shows that more farm diversification seemingly requires more frequent interactions with higher importance/ relevance of interactions.

5.1.2 Descriptive Sustainable Supply Chain Governance in the Swiss case

5.1.2.1 Sustainable Supply Chain Governance in less vs more mixed environments in response to value chain shocks and challenges (Swiss case)

The adaptability (used as synonym to SSCG) of farmers operating in both environment, more mixed or less mixed, is similar and deemed on average “easy”, with a change in outlet companies 10% more difficult in a more mixed system. Economic impact of changing outlet companies shows even less variation, being only 2% higher negative impact in more mixed. Table 10 provides an overview of these results, including the correlation of results.

Table 10: Overview of Sustainable Supply Chain Governance results by more and less mixed environments/ scenarios in the Swiss case

	More Mixed Environment / Scenario			Less Mixed Environment / Scenario			% Difference More vs Less Mixed		
	Mean Ease of Change (EoC)	Mean Economic Impact (EI)	Mean EoC x EI	Mean Ease of Change (EoC)	Mean Economic Impact (EI)	Mean EoC x EI	Mean Ease of Change (EoC)	Mean Economic Impact (EI)	Mean EoC x EI
Overall	**1.2**	**1.6**	**3.5**	**1.1**	**1.6**	**3.2**	10%	2%	9%
Correlation EoC:EI	0.80			0.76					
Corr. More to Less Mixed							0.90	0.98	

Legend EoC values: 0=very easy, 1=easy, 2=difficult, 3=very difficult, 4=impossible; EI values: 0=none, 1=very low, 2=low, 3=medium, 4=high, 5=very high

Interesting results are also seen when splitting the data by products (Figure 3) and type of outlet channel (Figure 4). Consistent with qualitative statements, cherries for fresh consumption and specialty or niche products like labelled (e.g. organic) meat products, nuts and prune plums experience the most difficulty and highest economic impacts of changing outlet companies, both in more and less mixed scenarios. Cherries for fresh consumption have specific quality expectations from buyers and very limited storage life, making short transport distances critical. This, in turn, results in the difficulty of changing outlet channels.

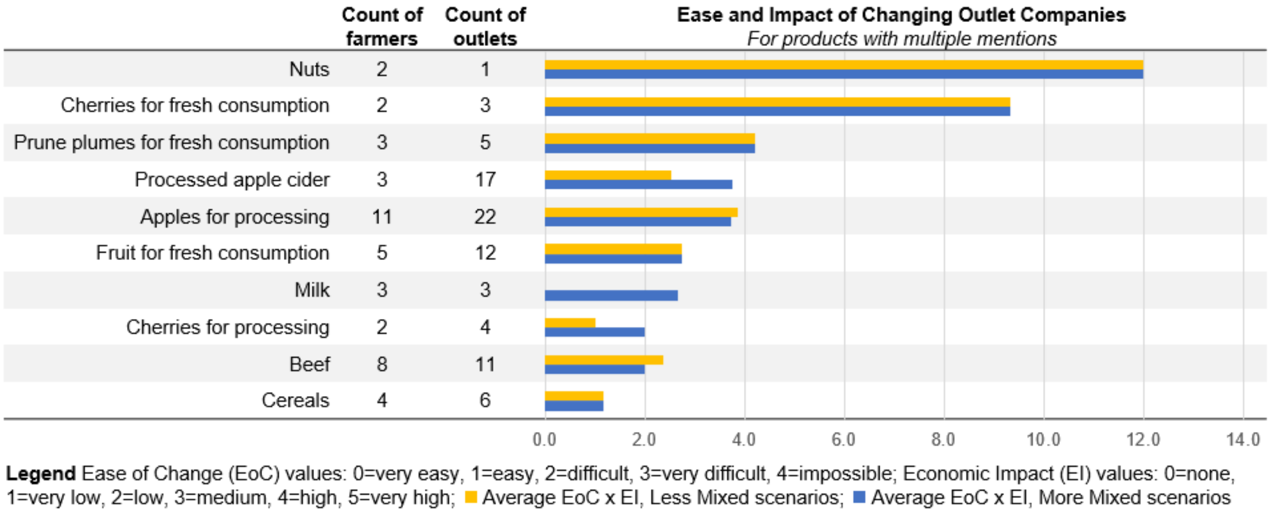

Figure 3: Sustainable Supply Chain Governance results split by product for products that were mentioned more than one time by Swiss farmers as a whole

With regard to products, biggest differences between more and less mixed scenarios can be seen among cherries for processing, processed apple cider and milk; however, all of these differences are due to time period, rather than level of mixedness differences. Of the farmers mentioning a difference in ease of changing outlet companies between past and present (10 of 22), 8 mention time-based rather than mixedness differences, namely that everything was more difficult in the past. This was due to a higher reliance on their farming income in the past, less flexibility in contracts, lower demand for high-stem fruits, lack of organizations promoting the value of high-stem fruit products and less variety of outlet channels/ companies. Similarly, 2 farmers discuss cherries for further processing, one of whom states no differences in ease or financial impact between environments, and the other respondent providing a time period difference, whereby in the past there were less distilleries of organic cherries, resulting in more difficulty to change outlets in his more mixed past.

Splitting the data by type of outlet channel (Figure 6), some differences are seen between systems. It appears that changing processors and consumers, meaning direct-to-consumer sales, is around 15% more difficult in a more mixed system, though still deemed as relatively easy in both environments. Again, these results need to be caveated with the impact of time period differences. Of the 16 respondents providing processors as outlet channels, 4 provide a difference in their response between more and less mixed operating environments. Though, all farmers mentioning a situation where cider fruits would need to be delivered to a different cidery, state high financial impact, since changing processors would mean finding a non-regional cidery and thus longer transportation routes, costing more. Additionally, farmers with personal relationships built around their processors and buyers state concern if they needed to change outlet channels, as this would force them into more of a commodities market, required to meet quality and quantity requirements of contracts with more standard outlet channels.

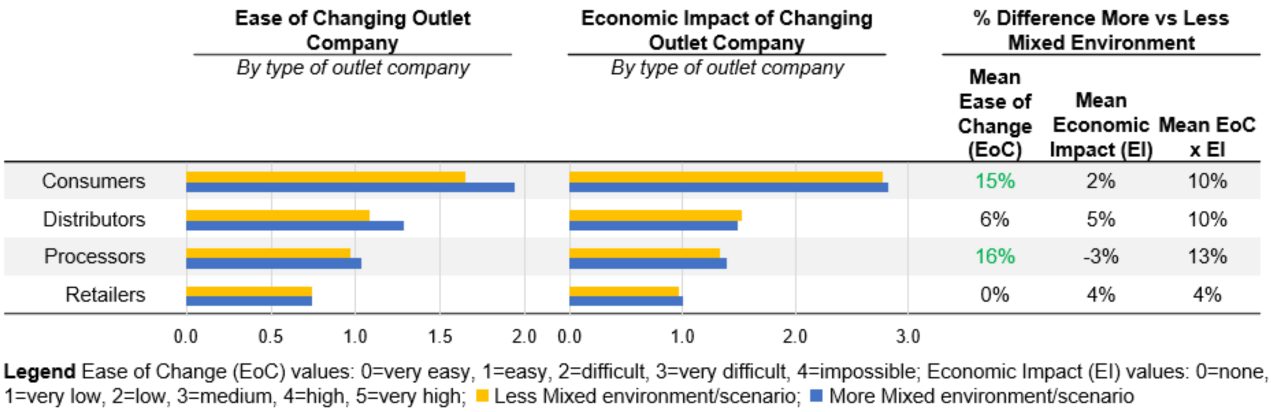

Figure 4: Sustainable Supply Chain Governance results split by type of outlet channel in the Swiss case

Of the 11 farmers using direct-to-consumer sales as an outlet channel, only 2 provide a difference in their response between more and less mixed operating environments that are not time period based. Two respondents claim that in a more mixed operating environment, it is more difficult to sell the greater variety of products to wholesale, thus raising the importance and reliance on direct-to-consumer sales. As one mixed farmer who produces and sells 200 different varieties of pumpkins elucidates, it would be impossible to replace the direct marketing outlet channel. The extent of variety within his pumpkin offering makes it impossible to sell to distributors or retailers as they are not interested in this lack of standardization and variety.

Seven of 22 interviewed farms mention a change in the direction of more direct marketing today. Four of these have moved in a direction of more diversification, suggesting that a focus on direct sales may be a result of diversifying, rather than a time period difference. Additionally, interviewed farmers state that they receive higher prices for direct marketed products and as such, would experience a higher financial impact if the ability to conduct direct marketing disappeared, since they would receive lower prices through other channels.

Overall, respondents disagree around which operational mixedness, more or less mixed, is more resilient. Three of 22 farmers state that more mixed operations means that it is easier to change outlet companies, because their operations are more diverse, thus they are less reliant on individual outlets and able to absorb challenges with gains in other enterprises. Four of 22 farmers explicitly describe that more mixed operations mean that it is more difficult to change outlet companies because, from their experience, greater diversification at farm level implies upscaling operations, resulting in a larger and more professional operation, thus requiring more embeddedness with outlet companies.

5.1.2.2 Sustainable Supply Chain Governance in currently less vs currently more mixed farms in response to value chain shocks and challenges (Swiss case)

Splitting responses by **currently** more mixed and currently less mixed respondents provides interesting results, though the data is more limited, as only those products and outlet channels could be included in analysis that are mentioned by both currently more and currently less mixed farms during the SSCG exercise.

