MIXED

EFFICIENT AND RESILIENT
MIXED FARMING & AGROFORESTRY

MIXED

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Executive Summary

Farming systems in Europe and the UK have become highly specialised, creating farms that are dependent on purchased feed and fertiliser inputs. This has impacted on the delivery of many ecosystem services and has resulted in the loss of soil organic matter in predominantly arable areas, reducing soil fertility, and the ability of farming systems to adapt to climate change. A lack of diversity in farming systems has also impacted on biodiversity. MiFAS systems typically provide a level of diversity in the landscape and have the potential to reduce the impact of climate change on the farming systems. This deliverable uses an expert elicitation approach to characterise the ecosystem services delivered by the networks through the eyes of those involved. It aims to compare the delivery of these services with local non-MiFAS systems.

The first step was conducted at the Basel Meeting, September 2024. Participants were asked to assess the ecosystem services that are delivered by the different types of networks. They were given post-it notes of various shapes and sizes and were asked to draw and score the ecosystems services provided. The second stage of the evaluation of the impact of the MiFAS ecosystem service delivery was an expert elicitation. This involved the network leaders scoring the services on a semi-quantitative seven-point scale (-3, -2, -1, 0, 1, 2, 3) and give a short explanation of why and how the MiFAS system altered the ecosystem services delivered.

The results of the workshop and the expert elicitation highlighted that the introduction of MiFAS systems were largely positive for ecosystems services. With the exception of the Danish manure/grass protein exchange network (DK2), MiFAS was perceived to be beneficial for cultural services. The introduction of MiFAS also led to the enhancement of social interactions for the farmers, either because they were collaborating with other farmers, or they were interacting with other businesses or consumers. The social and cultural aspects of adopting MiFAS systems are important to the farming community (Meunier et al., 2024). Regardless of the type of MiFAS, the network leaders believed that the provisioning, regulating and supporting services tended to be enhanced by the (re)introduction of MiFAS systems. The results suggest that mixed systems have the potential to buffer against the social challenges and environmental impacts associated with climate change.

It is important to recognise that the supporting and regulating ecosystem service benefits arising from MiFAS systems may not be apparent in the short-term (Bernis-Fonteneau et al., 2024). The particular MiFAS adopted in any region must be appropriate to the environment and take into consideration the economic and cultural heritage of the region (Franzluebbers & Martin, 2022). Although there was a belief amongst participants that the MiFAS systems are positive in terms of ecosystem service delivery, these results are based on expert elicitation. Nevertheless, the wider literature does support that integrated systems offer financial, social and environmental benefits (Alderkamp et al., 2025; Meunier et al., 2024; Pinsard, 2025; Silva et al., 2024; Taube et al., 2024).

Abbreviations

D	Deliverable
EC	European Commission
WP	Work Package
WT	Work Task

Contents

1 Background

In Europe and the UK, agricultural systems have become highly specialised. This decoupling of crops and livestock has multiple effects on the functioning of soils and the delivery of many ecosystem services. Loss of soil organic matter in predominantly arable areas reduces soil fertility and also extends the land areas prone to drought. Ground water pollution can be a major problem in areas with high concentrations of livestock. Lack of diversity in farming systems also leads to uniform landscapes (de Faccio Carvalho et al., 2021). Increased land use diversity affects biodiversity in a positive way with, for example, bird species richness and occurrence being strongly linked to land use through its impact on habitat diversity (Santana et al., 2025). Farmers are now typically highly dependent on purchased fertiliser inputs to supply nutrients for crop production, and livestock farms often depend on imported feed for nutrient supply. Reconnecting crop and livestock production has been shown to have positive effects on many ecosystem services including weed, pest and disease control (Franzluebbers & Martin, 2022), which in turn can reduce the need for purchased inputs. The lack of diversity and loss of soil organic matter, particularly in arable areas, is limiting the ability of our farming systems to adapt to the changing climate (Franzluebbers & Hendrickson, 2024). Baker et al. (2023) use the term buffering to describe the ability of mixed systems to “reduce the negative impacts of shocks and stresses associated with climate changes“. As a consequence of specialisation, agriculture in Europe is facing economic, ecological and societal challenges. This deliverable uses an expert elicitation approach to characterise the ecosystem services delivered by the networks through the eyes of those involved. It aims to compare the delivery of these services with local non-MiFAS systems.