Table 11: Count of outlet channels by **currently** more and less mixed farmers in the Swiss case

	Currently More Mixed Farmers		Currently Less Mixed Farmers	
	Count	Average per farmer	Count	Average per farmer
Total outlet companies	**45**	**4.1**	**67**	**6.1**
Total unique	*35*		*39*	
Consumers	8	1.3	9	1.8
Distributors	10	1.3	21	3.5
Processors	11	1.4	15	1.9
Retailers	7	0.9	20	3.3

As shown in Table 11, **currently** less mixed farmers interviewed tend to mention more outlet companies for their top three most financially important products, averaging 6 companies mentioned per **currently** less mixed farmer vs 4 companies mentioned per **currently** more mixed farmer. Despite an equal count of currently less and more mixed farmers interviewed, this amounts to a total of 67 outlet companies mentioned by currently less mixed farmers vs only 45 mentioned by currently more mixed farmers.

Based on SNA responses, a more mixed environment resulted in a denser, but more specific network. A similar trend is seen here with outlet channels mentioned, whereby currently more mixed farmers, despite having greater product diversity, mention fewer outlet channels. These findings indicate that, on average, less mixed farmers diversify through more outlet companies for the same number of products than do more mixed farmers, who appear to rely on fewer outlet channels for individual products. This is again consistent with qualitative statements, whereby more mixed farmers are less reliant on the income from a single business arm and thus are less concerned with poor yield of one product in a given year and place less emphasis on their high-stem apple trees, often selling their cider apples into the mass market via collection stations. Less mixed farmers, on the other hand, show more reliance on the products on which they specialize, and thus tend to diversify their outlet channels for the same product. This is elucidated by one respondent, who produces only apples, yet these are of 50 different rare species varieties and are processed into unique specialty ciders, vinegars or spirits, thus requiring a tailored and diverse marketing and sales strategy. "*If we had even more [trees], we would need to sell even more through direct marketing and would need to find new, unique outlet channels. Until now, we've been able to grow our sales channels in step with our enterprise, like the additional of [a farm-to-table cooperative]*". The diversification at product level of more mixed farms indicates more social resilience, while the lesser diversification in their outlet channels for one product decreases social resilience, and vice versa for less mixed farmers.

Table 12: Overview of Sustainable Supply Chain Governance results by currently more and less mixed farmers in the Swiss case

	Currently More Mixed Farmers			Currently Less Mixed Farmers			% Difference Currently More vs Less Mixed Farmers		
	Mean Ease of Change (EoC)	Mean Economic Impact (EI)	Mean EoC x EI	Mean Ease of Change (EoC)	Mean Economic Impact (EI)	Mean EoC x EI	Mean Ease of Change (EoC)	Mean Economic Impact (EI)	Mean EoC x EI
Overall	1.1	1.8	3.2	1.1	1.4	3.2	2%	24%	1%

Legend EoC values: 0=very easy, 1=easy, 2=difficult, 3=very difficult, 4=impossible; EI values: 0=none, 1=very low, 2=low, 3=medium, 4=high, 5=very high

As shown in Table 12, the average ease of changing outlet companies is only 2% higher for currently more mixed farms. Economic impact of changing outlet companies is 24% greater for currently more mixed farms, on average considered “low” impact for currently more mixed farms, while considered between “very low” and “low” for currently less mixed farms. The higher values for currently more mixed farmers may be reflected in the fact that of the 17 of 22 farmers interviewed who mention any challenges in the value chain within the last 10 years, a greater percentage (10 of these 17) are currently more mixed farms. Issues with value chain stakeholders mentioned more frequently by more mixed farmers include limitations in contractual requirements in cider fruits like binding contracts, specific quantity and quality requirements and limited control in pricing, challenges in the cherry supply chain. Similar values for ease of change can be explained by the trend that on years with low price or poor yield, specifically for farmers who do not rely on this income (often more mixed farms), they do not harvest in such years and leave fallen fruits on the field. As such, they may experience a financial impact in such a year but do not experience any difficulty with outlet channels because they have limited product to sell. This tendency is a key challenge mentioned during the workshop across types of participants. This habit results in large product fluctuations available to processors, where in poor yield years an even lower quantity of apples reaches collection stations. Additionally, value chain actors express concern that more mixed farmers, due to their diversification of products and lower reliance on income from high-stem fruit trees, do not always appropriately maintain the high-stem trees on their farms. “*The whole system built up around cider fruits is very unique. Cider fruit is often a side income for farmers, so the fruits aren’t always harvested*”.

5.2 Statistical analysis on farmers' relationships and Sustainable Supply Chain Governance

5.2.1 Farmers' relationships: Frequency & Relevance

As the Swilk test indicated that most data was not normally distributed across networks, only the non-parametric Kruskal-Wallis test was performed here. In that context, Table 13 first displays the mean scores for frequency and relevance in both more and less mixed environments. Frequency can have a score from 0 to 4, relevance from 0 to 5, and frequency multiplied by relevance from 0 to 20. The results of the Kruskal-Wallis test are then presented in Table 14.

Table 13: Descriptive statistics: Frequency & Relevance of farmers' relationships

Category	Country	All	AT	DK	PT	CH
	Variable / diff	Mean				
Frequency	f_mm	1.966	3.000	1.857	3.121	1.685
	f_lm	1.857	2.231	0.500	3.061	1.713
	diff	0.109	0.769	1.357	0.061	-0.028
Relevance	r_mm	2.748	3.231	3.643	4.303	2.354
	r_lm	2.555	2.615	0.643	4.424	2.354
	diff	0.193	0.615	3	-0.121	0.000
Frequency by Relevance	f_r_mm	6.878	10.769	7.429	14.182	5.197
	f_r_lm	6.353	8.692	2.214	14.091	5.073
	diff	0.525	2.077	5.214	0.091	0.124
Observations		238	13	14	33	178

When pooling all networks data together, the scores for frequency, relevance, and frequency multiplied by relevance are only slightly higher in the more mixed (MM) (1.97; 2.75; 6.88) versus less mixed (LM) (1.86; 2.56; 6.35). This means that farmers dealing with more mixed farming do not seem to rely on either a substantially higher number of relationships or more relevant relationships for running their business compared to farmers dealing with less mixed farming systems. In other words, the network in which more mixed farmers are embedded in does not appear to be structurally better from a systemic sustainability perspective nor offering a better overall social resilience.

However, for Austria, Portugal, and Denmark, the score for Frequency was higher in MM (3.00; 3.12; 1.86) versus LM (2.23; 3.06; 0.5). Contrariwise, for Switzerland, the score for Frequency was almost identical between MM (1.69) and LM (1.71).

For Austria and Denmark, the score for relevance is also higher in the MM (3.23; 3.64) versus LM (2.62; 0.64). For Portugal, the score is nonetheless slightly lower in the MM (4.30) versus LM (4.42). For Switzerland, the score is identical between MM and LM. These show that only Denmark enjoys both a higher frequency and relevance in MM compared to LM.

In turn, the score for frequency multiplied by relevance was substantially higher in MM (7.43) versus LM (2.21) in Denmark. For Austria, Portugal and Switzerland, the score for frequency multiplied by relevance was slightly higher in MM (10.77; 14.18; 5.20) versus LM (8.69; 14.10; 5.07).

To summarize the above we can say that, overall, the scores on frequency and relevance are higher in MM compared to LM, thus suggesting networks are more developed in MM; however the differences are rather marginal and are only interpreted in a descriptive way. In the next section, we would like to see whether results are statistically confirmed or not.

- **Kruskal-Wallis tests**

The scores for frequency and relevance were analysed statistically using Kruskal-Wallis tests. This was done for all countries when pooled together as well as for each country when taken individually. Table 14 specifies the corresponding results, which indicate that a positive and significant difference between MM and LM across all variables was only found in DK. Having said that, a potential limitation is that the limited sample size in DK could imply that the assessed situation is not actually very representative. In other words, there is a possibility that the selected DK farms are not very typical ones for the system they represent.

Table 14: Frequency & Relevance of farmers' relationships using Kruskal-Wallis tests

Category	Country	All		AT		DK		PT		CH	
	Mixed-ness	**Rank sum**	**Prob**	**Rank sum**	**Prob**	**Rank sum**	**Prob**	**Rank sum**	**Prob**	**Rank sum**	**Prob**
Frequency	More	58'236	0.326	196	0.293	277	0.000***	1117	0.883	31'763.5	0.992
	Less	55'290		155		129		1094		31'782.5	
Relevance	More	58'566.5	0.229	193	0.370	278.5	0.000***	1126.5	0.788	31'760	0.989
	Less	54'959.5		158		127.5		1084.5		31'786	
Frequency by Relevance	More	58'172.5	0.348	189.5	0.515	271.5	0.002**	1113	0.923	31'830.5	0.953
	Less	55'353.5		161.5		134.5		1098		31'715.5	
Observations		238		13		14		33		178	

As a whole, both the descriptive statistics and Kruskal-Wallis tests do not allow for decisive conclusions on whether and to what extent relationships among value chain related actors are particularly different in MM versus LM systems. We can observe a slight difference in favour of MM, but this remains somewhat hypothetical.

5.2.2 Sustainable Supply Chain Governance

In order to identify potential differences in adaptability (SSCG) between more and less mixed systems, both paired t-tests and Kruskal-Wallis tests were performed in accordance with the data structure.

- **Paired t-tests**

First of all, paired t-tests were conducted on the SCCG scores for all countries when pooled together as well as for each country taken individually. In the DK network, farmers were not able to reflect on the SSCG exercise, therefore this network was left out. The Swilk test indicated that the data was not normally distributed when considering all networks together as well as for the "Ease of change by Economics impacts" variable in the Austrian network. Therefore, the significance of the test should not be considered for those ones (grey cells). Table 15 illustrates the corresponding results. Note that "Ease of change" as well as "Economic impacts" have each a possible score from 0 to 5; and so the multiplied score of "Ease of change by Economic impacts", a possible score from 0 to 25.

Table 15: Ease of change & Economic impacts of changing outlets for farmers, using paired t-tests

Category	Country	All (1)		AT (1)		PT		CH	
	Variable / diff	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Ease of change	ease_mm	2.113	0.092	2.688	0.254	1.613	0.128	2.175	0.117
	ease_lm	2.053	0.087	2.625	0.221	1.742	0.146	2.058	0.111
	diff	0.060	0.038	0.063	0.063	-0.129*	0.061	0.117*	0.050
Economic impacts	econ_mm	1.393	0.142	2.438	0.465	0.226	0.159	1.583	0.172
	econ_lm	1.340	0.138	2.125	0.437	0.226	0.159	1.553	0.169
	diff	0.053*	0.028	0.313*	0.176	0.000	0.000	0.029	0.029
Ease of change by Economics impacts	ease*econ_mm	4.500	0.531	8.063	2.003	0.806	0.584	5.058	0.644
	ease*econ_lm	4.133	0.504	6.625	1.633	0.935	0.699	4.709	0.628
	diff	0.367**	0.149	1.438*	0.785	-0.129	0.129	0.350*	0.172
Observations (total number of outlets in combination with individual farmers)		150 (2)		16		31		103 (2)	

(1) The significance of the test, when pooling all countries together, has no scientific value as the data is not normally distributed. Nevertheless, values can still be considered in a descriptive manner. The same applies for AT for the ease*econ_mm and ease*econ_lm variables.
(2) 12 missing values (no answer given for 12 outlets, either for more mixed or less mixed).

When pooling all networks data together, the score for easiness of changing outlets is slightly higher in MM (2.11) versus LM (2.05), meaning it is seemingly more difficult to change in MM. In addition, the score for economic impacts due to change of outlet is slightly higher in MM (1.39) versus LM (1.34), meaning there could be more economic impacts from changing outlets in MM versus LM. Consequently, the score for easiness of change multiplied by economic impacts is also higher in MM (4.50) versus LM (4.13), suggesting there are more negative impacts overall in MM. One possible explanation could be that MM systems rely more on “specific assets” and that therefore it is also more challenging to depart from those assets without negative consequences.

For Austria, the score for easiness of change is slightly higher in MM (2.69) versus LM (2.63), but not statistically significant. For Portugal, however, the score is statistically significantly lower in MM (1.61) versus LM (1.74), suggesting that it would be slightly easier to change outlets in LM. The underlying reason remains unclear. For Switzerland, the score is statistically significantly higher in MM (2.17) versus LM (2.06), implying that contrary to Portugal (but in line with Austria), it would be more difficult to change outlets in MM.

For both Austria and Switzerland, the score for economic impacts due to change of outlet is higher in MM (2.44; 1.58) versus LM (2.13; 1.55), but not statistically significant. For Portugal, the scores for economic impacts are identical (0.23). The latter result actually downplays the result on the easiness of change for Portugal. Even though farmers said it is more difficult in LM, actually there is no difference in terms of economic impacts between MM and LM in Portugal.

For Switzerland, the score for easiness of change multiplied by economic impacts is statistically significantly higher in MM (5.06) versus LM (4.71), meaning there are supposedly more negative impacts overall in MM. For Portugal, the score is lower in MM (0.81) versus LM (0.94), but neither very relevant based on the above explanation nor statistically significant. For Austria the corresponding results are irrelevant due to the abnormality in data distribution.

- **Kruskal-Wallis tests**

In the same vein, Kruskal-Wallis tests were conducted as the data was not normally distributed when pooling all networks together and partly for the Austrian network. Table 16 illustrates the corresponding results.

Table 16: Ease of change & Economic impacts of changing outlets for farmers, using Kruskal-Wallis tests

Category	**Country**	**All**		**AT**		**PT**		**CH**	
	Mixedness	**Rank sum**	**Prob**	**Rank sum**	**Prob**	**Rank sum**	**Prob**	**Rank sum**	**Prob**
Ease of change	More	24’416.5	0.847	265.5	0.955	932.5	0.636	12’052	0.987
	Less	24’411.5		262.5		1020.5		11’819	
Economic impacts	More	24’539	0.969	276	0.651	976.5	1.000	11’938.5	0.819
	Less	24’289		252		976.5		11’932.5	
Ease of change by Economics impacts	More	24’579	0.991	276.5	0.638	976	0.995	11’979	0.887
	Less	24’249		251.5		977		11’892	
Observations (total outlets number in combination with individual farmers)		155- LM (1) 157- MM (2)		16		31		108- LM (1) 110- MM (2)	

(1) 7 missing values (no answer given for 7 outlets).
(2) 5 missing values (no answer given for 5 outlets).

None of the Kruskal-Wallis results are significant when performing Kruskal-Wallis tests. Results that were found significant using paired t-tests in individual countries remain statistically valid, however they do not seem to be very robust as they are not confirmed with the Kruskal-Wallis tests.

5.3 Insights on Robustness, Goals & Conflicts

5.3.1 Switzerland

From the interviews, 17 of the 22 Swiss farmers mention weather issues as major challenges or shocks to their operations, namely hail, unexpected frost year of 2017 (among other frost years) and the fluctuating drought and flood years. This issue also appeared at the forefront of concerns during the workshop, as one farmer said, "*In our region, the high-stem cherry tree will disappear in the foreseeable future if we don't get a handle on the cherry fruit fly!*" and was deemed as highest priority for further discussion by 6 attendees. In addition, 10 of 22 farmers mention diseases and pests, with some having the feeling that these issues are on the rise. Interestingly, of the farmers mentioning pests and diseases as a shock or challenge, 80% of these farmers manage by conventional methods and 20% by organic management methods, despite overall distribution being 68% conventional and 32% organic management. Four of 22 mention personnel issues, such as finding qualified staff in times of need or other staff injury and illness.

Eleven of 22 farmers describe the impact of shocks and challenges as low/small. The other 11 of 22 describe a high or very high impact, including total loss of fruit products and upwards of 20% loss of income in affected years. Fourteen of 22 farmers feel that they recovered well from the shocks, with 8 of the 14 attributing their success to the ability to their diversification. Of these farmers attributing their recovery to diversification, 50% manage by organic methods and 50% by conventional management methods. Four of 22 farmers specifically state a poor recovery, due to a reliance on high-stem trees as their income and lack of preparedness or a lack of anticipation of such issues in their business planning. One currently less mixed farmer describes, *"These diseases were not at all included in our business planning back in 2013 [when we took over the farm]. This quantity of plant protection was not planned for and there's a lot more effort required"*.

Of the 17 farmers mentioning any issue in the supply chain, 6 express concern over price deterioration coupled with increasing quality expectations for cherries, despite decreasing yields and suffering quality of harvested cherries due to the cherry fruit fly. Due to their short storage life, short transport distances and local distributors and processors are required; however, 2 of these 6 farmers express uncertainty or lack of confidence in the future stability of existing cherry buyers and distributors. Interestingly, of the 6 respondents expressing concerns over the cherry supply chain, 5 farmers are managing currently more mixed farms.

Specific political and social concerns entail the changing regulations that make it difficult to implement long-term investments and keep the general public content and informed, as Swiss democratic popular initiatives targeting agriculture have been on the rise, like the clean drinking water initiative. Here it appears that more mixed systems exhibit more robustness, as farmers can absorb losses with gains from other enterprises, and generally feel the cider fruit supply chain is relatively stable and are confident in its prolonged existence.

Despite the above, 13 of 22 farmers interviewed are assessed as having low robustness to past shocks and challenges, since most of the challenges mentioned include significant yield and financial losses. This means that, these fruit farmers, regardless of their level of mixedness, are affected by extreme weather, pest events and value chain issues and do not have infrastructures in place to withstand the impacts of such events. Only 2 of 22 interviewed farmers, both managing by organic agricultural methods, are deemed as having high robustness. One of these farmers does not mention any specific weather or pest events as being any issue, rather, a past disease outbreak among his cattle herd, while the other farmer is using regenerative agriculture techniques to minimize impacts of anticipated weather and pest events.

Moreover, the difficulty of producing fruit of sufficiently high quality, mainly due to harvesting causing damage to fruit, poses both storage and commercial difficulties. For commercialisation, the problem resides in the high standard expected by customers in terms of the 'visual aspect', but also in the strategy of some retailers that prefer to deal with larger quantities of products.

Forward looking, 6 of 18 farmers feel they are well prepared for future shocks to the value chain, like disappearance of certain actors or outlet channels, which they attribute to the strong and personal relationships that they have built with customers or to their farm diversification.

5.3.2 Portugal

It was observed that stakeholders have a shared commitment to **developing sustainable management practices** associated to Montado products, with the main corresponding practices being as follow:

- Promoting natural regeneration through various techniques such as :
    - Increasing the number of natural parks associated to the Montado system and creating reserve zones
    - Reducing livestock grazing pressure
    - Utilizing individual animal protectors
- Developing organic farming
- Developing precision agriculture as well as agroforestry
- Genetic improvement of the trees
- The following practices, which are more in control of the farmers only but still require collaboration with actors like advisors:
    - Minimizing soil disturbance through implementing alternative methods:
        - No-till farming or reduced tillage
        - Strip tillage
        - Cover cropping
        - Direct seeding
    - Embracing conservation agriculture:
        - Maintaining permanent soil cover
        - Diversifying crop rotations
    - Establishment of permanent pastures
    - Adoption of good cultural practices (alternatives to the technique of removing stumps, pruning, soil, managing canopy, nutrient availability, etc.)