2 Methodology

The 14 networks were chosen to represent three types of MiFAS systems; namely, arable crops integrated with livestock, livestock and energy crops (or other fodder trees), and fruit/nut trees/bushes and livestock or arable crops (Tables 1 and 2). At the Basel Meeting, September 2024, a workshop was held to assess the ecosystem services that are delivered by the different types of networks. The participants were given post-it notes of various shapes and sizes, and the instructions for the workshops were:

1. Big post-its – draw one ecosystem service per post-it that YOUR network delivers
2. Draw and add disservices
3. Form groups with other networks who have similar characteristics. Within the network groups, organise the ecosystems into the provisioning, regulating, maintaining, cultural ecosystem services.
4. Discuss within your group what are the most important services that your systems deliver compared with monoculture? – score (1-5, 5 = best) using heart shapes.
5. What is the worst disservice possible from your systems? – score using rectangles (1-5 but 5 is worst)

6. Prepare to present this to the big group – what is common to all your networks (within group) – are there any conflicts? Are there any major differences?

This exercise was completed by 12 of the 14 networks. The Austrian team were unable to attend the Basel meeting due to flooding in Austria, and the network lead for DE network 6 was also unable to come to the meeting.

The second stage of the evaluation of the impact of the MiFAS ecosystem service delivery was an expert elicitation, similar to an approach adopted by Zhao et al. (2022). This involved the networks leaders scoring the services (Table 3) on a semi-quantitative seven-point scale (-3, -2, -1, 0, 1, 2, 3) and each of them asked to give a short explanation of why and how the MiFAS system altered the ecosystem services delivered. The classifications for the ecosystem services are based on the Common Internation Classification of Ecosystem Services (CICES) framework (Haines-Young & Potschin, 2018).

Table 1: MiFAS characteristics of the 14 networks

Network	Mixed farming characteristics	National team	
		Country	Network coordinator
1	Pig and dairy production integrated in energy crop production, local pig breeds integrated in fruit/nut production.	DK	Organic Denmark
2	Manure/grass protein exchange within a network of livestock and arable farmers		AU
3	Grazing cattle/fodder exchange within a network of beef suckler herds and arable farmers (East↔West Scotland)	UK	SAOS
4	Grazing sheep/fodder exchange within a network of livestock and arable farmers (foraging winter cereals)		SRUC
5	(Re)wetting of arable land, exchange of land between arable and livestock farmers	DE	ARGE
6	Integrated agroforestry, grassland and livestock systems		IFLS
7	Tall tree fruit farming mixed with livestock and cereal production	CH	Hochstamm Suisse
8	Poultry production (laying hens) integrated in fruit production	AU	BOKU
9	Pigs integrated in agroforestry systems and cooperation with arable farmers to provide local produced feed sources	FR	AGROOF
10	Crop and livestock/manure exchange between farms to produce young cattle meat fed on local produced feed sources		INRAE
11	Integrated livestock, natural pastures and trees supporting agro tourism	RO	LAG-Tinutul Posadelor
12	Land and manure exchange within a network of arable (peat, sandy land) and livestock farmers	NL	WU
13	One farm (>2000 ha, 100 employees) with agriculture and product processing. Agroforestry in pasture and crop systems.	PL	FSK Juchowo
14	Integrated production of pasture, cork and high value meat products based on local pig, cattle and sheep breeds	PT	CONSULAI

Table 2: Network theme organisation and general characteristics of 14 existing networks.

* 1: Arable crops integrated with livestock, 2: Livestock and energy crops (or other fodder trees), 3: Fruit/nut trees/bushes and livestock or arable crops

		Network theme*			No. of farms				Livestock specie				Production		Market		Mixed scale	
Network no.	Country	1	2	3	1-10	11-30	31-50	>1,000	Cattle	Pig	Poultry	Sheep	Conventional	Organic	Mainstream	Niche	Within farms	Between farms
1	DK		X		X				X	X	X			X	X	X	X	
2	DK	X				X			X	X			X		X			X
3	UK	X			X				X				X		X			X
4	UK	X			X							X	X		X			X
5	DE	X					X		X				X			X		X
6	DE		X	X		X			X		X		X			X	X	
7	CH			X				X	X				X	X	X		X	
8	AU			X	X						X			X	X		X	
9	FR		X			X				X			X	X		X	x	X
10	FR	X				X			X				X		X			X
11	RO			X			X		X			X	X	X		X	X	X
12	NL	X						X	X				X		X			X
13	PL		X		X				X		X			X		X	X	
14	PT	X	X			X			X	X		X	X	X	X		X	