As already said, some of the above sustainable practices are more in control of the farmers themselves, however, it is interesting to see that all stakeholders involved agreed with these or at least were open to the idea that farmers produce in a more sustainable manner. In fact, it is clear that implementing such practices has in turn consequences on the type and quality of products sold on the market, thus affecting how the value chain is operating. In other words, all value chain actors are affected, whether directly or indirectly, implying that their openness towards sustainability and mixed farming systems is positive in terms of the governance scheme and in turn of social resilience.

In addition to the common agreement on the above practices, there was unanimous desire to create new economic opportunities within the sector. Such opportunities are as follow:

- Envisioning acorn as a value-added and differentiated product
- Complementing activities and value enhancement through tourism and hunting

Nevertheless, there were also some differences of viewpoints among people, which are listed in the following:

- Increased research on pest prevention and control, and support alternatives for pest control
- Development and use of predictive models for :
    - Reduced crop losses
    - Improved decision-making
    - More targeted control measures
    - Enhanced sustainability
- State support and compatibility with the productive and conservation objectives of the Montado, as existing support schemes are not necessarily adapted to Montado.

In a nutshell, it turns out that there is no explicit disagreement among the value chain actors in the Montado case. Farmers agree that more research, information exchanges and the co-development of solutions are needed to cope with pests. Nonetheless, slight differences transpired between actors in terms of how exactly the agreed sustainability goals can be achieved best. An example are the use of predictive models which, while mentioned positively by technical advisers, are not perceived as being an effective solution by farmers. Such predictive models are used to improve decision-making by e.g. reducing crop losses and better targeting control measures. In order to enhance the viability and sustainability of the Montado system, an even better alignment of views among actors could help. This in part requires to improve the link between farmers and research, including by ensuring a needs assessment, implementing case studies in a collaborative manner, improving communication channels and better communicating the results. From this perspective, the role played by government support should not be forgotten and needs to find common ground with the productive and conservation objectives of the Montado. The creation of a certification for the mixed agroforestry system and associated products could also help in that it would “name it” for all to see.

Moreover, improving the bureaucracy system in a way that it both allows sustainability and relative easiness of implementation for farmers, may improve the governance and social resilience of the system. Such a strategy would imply for example simplifying the processes and the associated legislation, enhancing inspection capacity by authorities, as well as making processes more automatic and working in a “notification” based way e.g. instead of asking for permission for activities like pruning.

5.3.3 Denmark

The drivers for the group of farmers to work together are specifically to improve biodiversity, carbon sequestration, and animal welfare and to address environmental issues such as nitrogen (N) leaching. The agroforestry systems established by the farmers on their land represent a huge diversity in age, function, and spatial arrangement of trees/shrubs.

On the [XXY] farm, marketing has been the main challenge and it has taken several years and much effort to establish their brand. They realized the huge importance of communicating the story behind the pork. One example is that, in the beginning, they received complaints from consumers due to the more fatty pork. However, after they invested time and effort in telling the story and the idea behind the use of traditional breeds that produce more fatty meat, the responses became positive.

In 2018, the organic pig producer from [XXZ] and his Poplar-pigs concept was elected as ‘the Organic craftsperson of the year’ in the category ‘Economy in organics’ due to an extraordinary economic performance. This is an annual event organised by Organic Denmark and with nominees within various categories (e.g. economy, animal welfare, social engagement, and climate), showing also that value chain actors do take care of each other. In 2019, [XXZ] was nominated to the Nordic food awards EMBLA in the category ‘Nordic primary food producer’ 2019 and was elected as ‘the second best’ within the Nordic countries.

Despite the above considerations, the network still suffers from a lack of knowledge including on technical agronomic aspects and social factors, resulting from a certain lack of initiatives and collaboration among actors. Particularly, there is a lack of knowledge on how to design agroforestry (AF) systems to maximize the desired positive effects on e.g. animal welfare, climate, environment and biodiversity given the specific conditions on the farm. More knowledge is needed to encourage additional farmers to implement AF but also to support authorities to improve regulation and subsidy systems. There is also a lack of knowledge on the effects of ‘soft’ parameters and how to communicate these among the network actors. Scientific-based evidence is not sufficient. In addition, consumers are not necessarily aware of the co-benefits of AF and/or may not be willing to pay more for products coming from such systems. Here, farmers seem to agree that one should focus on telling a “good story” to consumers as well as strongly on animal welfare, however it remains uncertain how retailers would react especially in the longer term. This also highlights that more communication is needed between all linkages of the value chain. Moreover, there is a broader issue that the actors of the network somewhat resist from reflecting on a longer-term perspective. A long-term perspective is needed, not only for knowledge co-creation and transmission but also for implementing an AF system as such.

More details on the specific farmer’s goals, opportunities, challenges, risks and potential solutions are provided in Table 17 thereafter. Note that the categorisation into the different categories is according to farmers’ themselves and was not challenged. In fact, we are more interested into the inputs provided rather than in which exact category they fall.

Table 17: Goals, opportunities, challenges, risks and possible solutions across the social, economic, environmental, political and technical areas in the Danish case

Dimen-sion	Goals	Opportunities	Challenges	Risks	Possible solutions
Social	Take social responsibility for vulnerable individuals in the society. To ensure good working conditions for employees, provide them training, facilitate sharing of experiences through meetings, celebrations, etc; to contribute to 'life' in the local community. Research and education at the highest international level. Improving conditions and developing solutions for the organic farmers. To develop and sell the best animals. Create new and/or preserve jobs, especially in rural areas; educate growers, industries, and advisors about economically and environmentally sustainable pathways forward.	To help convey how to produce food in DK. Use of social media and offer of tours, thus creating value for visitors. AF significantly contributes to developing farming towards more sustainable and holistic systems. AF often plays a role in "good stories," such as with "poplar pigs." Diversification of crop production that optimally utilizes resources. Exploit synergies and complementarities between crops to increase productivity per area, add value to raw materials locally, and maintain primary producers' ownership of products development. AF contributes to being decent towards the animals, as they have the opportunity to seek shade and express their natural behavior as forest animals. Additionally, it helps with CO2 absorption.	Social responsibility and dedicating time to outreach is time-consuming. Timing aspects of AF pose a challenge regarding climate change. Lack of data to support the promotion of beneficial systems; lack of knowledge about the effects of AF on ecosystem services. Consumers' willingness to pay. The value of raw material products from the forestry component of AF must provide at least as good an economic return per area as competing annual crops, or provide significant derived environmental or economic benefits. Models are still imprecise to support investment decisions.	It can be challenging to secure funding. Visitors to farm tours may introduce infections to the animals. Consumers may not prioritize buying organic products or willing to pay an extra to provide a good life to animals. Lack of Danish examples of successful systems. Without evidence-based knowledge, investments are uncertain. Unprocessed raw materials from AF often lacks competitiveness with more intensive and specialized production.	A clearer definition of AF. More specific knowledge on profitability and resilience of AF systems should be designed and implemented. This should also be communicated to end-users. A rethinking and re-prioritization of food pricing so that "sustainable" food is more affordable. Creation of clusters related to marketing, innovation and product development could strengthen the local AF economy. More research and advisory services regarding optimal management of AF and need of support from authorities. Scaling up to large areas that can support machinery investments.
Econo-mics	Economic performance, balance; to earn money in order to be financially independent. Focus on breeding and producing organic meat for consumers who prioritize high animal welfare.	Forest farming can be an important part of a "story telling"; trees to enhance animal welfare and create a bit more nature; additional income through telling a "good story". There can be a great interest among small and medium-sized landowners.	Crises in society can lower demand. Consumers still prioritize the cheapest, least sustainable products. For producers, it can be challenging to market themselves effectively and share the story as to why their products deserve a premium.	There can be new political initiatives that do not promote organic farming and forest farming. Are the selected species of trees/shrubs economically viable in the climate of the future?	A shift in people's understanding of the value of food, the origin and production process. To improve communication to consumers. To implement the "good story" strategy; identify valuable niches.

Dimen-sion	Goals	Opportunities	Challenges	Risks	Possible solutions
	To expand organic practices, including AF systems, and consequently also address the potential for more citizens to purchase local and sustainable products. To find a few systems that can be entirely market-driven while optimizing ecosystem outputs; to ensure profitabiliby of organic.	AF offers a promising solution for producing sustainable goods locally. In the long term, a premium price for AF products (?) Combinations of crops that respond well to e.g. additional tree shelters that exert limited competition on the crops, resulting in little reduction in crop yield.	There is a lack of decision-support systems based on evidence/trials. Estimates and assumptions play a significant role in models and create uncertainty. Not profitable without a premium.	Lack of financing options and market development for AF products. Introducing new tree crops requires new specialized knowledge among growers. Significant risk that buyers switch over time to cheaper raw material suppliers. Challenges in sourcing adequate labor.	Economies of scale may ensure that sufficient knowledge is built up and investment costs reduced. Clusters could increase chances of success. Binding agreements over years are crucial. Significant need for education, advisory services, etc. High subsidies for ecosystem services; AF premium.
Enviro-nment	Climate neutrality in alignment with the Danish Parliament's goals, improved climate; more biodiversity (e.g. more mycelium in the soil, beneficial insects..) To focus on the welfare of the livestock and to increasingly consider environmental sustainability. To develop and expand organic practices; to focus on the environment, climate, and nature in and around the fields. This includes e.g. increased biodiversity, reduced leaching, enhanced carbon sequestration, healthier soil.	AF is a holistic system that provides countless positive benefits for nature, the environment, and climate resilience. Roots reduce erosion and retain water and nutrients, while trees enhance carbon sequestration and contribute to a more resilient system capable of withstanding extreme weather. AF creates more habitats on farmland and provides food sources for insects and birds at times when food is otherwise scarce. Advisory contributions to implement biodiversity and climate initiatives.	Challenging to figure out how to achieve the best results. More knowledge is needed about which tree species in which configurations (spacing between rows, etc.), with which crops/livestock... yield the most positive impacts. Lack of communication to farmers on knowledge, e.g. on overview of tree species that sequester $C0^2$. Lack of data on the impact size on both biodiversity and climate. There is a lack of Danish evidence-based solutions for optimal design, establishment, and maintenance of the forestry component to achieve optimal effects.	Decreasing demand for the meat produced. Risk of new political or environmental requirements that cannot be met. It may be challenging to scale it up If it proves difficult/impossible to document the positive effects. The certainty of achieving improvements is considered high, but the extent of the improvements depends on systems and conditions. AF is minor in terms of contribution to less $CO2$.	Focus strongly on improving sustainability and animal welfare as well as communication with consumers. Generating more knowledge on these topics and ensuring clear and accessible communication about them. Support for new AF farmers. Documented effects; research studies and financing options. Need for more research and advisory services to optimize in DK, but some fundamental knowledge can be obtained from other tree uses (e.g. bioenergy plantations, shelter planting, small biotopes)

Dimen-sion	Goals	Opportunities	Challenges	Risks	Possible solutions
Politi-cal	To make AF more widespread and accepted as a robust and sustainable system. AF as a bridge between forestry and agriculture; to produce good meat and take care of the planet at the same time. To provide evidence-based knowledge on optimal AF systems, combinations of crops and forestry, productivity, etc.. Support the development of meaningful systems with high ecosystem effects from the use of public subsidies. Contribute to knowledge on how the effects are evaluated and compared.	To engage in political debate; share the ”stories”, make films, participate in the news and discussions... AF may support the goal of being a natural partner for forest/landowners in terms of nature/production consulting and management. Public funding for research, development, and advisory services is critical for developing the AF sector and providing knowledge to both political systems and control systems, as well as to the industry and grower/producer.	Lack of knowledge on economics; low exchanges and understanding among value chain actors. Need for an infusion of competencies through recruitment or partnerships. Without investment in R&D, the development of AF may be slow and not get started on a large scale. The time factor for evaluating AF over a long period is a challenge, especially as investors need to be convinced. There are many rules regarding which species and diversity farmers can have and how long they can remain before harvest/cut, in order to keep EU subsidies.	Bureaucracy, regulations that could be very demanding like to measure and weigh ”everything”. The media can quickly judge any attempts as either insufficient, incorrect, or misleading. Changing agendas in research funding can lead to a lack of funding. Much funding goes to technology while actual green landscape solutions often struggle to find funding over several years.	Facilitated communication between links in the value chain. More knowledge, more dissemination. Strong professional advisory anchoring and caution. Dialogue about the potential contributions of AF, especially regarding climate, environment, and biodiversity. To maintain the focus on the need for funding, emphasizing areas of AF producing significant effects.
Tech	Ressource efficiency; optimization of the consumption of electricity, water, feed, etc. To study the production potential of AF. To check which machines are relevant for AF and whether some machines can be used for multiple purposes.	Research may develop specific AF models (trees and crops) and operational guidelines for how individual AF systems can be established, maintained, and ensure economic returns.	Unclear concepts and definitions.	If recommendations are developed based on foreign research, there is a risk of errors and thus a failure to make the expected results, and ecosystem effects may be less than anticipated.	Improved definitions and concepts. Incorporating Danish knowledge and critically evaluate individual components in AF plans - operational management should reduce the risk of serious errors and large economic losses.

5.3.4 Austria

‘’Von Herzen Biobauern GmbH’ is one of the leading organic fruit marketers in Austria. The company only markets organic fruits. By pooling interests, the organization has a strong negotiating position vis-à-vis the food retail sector. The activities of organic fruit marketing have led to a greening of the organic fruit cultivation in the Eastern Styria region, but also to a raised awareness among the fruit growers. For example, the preoccupation of organic farmers with the philosophy of organic farming led to a return to the traditional concept of a stable “farm organism”. Among other outcomes, this fostered the re-integration of animals into the organic farming system.

Organic egg production has so far played a subordinate role in the Eastern Styria region. The relatively few organic farms with poultry are professionally organized. The integration of animal husbandry into the cycle of professional fruit production has been completely lost in the last few decades. This applies not only to organic but also to conventional farms. In this respect, the ‘Apples-Hens’ is a new initiative, which receives much sympathy in the neighbourhood and the wider public.

It is not yet entirely clear in what form keeping hens in the orchard is legally possible, particularly the period of time before harvest for which the hens have to be locked out of the orchards for hygienic reasons. The current practice is still subject to an exemption, but there is no formal (written) commitment yet, which would be necessary to achieve legal certainty. In addition, it is still unclear whether grazing by poultry is possible all year round in the case where farmers receive subsidies for the prevention of soil erosion in fruit production. In order for the above to be improved, it would be necessary to clarify how legal requirements, such as on the topic of keeping hens in orchards, can be lessened or improved.

There is also a need for knowledge co-creation and skills development, especially in terms of feeding and on what to do with pullets/spent hens, egg marketing, and mobile housing. Direct marketing is also a challenge in particular due to seasonality. To deal better with this, new marketing channels would be needed together with the strengthening of regional networking of direct marketers, trade and gastronomy, including in terms of logistics. The creation of a joint delivery and collection service was mentioned as a potential solution by stakeholders.

Specialised fruit producers can bring in extra income by introducing laying hens in the orchards. However, the economic dimension is not the most important factor given the reasons highlighted above and it also requires a long time to assess whether a new development on the farm actually brings profit. The introduction of laying hens into intensively managed orchards is considered by farmers to be just one step towards developing future innovations. Moreover, the typical occurrence of conflicts or disagreements between farmers and value chain actors within conventional marketing channels is likely to force farmers to look for alternative marketing channels and partners.

In the end, although the system has been demonstrated, upscaling is still being hindered by several factors such as rising feed costs, avian influenza, regulations hindering integration of activities, uncertainty about subsidies, increased labour requirements, the need to have a good understanding of animals’ specific needs including for their welfare, as well as the occurrence of overproduction in some years and the marketing challenges.

6 The specific case of The Netherlands

6.1 Overview & Approach

The MIXED network in NL consists of two clusters of collaborating farmers. Cluster A consists of 4 farms, involving 2 mixed farms with dairy & arable farming, 1 dairy farm and 1 farm with arable & poultry farming. As for cluster B it contains two farms that include 1 arable farm and 1 dairy farm.

This MIXED network hence focuses on the inter-farm collaboration within the two clusters. In other words, the mixedness dimension in this case is about actors' collaboration itself. The more the collaboration the higher the "mixedness" of the whole system is. This implies that there would be an endogeneity issue when it comes to assessing whether and to what extent a mixed system is more resilient than more "classical" ones from a governance perspective, which is the purpose of Task 4.4 in MIXED. In effect, the underlying assumption was that improved relationships among actors along the value chain is leading to an enhanced governance model and therefore to a higher level of system resilience overall. And "better" relationships were hypothesised to be associated with "more mixed" as more complex systems may need or desire a more collaborative type of governance model.

Consequently, it was not scientifically sound in this case to try to compare "more mixed" and "less mixed" in terms of how they perform from a collaboration viewpoint. In addition, it was observed that farmers had great difficulties in imagining how different their farm would be if they would not collaborate within their cluster. As a consequence, it was decided to only look at the performance of the collaboration as such while drawing corresponding relevant implications. This means that the questions focusing on sales were not addressed nor the specific questions asking for "scores" of relationships among actors. In fact, such "scores" are more relevant when used to compare two different situations. The collaboration was discussed in a participatory workshop on the 21st of November 2022, involving 8 farmers and 2 scientists from the MIXED project team.