Table 3: Ecosystem services scoring template

Type of ecosystem service	Ecosystem service
Cultural Services	Culture
Cultural Services	Social
Provisioning/ regulating	Soil health
Provisioning/ regulating / supporting / cultural	Above-ground biodiversity
Provisioning/ regulating / supporting / cultural	Conservation of water
Provisioning	Productivity
Regulating / cultural / Provisioning	Animal health
Regulating / cultural / Provisioning	Animal welfare
Regulating / cultural	Animal species diversity
Regulating / cultural	Plant species diversity
Regulating	Weed control
Regulating	Disease control
Regulating	Nutrient cycling
Regulating	Soil erosion
Regulating	Soil carbon
Regulating	Water purification
Regulating	Flood prevention

3 Results

The networks formed themselves into three groups (Table 4), which were based on agroforestry, exchanges occurring between the farmer groups, collaboration between farmers. A fourth group was the DE 5 network as it is focused on providing the benefits of rewetting land, and therefore the team felt that the ecosystem services they delivered were unique to their system.

The impacts of agroforestry in ecosystem services (Figure 1) were largely positive. The ecosystem services the Agroforestry team most valued were the reduced leaching, the provision of food, the ability of the land to withstand extreme events, and the cultural value of the landscape. Although it was recognised that the inclusion of trees could increase biodiversity, there was also the possibility that certain plant and insects may be reduced. The inclusion of trees in the landscape may also reduce productivity of the crop due to competition for nutrients and water, which may result in an increase in imported goods / feed into the region.

In France, the Netherlands, and Denmark (Exchange of goods), exchanging land and manure had economic, social and environmental benefits (Figure 2). A major benefit of the exchanges was an improvement in soil quality. Although crop diversity also increased in the Netherlands, this could result in an increased planting of crops that have negative environmental impacts. The challenges associated with the biogas refinery in Denmark were due to the additional impacts of transporting manure and grass.

The UK, Swiss, and Romanian networks were very different MiFAS systems, although they all foster direct collaboration between farmers, (Figure 3). In the UK MiFAS systems, there was likely to be a positive impact on soil health, above and belowground biodiversity and animal health and welfare. There was also the major benefit of a reduction in imported feed and fertilisers. In the Swiss and Romanian networks one of the main driving forces for the collaboration is agrotourism. These three

MiFAS systems all enhanced the on-farm biodiversity and have the potential to increase the soil carbon content. Cultural ecosystem services were delivered through agro- tourism, and livestock being outdoors for an extended period.

In the DE5 network, cattle have been re-introduced. The main aim of the MiFAS system was to restore the wetland features. The benefits were carbon storage, water retention and increased biodiversity (Figure 4).

Table 4: Network Grouping

Network	Mixed farming characteristics	National team	
		Country	Group
1	Pig and dairy production integrated in energy crop production, local pig breeds integrated in fruit/nut production.	DK	Agroforestry / trees
9	Pigs integrated in agroforestry systems and cooperation with arable farmers to provide local produced feed sources	FR	
13	One farm (>2000 ha, 100 employees) with agriculture and product processing. Agroforestry in pasture and crop systems.	PL	
14	Integrated production of pasture, cork and high value meat products based on local pig, cattle and sheep breeds	PT	
2	Manure/grass protein exchange within a network of livestock and arable farmers	DK	Exchange of good or products
10	Crop and livestock/manure exchange between farms to produce young cattle meat fed on local produced feed sources	Fr	
12	Land and manure exchange within a network of arable (peat, sandy land) and livestock farmers	NL	
3	Grazing cattle/fodder exchange within a network of beef suckler herds and arable farmers (East↔West Scotland)	UK	Collaboration between farmers
4	Grazing sheep/fodder exchange within a network of livestock and arable farmers (foraging winter cereals)		
7	Tall tree fruit farming mixed with livestock and cereal production	CH	
11	Integrated livestock, natural pastures and trees supporting agro-tourism	RO	
5	(Re)wetting of arable land, exchange of land between arable and livestock farmers	DE	Rewetting
6	Integrated agroforestry, grassland and livestock systems	DE	Network lead not able to come to the meeting
8	Poultry production (laying hens) integrated in fruit production	AU	Unable to attend the event

Figure 1: The positive and negative impacts of agroforestry / inclusion of trees on ecosystem service delivery for DK1, FR9, PL13 and PT14.