6.2 Relevant findings

The workshop conducted has allowed to make interesting observations in terms of the current and future possible patterns of collaboration as well as on productivity and sales, the role played by advisory services and finally the possible strategies to increase collaboration.

a. Description of farm activities and current patterns of collaboration:

Collaborations relate to exchange/sharing/application of (i) land, (ii) manure, and (iii) labour & machinery. The farmers collaborate based on mutual trust and principles of sharing. Although the farmers already collaborate for many years, their contacts generally materialise bilaterally, i.e. they normally do not meet at cluster level. The cluster meetings organised by MIXED are therefore highly appreciated and perceived as an added value. Despite the complexity of new crop management planning, the fact of openly discussing altogether new rotation options as well as positive and negative implications of joint rotations is welcomed.

b. Possible future patterns of collaboration:

Over the past 10 years, not many changes occurred. However, looking at the future, farmers expect that informal agreements would need to be changed into formal agreements. The value and potential of regional inter-farm collaboration is increasingly entering the policy domain, for instance in the context of circularity. This is the reason why formal agreements would then be necessary, e.g. to demonstrate that manure has indeed been applied locally. Such a change would be needed and likely possible although administrative issues related to exchanging land are mentioned as barrier.

c. Uncertainty with respect to production levels and sales in the future:

Farmers do not sell their products directly to consumers. Instead, they sell to mainstream cooperatives in the region (sugar beet, starch potatoes, seed potatoes). It is expected that through their collaboration they might be able to increase the total amount of cash crops sold to the cooperatives – as crop rotations can be optimised across a larger area. However, also the opposite may occur if the cluster decides to produce other crops such as lilies or more fodder crops. If ‘new’ crops such as onions, carrots or sorghum are introduced, this may lead to new sales channels.

d. Farm advisory services generally do not focus on intra-farm collaboration:

The farmers’ regular advisers / consultancy services are specialised in arable or dairy farming and have limited capacity about mixed systems and on how to conceptualise and discuss implications of the inter-farm collaborations. Even more, they sometimes qualify the collaborations as “vague and unclear”. This hampers the communication about inter-farm collaborations in the media and the policy domain. To adequately support farmers this issue needs to be addressed, i.e. advisory services need to increase their knowledge on mixed farming systems. Nevertheless, it should be possible to implement strategies to address this.

e. Possible strategies to increase collaboration in the future:

- More joint consultation to further optimize crop rotations, e.g.:
  - Reconsider choice of crops rotation, e.g. towards more fodder crops.
  - Find more intensive strategies to increase the amount of grass and maize.
  - Utilize better the knowledge on field-specific characteristics.
  - Increase production of biomass as resource for building materials etc.
  - Increase the amount of high-value crops such as lilies.
- Better utilization of the expertise of arable farmers to optimize crop-related decisions in dairy farms.
- Further intensification through precision farming.
- Increased sharing of data to improve decision making, e.g. in relation to questions like:
  - Why does grass have a lower protein content if preceded by potatoes?
  - How can the quality (composition of nutrients) of manure be improved?

Moreover, there is neither well-developed water holding nor enough water drainage capacity, making the area sensitive to extreme droughts and rainfalls (Prins et al., 2011). Environmental challenges at farm level negatively affect food production, with potentially negative impacts on farm incomes. However, the cooperative Avebe compensates lower yields with higher starch potato prices.

6.3 Takeaways

It was observed that the farm intra-collaboration proves both to be promising in terms of feasibility and performance although it also raises some challenges that need to be addressed. Some of those relate to the fact that stakeholders and advisers in particular need to develop their skills and develop their capacities in handling and supporting such an innovative system. In absence of this adaptation, the viability of such a system in the longer term could be called into question.

7 Discussion

Overall, it is difficult to conclude whether “more mixed” or “less mixed” value chain related systems in Europe contribute to better social resilience, rather, that there are pros and cons to each type of system that need to be considered in their specific context. In addition, the study finds that semi-quantitative indicators alone are not sufficient to assess the contribution to social resilience and thus need to be placed in the qualitative context. Having said that, inputs to semi-quantitative indicators could not be collected extensively in many cases, therefore the results have become more qualitative in nature than initially envisaged.

7.1 Evaluation of “more mixed” versus “less mixed” systems

The results of this study distinguish little difference in the overall social resilience of “more mixed” and “less mixed” systems. It appears that, overall, value chains exhibit stronger impacts on social resilience, than level of farm mixedness itself. This is particularly apparent in the Swiss case though Swiss farms were already operating with relatively high diversification. The lower value chain social resilience is in part caused by a lower level of diversification that more mixed farms seem to exhibit in their outlet channels for each of their products. In addition, “more mixed” seem to be associated with a more connected network as well as a higher influence of central and specific actors. This means, for the various farmers, a greater reliance on more of the same actors and in the end a more specific network. In economic terms, this can be translated into the concept of “specific assets”, implying that such assets have a significantly higher value within a particular relationship than outside that relationship. In other words, the farmer supposedly enjoys a relationship of greater value though, at the same time, the theory is that he/she becomes highly dependent to that asset and may have difficulties to switch to another actor should it need to be replaced.

The above is consistent with the study by Le Goff, Barjolle and Six (2022), showing an enhanced learning and knowledge transmission and education in more diversified systems and that such systems are more connected to their local socio-economic environment; however, not accounted for in that study is that this, in turn, could indicate lower social resilience of the broader network, as disappearance of important actors and outlet channels would have broader impact on the network and greater financial impact on individual farms.

On the other hand, it can be observed that “less mixed” farms, in terms of their activities, tend to diversify more their outlet channels for single products – this way farmers balance, either intentionally or not, the risk associated with their heavy reliance on individual raw products. Interestingly, it was also observed, here specifically in the Swiss case, a greater product diversification on “less mixed” farms, who are e.g. more likely to specialize on many different varieties of the same fruit. The underlying reason could be that farmers compensate the lack of diversification on the number of farm enterprises by a higher diversification within a single enterprise.

Given the EU priorities to develop knowledge and information to encourage the transition to MiFAS, knowledge materials supporting a transition to mixed farming systems should recognize that:

- More “mixed systems” appear to rely on tighter, more insular channels of knowledge and information transfer;
- More “mixed farmers” seem to rely more on “specific assets”, meaning they enjoy tighter relationships that help them to perform economically, however they are also more at risk from a social resilience perspective since they are more dependent on their current relationships;
- More “mixed farmers” seem more likely to diversify enterprises whereas less “mixed farmers” are more likely to diversify their product offerings and associated outlet channels;

- Greater diversification or "mixedness" may require more time, energy and effort in interactions and thus require or enjoy more efficient and eventually online marketing channels.

7.2 Limitations

The selected methodology allowed for qualitative and quantitative insights from farmers and value chain actors to be combined. An approach relying strictly on semi-quantitative indicators would not have allowed for the insights gathered on value chain differences between the two systems.

In all cases, farmers struggled to identify clear differences between more and less mixed environments when thinking back to past experiences on the farm and even more so when imagining scenarios of changing the level of mixedness of their farm. In Switzerland, given the long-standing mixedness of the farms, the comparison analysis between mixedness environments/ scenarios was coupled with comparisons between currently more and currently less mixed farms, which produced insightful complementary information.

A limitation of the network analysis is the inability to interview all actors without generating massive research costs. It is important to highlight that the semi-quantitative data is from the perspective of farmers' stated relationships as opposed to a more composite view from all actors of each network. Furthermore, doing a classical Social Network Analysis requires having a large enough sample, which was only feasible in the Swiss case. In the other cases, the approach was adapted and statistical comparisons between "more mixed" and "less mixed" environments were done. However, such statistical comparisons also had limitations given the rather small samples size.

Despite these limitations, the research allowed for observations to be made on the specificities of more and less mixed value chain related systems across Europe and their implications for social resilience.

8 Conclusion

This study aimed to assess the social resilience of mixed farming systems in Europe, specifically in CH, NL, DK, AT and PT. The Swiss network comprises high stem fruit trees within cattle livestock. The Dutch network focuses on an emerging cooperation between dairy and arable farmers. The Danish network focuses on trees and shrubs in combination with crops, cattle or pigs. The Austrian network focuses on apples and organic egg production. Finally, the Portuguese network is focused on an AF System dominated by scattered oak trees in combination with native pastures, foraging, or feed crops. This study also aimed to provide an assessment of selected indicators that may aid in the evaluation of the social resilience of value chain related systems. These objectives were assessed by measuring selected indicators and comparing the performance of more and less mixed systems against those indicators. A mix-methods approach was used through applying qualitative interviewing with semi-quantitative data collection and analysis.

This research finds little differences between more and less mixed farming systems. Judging which system (more or less mixed) exhibits greater overall social resilience remains inconclusive, rather this study finds that there are pros and cons to each system that need to be evaluated in their specific context. More “mixed farms” appear to exhibit more social resilience at a farm-level while “less mixed” farms may contribute to a more resilient related value chain. These suggest that more diversified farms in terms of their number of enterprises would benefit from a higher diversification of their outlet channels.

This research also finds that the selected indicators require both qualitative and quantitative insights to assess the effect on social resilience and to make insightful comparisons between more and less mixed systems. In this study, Social Network Analysis (SNA) data showed higher network Density in more mixed farming systems in the Swiss case. This higher network Density was a result of a tighter, more connected network that was comprised of lower count of unique actors, than was mentioned in a “less mixed” system. Even though a classical SNA could only be done fully in the Swiss case, it was also found in the other cases that relationships were generally tighter in “more mixed” compared to “less mixed” system. A denser network would typically imply greater social resilience, but given the above explanations, it rather indicates a lower social resilience because of the vulnerability such a network would be exposed to if those central actors disappeared.

Additionally, findings from the Sustainable Supply Chain Governance (SSCG) analysis showed greater economic impact on more mixed systems if outlet channels were to disappear compared to less mixed systems. Qualitative statements revealed that, interestingly, this is due to a lower diversification of outlet channels for the same type of product by more mixed farms. In other words, they are more dependent on the outlets they have despite the fact that they rely on a more diversified farming system.

In the end, this study made it clear that mixed value chain related systems are very complex in nature, still new in many places, and whose performance is highly difficult to assess when a long-term controlled experiment, or the use of an expensive large sample, is not feasible nor expected like in the MIXED project. In the future, follow-up studies would greatly benefit from a longer-term exploration together with farmers and stakeholders, ideally by implementing controlled and/or rather large trial experiments in order to both increase the spectrum of possible relevant analyses and ensure a higher robustness of the results. System changes are slow and only show their first results after years. A bigger study should be combined with the use of big databases in order to control for external factors (e.g. pedoclimatic conditions) to the extent possible. In order to be implemented, these research recommendations would require clear and strong policy support in this direction.