Figure 2: The positive and negative impacts of exchange of good or products ecosystem service delivery for DK2, FR10 and NL12.

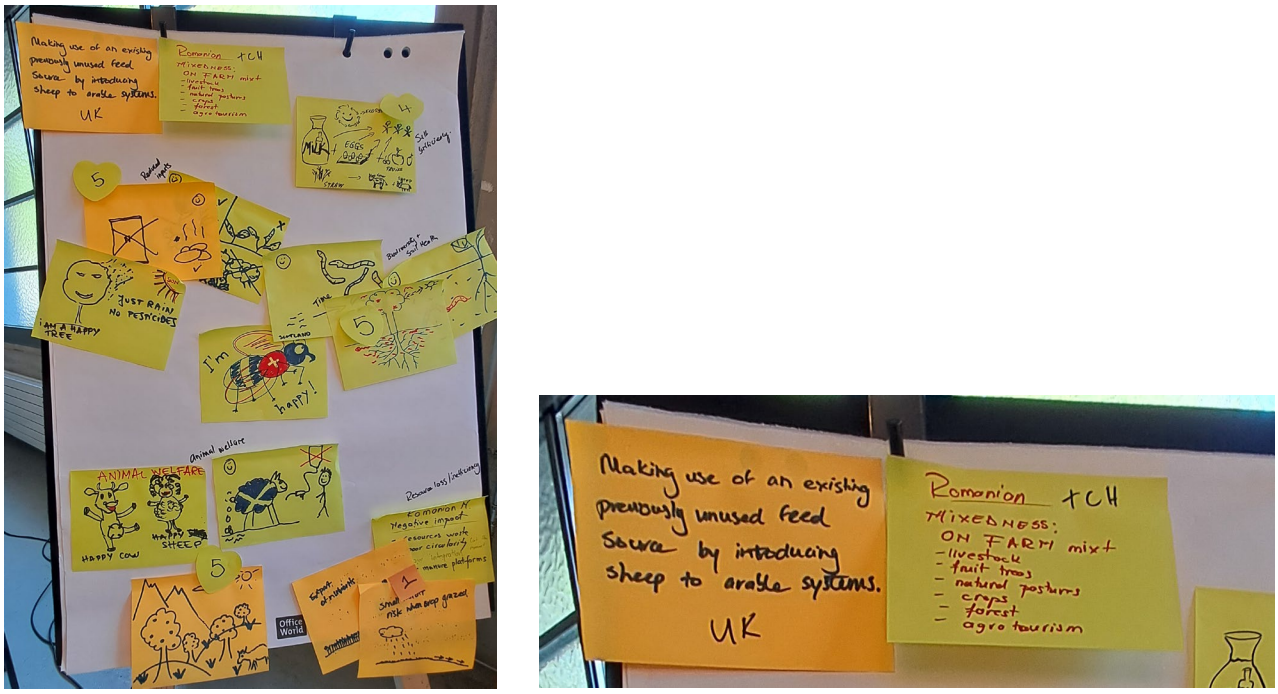

Figure 3: The positive and negative impacts of collaboration between farmers on ecosystem service delivery for UK3, UK4, CH7 and RO11.