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10 Annex: Summary on value chains activities and main actors involved in each network

A short description of the value chains is provided along with a list of the key actors involved. The involved actors include not only the value chain actors as such but also any key AKIS (Agricultural Knowledge and Innovation Systems) actor interacting with the MiFAS network.

10.1 Switzerland – Fruit Trees & Cattle

The Swiss MiFAS includes mainly apple and pear production, but also the production of other high stem fruit trees like cherries, plums, mirabelle, and quinces; associated with livestock systems (dairy and/or beef). We can distinguish two main types of corresponding value chains:

- Fresh fruits: The direct market include mainly farm market and online shops; and the more 'typical' chain is handled by 'mainstream' retailers such as Coop and Migros.
- Fruit juice, alcoholic drinks, and other transformed products: The production of alcoholic drinks is mainly derived from cherries and plums; and the other transformed products concern products such as yogurt and marmalade based on various fruits.

The main Swiss relevant actors in relation to the Swiss network are as follows:

- Ramseier Suisse AG: It produces various products including fruit juices and syrup. The company presses on average about 50-60% of Swiss cider fruits. In 2020, 82kt of conventional cider apples and 354kt of conventional cider pears were supplied by Hochstamm Suisse members. No organic products were supplied by Hochstamm Suisse. But in addition to the Hochstamm Suisse label, the company uses some organic or additional sustainable labels such as BIOSUISSE, Suisse Garantie, and Fairtrade / MAX HAVELAAR.
- E. Brunner AG: Sweet pasteurized cider, various concentrates from apples and pears e.g. sweet cider concentrate, and other types of sweet made from pure pear juice are produced. In 2020, 82kt of conventional cider apples, 417kt of organic cider apples, 9kt of conventional cider pears, 392kt of organic cider pears and 25kt of conventional "industrial cherries" were supplied by Hochstamm Suisse members. E. Brunner AG is therefore dealing with both organic and conventional products from Hochstamm Suisse members, but organic products largely dominate in terms of traded volume.
- Muff: The company produces apple juice from fruits coming from standard trees. Around 300 Swiss farmers deliver approximately 1kt of fruit per year, which Muffs processes into around 0.8M litters of juice. In 2020, 532kt of conventional cider apples and 496kt of conventional cider pears were supplied by Hochstamm Suisse members. Around 9kt of organic "industrial cherries" were also supplied by Hochstamm Suisse members, but overall conventional products largely dominate in terms of traded volume. In addition to the Hochstamm Suisse label, the company uses some organic or sustainable labels such as BIOSUISSE and Suisse Garantie ([2]).
- Nutrex (Coop): Coop is one of the main retailers in Switzerland, selling various products derived from Swiss fruits. In 2020, 237kt of conventional cider apples were supplied by Hochstamm Suisse members. The cider that is sold to Nutrex is converted into vinegar. No organic products were sold by Hochstamm Suisse members but the company largely deals with organic products.

[2] Products attached to the Hochstamm Suisse label can be either organic or conventional; only the Hochstamm Suisse label requirements apply. However, it is common for one product to be associated to more than one label.

In addition to the Hochstamm Suisse label, the company uses several organic or sustainable labels such as BIOSUISSE, Naturland, IP-SUISSE, Demeter, Suisse Garantie, and Fairtrade. According to the company, it pursues the goal of considering not only economic, but also social, ethical and ecological aspects when procuring products. Their business partners must have social-ethical certification as well as guaranteeing their employees adequate wages and decent working conditions.

- Humbel Spezialitätenbrennerei AG: The company distils a large number of fruits from their own but also purchases other Swiss fruits. In 2020, 67kt of conventional cherries, 5kt of organic cherries, 5kt of organic cider apples, 3kt of conventional “industrial apples”, 7kt of organic cider pears, 37kt of conventional plums and 4kt of organic plums were supplied by Hochstamm Suisse members. The company is therefore dealing with both organic and conventional products from Hochstamm Suisse members, but conventional products largely dominate in terms of traded volume.
- Biofarm: This cooperative buys and commercialises organic products from its producers’ network. They cover a broad range of products and markets (from raw material for the industry to products for retailers using their own label). Biofarm is the main collector of organic Hochstamm Suisse stone fruits (cherries and plums). Biofarm focusses on accompanying well their producers and providing fair conditions, contributing to their quite good reputation among organic farmers. In the case of cherry preserves (rich dark fruit), they are committed to preserving and utilizing the many existing high-trunk cherry trees. This is an important and significant challenge, especially for organic farming. They are also actively following the development towards smaller trees with shakeable varieties.

In addition to the network partner Hochstamm Suisse, Key AKIS actors interacting with the Swiss MiFAS are as follows:

- Fruit-Union Suisse: Private organization active at national level to defend producers and processors of indigenous fruits.
- IP-SUISSE: They own a label of production and around 18’500 farmers are involved.
- BIOSUISSE: Federation of Swiss organic farmers with 7'100 members. In addition, more than 1’000 processing and trade companies have a license contract with Bio Suisse to use their label.
- Institute for Environment and Natural Resources, which is part of the ZHAW Zurich University of Applied Sciences.
- Pro specie rara: The farmer interviewed said that this partner helps to preserve very local varieties, which are specifically adapted to the microclimate.
- NGOs that focus on ‘preservation’ and biodiversity.

The above main AKIS actors, among others, play an either direct or indirect role in terms of value chain governance. The ”fear or excess supply” among the Swiss organic apple value chain until 2017 has shown, for example, how the network of actors can play an important role in ”governing” the value chain (Wyssenbach, 2020). Until 2017, it was feared in the community that the organic apple harvest of 3’500 tons would not be sold in wholesale and retail businesses. Then the record harvest of 2018 disseminated more than 5’500 tons of organic pears and apples into the stores. At that time, relevant questions associated to the challenge were raised and discussed within the organic branch. The simultaneous growth in demand in 2018 has helped in absorbing the high production level, but the harmonious cooperation within the organic the supply chain was also perceived as a success factor.

Moreover, Table 18 provides additional details on the Swiss farms, organic or conventional, that were involved in the data collection.

Table 18: Overview on characteristics of the Swiss farms involved

Farmer ID	Current level of mixedness	Management	High-stem species	Livestock	Key products/ services	Direct marke-ting
ch1	Less mixed	Conv	Quince, prune plum, apple, pear	Cattle	Milk, tree maintenance, spirits	Yes
ch2	More mixed	Org	Apple, pear, cherry, prune plum, quince	Cattle	Beef, cereals, lentils, sunflowers, flax, dried fruit, fresh fruit	Yes
ch3	Less mixed	Conv	Apple, pear	Cattle, pigs	Milk, pork, fresh fruit	No
ch4	Less mixed	Conv	Apple, pear, prune plum, quince, cherry	None	Juice, spirits, fresh fruit	No
ch5	More mixed	Conv	Walnut, prune plum, plum, mirabelle (Prunus domestica subsp. syriaca)	None	Pumpkins, nuts, cereals, sunflowers, fresh fruit	Yes
ch6	More mixed	Conv	Apple, pear, prune plum, cherry	Cattle	Beef, cereals, Christmas trees, fresh fruit	Yes
ch7	Less mixed	Conv	Apple, cherry, prune plum	Cattle	Beef, vegetables, berries, jam, juice, syrups, fresh fruit	Yes
ch8	More mixed	Conv	Apple, pear, cherry, mirabelle, nuts, quince	Cattle, laying hens	Beef, eggs, cereals, juice, spirits, agritourism	Yes
ch9	More mixed	Org	Apple, pear, prune plum, cherry, chestnut	Cattle	Beef, pumpkins, cereals, juice, spirits, jams	Yes
ch10	Less mixed	Org	Apple, pear, quince, prune plum, mirabelle, incl. ProSpecieRara varieties	None	Fresh fruit, juice, vinegars, berries, nature conservation consulting	Yes
ch11	More mixed	Org	Apple, pear, quince, prune plum	Cattle, sheep, laying hens	Beef, mutton/lamb, eggs, fresh fruit, juice	Yes
ch12	Less mixed	Conv	Apple, prune plum	Cattle	Milk, fresh fruit	No
ch13	Less mixed	Conv	Apple	Cattle	Beef, juice, Maize	No
ch14	Less mixed	Org	Apple, pear, cherry, prune plum, greengage (Prunus domestica subsp. italica), peach, incl. ProSpecieRara varieties	Sheep	Juice, mutton/lamb	Yes
ch15	Less mixed	Conv	Apple, pear, prune plum	Deer	Deer meat, juice	No
ch16	More mixed	Org	Apple, pear, cherry, prune plum, quince, mirabelle	Water buffalo, laying hen rearing, labrodor rearing	Water buffalo meat, water buffalo milk cheese, lay-ready hens, spirits, labrodors, agritourism	Yes
ch17	Less mixed	Conv	Apple, pear, cherry, quince	None	Juice, vinegar, wine	Yes
ch18	More mixed	Conv	Apple, pear, chestnut, cherry, prune plum	Goats, sheep	Juice, fresh fruit, vegetables	Yes
ch19	More mixed	Org	Apple, pear, cherry, prune plum	Cattle	Beef, spirits, cereals, maize, firewood	Yes
ch20	Less mixed	Conv	Apple, cherry, prune plum	Cattle	Milk, fresh fruit, juice, flowers	Yes
ch21	More mixed	Conv	Apple, cherry	Cattle, chickens	Beef, chicken meat, spirits	Yes
ch22	More mixed	Conv	Apple, pear, cherry, prune plum	None	Cereals, soy, rapeseed, fresh fruit, jam, spirits, high-stem tree consulting	Yes

10.2 The Netherlands – Dairy & Arable Farming

The Dutch MiFAS includes dairy and arable production. We can distinguish three main corresponding value chains:

- Dairy products: Raw milk collected by the dairy cooperative 'FrieslandCampina', which belongs to the farmers. 'FrieslandCampina' supplies consumer products such as milk, yogurt, cheese, infant nutrition, and desserts, as well as products for the professional market, such as cream and butter products, ingredients, and semi-finished products for producers of infant nutrition, the food industry, and the pharmaceutical sector. However, so far these two actors did not play an important role in the emerging cooperation between dairy and arable farmers.
- Potatoes and derived products: Potatoes collected by the potato cooperative Avebe (starch), which belongs to the farmers. Traditionally, Avebe only focused on extracting starch from potatoes. However, by developing innovative methods they now also extract proteins from potatoes that are intended for the food industry.
- Sugar beet, wheat, and derived products.

Key AKIS actors interacting with the Dutch MiFAS include:

- Innovation Centre Veenkoloniën: It plays a role in knowledge creating and sharing; and puts cooperation between dairy and arable sector on the agenda.
- Experimental farm Valthermond: Valthermond is one of the WU business unit Field crops' field test locations. Field crops in Valthermond are used to conduct research into arable farming, multifunctional agriculture, and field production of vegetables.
- Water board: They influences water tables through their regulatory decisions.
- Nature organisations: They influence decision making on sustainability issues.

10.3 Denmark - Organic Agroforestry Livestock Systems

The Danish MiFAS includes trees/shrubs production in combination with crops, cattle, or pigs. We can distinguish two main corresponding value chains in this MiFAS:

- Pigs from [XXY]'s farm: All pigs from [XXY] are slaughtered at a local slaughterhouse. The carcasses are then transported to another slaughterhouse for production of sausages or to the [XXY] farm shop. The plan is to produce sausages on the farm in the future. The pork is mainly sold through the farm shop (self-service) and online to private consumers (90%) but before the Covid-19 restrictions, approximately 60% was purchased as wholesale by restaurants, etc.
- Organic Poplar pigs from [XXZ]'s farm: The brand 'Poplar pigs' from [XXZ] was launched in 2016 by COOP. These are considered as pigs with improved animal welfare compared to 'mainstream' organic pig production (and not branded as an agroforestry system as such). Organic pork from poplar pigs is labelled with four (the highest obtainable number) 'welfare hearts' (indicating 'the extra good life') according to COOP's animal welfare brand scheme.

With 500 pigs slaughtered every week, the farm [XXZ] is producing about 12.5% of all organic pigs slaughtered in DK. They slaughter the pigs in cooperation with a private slaughterhouse, which is in opposition to the majority of organic pigs which are slaughtered in one of the large Danish Crown slaughter houses. Approximately 200 of the pig carcasses produced weekly are sold to COOP, which buys the whole carcass (Jeppesen et al., 2021) that is then processed into various products, including sausages. The remaining carcasses are sold to – among others – food services.

The [XXY] and [XXZ] farms not only represent different mixed farming systems, marketing strategies and value chains, but also target different consumer segments: a) The ‘mainstream’ organic consumers highly interested in, and willing to pay for, extraordinary animal welfare (farm [XXZ]); and b) the organic consumers searching for high-quality distinctive pork with a story attached to it (farm [XXY]).

Moreover, the development of the third product mentioned, the agroforestry cheese, and the related marketing strategies, are still in progress.

In addition to the network partner Organic Denmark, key AKIS actors interacting with the Danish MiFAS include:

- Advisory services for farmers.
- Public authorities:
  - Ministries: They are framing the environmental and animal welfare regulations as well as the subsidy system for organically managed farmland (e.g. planting trees on farmland).
  - Municipalities: They are relevant for environmental regulatory control.
- Animal Protection Denmark: This is an animal protection association. They endorse sustainable farm system by labelling pork as ‘Recommended by Animal Protection Denmark’.
- Green investments companies.

Moreover, Table 19 provides additional details on the Danish organic farms that were involved in the data collection.

Table 19: Overview on characteristics of the Danish organic farms involved

Farmer ID	Main products	Direct marketing
dk1	Slaughtering pigs: 55-60% of the meat is sold using the story about the trees. The remaining 40-45% are sold as regular eco pig meat	No
dk2	Slaughtering pigs	No
dk3	Cuts, carcasses, Chartueri	Yes
dk4	From pigs: boxes of meat (10 kg of meat cuts), processed meat (salamis, hams, etc.)	Yes
dk7	Pig meat, milk	No

10.4 Austria – Organic Apples-Hen

The Austrian MiFAS focuses on organic apples and hens eggs production whose value chains are largely organized vertically. Besides the specificity of organic management of orchards and layer flocks, there are no substantial differences between organic and conventional supply chains.

Apples are marketed via the company 'Von Herzen Biobauern GmbH'; and eggs are marketed directly on farm. The role of 'Von Herzen Biobauern GmbH' is to collect organic apples and other fruits as well as to distribute them to retailers and other marketing partners in Europe. They supply all major players in the Austrian and European food retail sector.

For the fruits that cannot be marketed as 'fresh products', the company 'Von Herzen Biobauern GmbH' is looking for a solution with all potential fruit juice processing companies (e.g. Pfanner, Rauch, Ybbstaler), but which should also be financially interesting for the farmers. In addition, 'Demeter Austria' collects apples and eggs from a Biodynamic organic association, but the collaboration is still under development. Apples and eggs are then marketed as 'Demeter' to retailers.

This implies a major role played by farmers on governance in the 'Apple-Hen' project. Farmers decide on how many hens to keep, their genetic origin, the intensity of the feeding, and the on-farm direct marketing strategy and activities. Key AKIS actors interacting with the Austrian MiFAS include:

- Research Institute of Organic Agriculture (FiBL) in Austria: They accompanied the development of the Apples-Hens initiative that started in 2020 with four farmers.
- The regional development institution of Eastern Styria that financially supports the "Apples-Hens" initiative as an opportunity to establish innovative added value activities in the region.
- Rewe Group: They supported the Apples-hens project in 2020 (incl. financially) and may continue to invest onto the project in the near future.
- Organic fruit growing advisor from the Styrian Chamber of Agriculture.

Table 20 provides additional details on the farms that were involved in the data collection.

Table 20: Overview on characteristics of the Austrian organic farms involved

Farmer ID	Animals	Trees	Main products	Direct marketing
at1	Chicken farming	Apple	Apples, eggs	No
at2	Chicken farming	Apple Vineyard	Dessert fruits, wine, juices	Yes
at3	Chicken farming	Apple	Apples, eggs, wood	Yes
at4	Chicken farming Sheep farming	Apple	Apples, juices, eggs, products from arable farming	Yes
at5	Chicken farming Bees Pigs (own consumption)	Apple	Apples	No
at6	Chicken farming	Apple	Apples, juices, eggs	Yes

The Apple Hen initiative will be continued after the accompanying development work done in the frame of the MIXED project. Until the end of the project, decisive improvements will be made to the housing system, marketing and sales. This should ensure an expansion of production from 2025 onwards.

10.5 Portugal – Agroforestry Systems Montado

The Portuguese MiFAS focuses on cork oak trees and livestock systems. About 700 companies are involved in the Portuguese cork industry, and produce several products. There are different types of cork industries (Mendes and Graça, 2009; Branco and Lopes, 2018):

- The cork planks industry that produces planks as intermediary products. The latter can then be used to produce bottle stoppers. Cork goes through a series of stages, from the cork plank to the cork stopper, depending on the type of stopper to be produced.
- The natural Cork industry that produces stoppers and discs as well as agglomerate products such as floor and wall coverings.

Natural cork stoppers are punched from a single piece of cork, whereas technical stoppers are produced from a body consisting of agglomerated cork granules.

In addition to CONSULAI, Key AKIS actors interacting with the Portuguese MiFAS include:

- Forest and agriculture associations, including e.g. 'Forestis' that is an associative movement of national scope, with the aim of actively supporting the management and defence of the private and community forest.
- Academic sector; public institutions.

Moreover, Table 21 provides more details on the farms that were involved in the data collection.

Table 21: Overview on characteristics of the Portuguese farms involved

Farmer ID	Current level of mixedness	Management	Activities	Main products	Direct marketing
pt1	Less mixed	Conv / Org	Cork production with permanent grassland and grazing (cattle and pigs)	Cork, calves, pigs	No
pt4	More mixed	Conv / Org	Cork combined with cattle grazing under trees	Cork, cattle	No
pt5	Less mixed	Conv / Org	Cork production with calves and pigs grazing under the trees	Cork, cattle	No
pt6	Less mixed	Conv	Cork production with permanent grassland and grazing (cattle)	Cork, olive oil, olives	Yes
pt7	Less mixed	Conv / Org	Cork production with permanent grassland and grazing (cattle)	Cattle, cork, grapes	No
pt8	More mixed	Conv / Org	Cork production with permanent grassland and grazing (cattle and sheep)	Cattle, sheep, cork	No
pt9	More mixed	Org	Cattle raised for slaughter with permanent pasture and grazing	Calves	No
pt10	Less mixed	Conv	Dairy sheep production with production of sheep milk	Sheep milk, cow milk	No
pt11	Less mixed	Conv	Cork, olive, grape and corn production	Corn, grapes, cork	No
pt12	Less mixed	Conv	Cork and pine cone production	Cork, pine cone	No