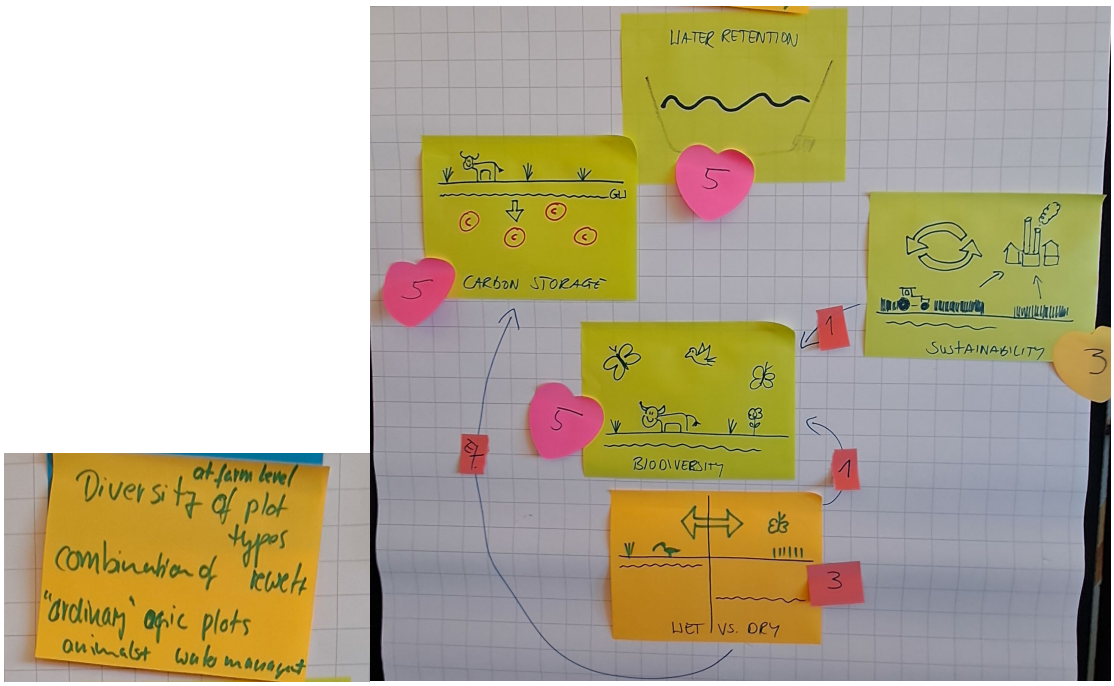

Figure 4: The positive and negative impacts of rewetting on ecosystem service delivery for DE5

The scoring matrix illustrated (Table 5, Figure 5) illustrates that change from simple, specialised systems to a MiFAS system was largely viewed by the networks leaders as having a positive impact on the ecosystem services delivered. The scoring does not suggest that inclusions of trees was better for ecosystem service delivery than arable livestock integration (Figure 5).

With the exception of two networks (DK2, DE6), MiFAS were viewed as benefiting the cultural services (Table 5, Figure 5, Culture). The adoption of MiFAS systems in DE6 had no impact on culture. For DK2, the negative score was attributed to the need for arable farmers to switch to

growing grassland. This would impact on the landscape, and the cultural experience of the farmers. The positive scores were attributed to reverting to or maintenance of traditional practices and landscapes. Social services were either not affected or were positively impacted by the adoption of MiFAS (Table 5, Figure 5, Social). The positive impact was largely due to the need for collaboration between farmers (e.g. UK3, UK4, DE5, FR10, RO11) or the interaction between farmers and consumers / business (e.g. DK2, DE5, CH7, AT8, FR9, RO11). In Portugal, the social benefits were attributed to the rural development that supports the wider local population.

The adoption of MiFAS was seen to be positive for soil health (Table 5, Figure 5, Soil Health). In some cases, MiFAS were increasing the soil microbial communities (DE5, AT8, FR9, PL13) or worm populations (UK4). The introduction of new crops or the inclusion of trees would impact on organic matter returns to the soil (DK2, CH7), and resultant soil structure (PT14). With the exception of FR9 and UK4, the change to a MiFAS system either had no impact on above-ground biodiversity, or increased it (Table 5, Figure 5 Above-ground biodiversity). In the FR9 network, the reduction in soil biodiversity was likely to be due to the damage the pigs do to the soil. In UK4, the effect on soil health was due to the sheep grazing the weeds; however, this impact will be small as the farmers are likely to spray the cereal crop with an herbicide later in the season. The adoption of MiFAS had a positive impact on conserving water for 7 of the networks, and a negative impact for UK3 (Table 5, Figure 5, Conservation of Water). In UK3, there was the risk of the cattle poaching the land and therefore reducing percolation. With the exception of DK1 and UK3, the MiFAS systems had a positive impact on productivity (Table 5, Figure 5, Productivity). The reason for the decline in productivity in DK1 was because the poplar trees are planted on land that could be used for growing crops, and they only produce a yield every two years. In UK3, the benefit was due to the sheep grazing the winter cereal, and as the yield of winter cereal was not affected by the adoption of the practice, there was a reduction the requirement for purchased animal feed.

Animal health was perceived to be negatively affected in UK3 and FR10 (Table 5, Figure 5, Animal health). In UK3, this was because cattle were being transported to new areas. Therefore, there was the risk of diseases being transmitted to new places and the possibility of stress caused by transporting the livestock. In FR10, the reason was attributed to the livestock farmer not seeing the livestock regularly. With the exception of UK3 and NL12, which had no perceived impact on animal welfare, animal welfare was enhanced by MiFAS adoption. Animal species diversity was either not affected by or enhanced by MiFAS adoption (Table 5, Figure 5, Animal species diversity). In the case of AT8, the increase in animal species diversity was due to the use of traditional, local breeds of hen on the Apple hen system. In the other networks, the increase in animal biodiversity was due to the increase in birds and below-ground fauna.

Plant species diversity was either not affected by or enhanced by MiFAS adoption (Table 5, Figure 5, Plant species diversity). The planting of trees or the introduction of new crops were seen as the direct activities of the farmer impacting on plant diversity. The adoption of MiFAS also resulted in systems with an increase in the native species or weeds. In contrast, weed control was enhanced in nine of the networks (Table 5, Figure 5, Weed Control). Similarly, in eight of the networks, disease control was thought, by the network leads, to be enhanced (Table 5, Figure 5, Plant disease control). The reasons for the positive impact on plant species diversity included the grazing of the weeds / diseased crop by the livestock, and the change in crops / crop rotation controlling the weeds and diseases. However, weed control was viewed as being more difficult in the biodynamic PL13 MiFAS system, as the inclusion of trees provided the weeds with shelter.

With the exception of DE6 and FR9, nutrient cycling was enhanced by the adoption of MiFAS (Table 5, Figure 5, Nutrient cycling). Nutrient cycling was unaffected in DE6, but in FR9, there was an increased risk of pollution due to the activity of the pigs. DK1 and DE5 indicated that leaching would decrease, whereas UK3, UK4, CH7, AT8, focused on the increase in the return of excreta either directly through grazing or the return of manure. DK2 stated that the improvement in nutrient cycling was the main driver for the adoption of the MiFAS practice. In general, the adoption of MiFAS was perceived to reduce soil erosion and increase soil carbon storage (Table 5, Figure 5, Soil erosion, Soil Carbon) due to the inclusion of trees, or the changing in the cropping system which resulted in returns such as the soil being covered for a greater period and an increase in quantity of organic

matter returned to the soil. However, in FR9, due to the activity of the pigs and in UK3, due to cattle poaching the land, there was an increased risk of soil erosion.

In six of the networks, MiFAS was perceived to be beneficial for both water purification and flood prevention (Table 5, Figure 5, Water purification and Flood prevention). The main benefit arose because of the inclusion of trees in the landscape or changes in the crop rotation / crop grown. FR9 and UK3 had negative scores for water purification. In the case of FR9, this was due to the activity of the pigs. UK3 also had a negative score for flooding. The reason for these scores was because of the risk of poaching by the cattle, which may have resulted in runoff and flooding during periods of heavy rain.

Table 5: The networks by MiFAS and the ecosystem services delivered by each of the networks.

Arable / livestock								X	X	X	X	X	X	X
Livestock with energy or fodder trees	X	X	X				X	X						
Fruit/nut trees with livestock or arable				X	X	X	X							

	DK1	PL13	FR9	CH7	AT8	RO11	DE6	PT14	DK2	UK3	UK4	DE5	FR10	NL12
Culture	2	2	1	3	3	3	0	3	-1	2	1	2	1	2
Social	2	0	2	3	3	3	0	2	1	3	2	2	3	3
Soil health	0	2	0	3	1	1	1	2	2	1	2	3	3	2
Above-ground biodiversity	0	2	-2	3	1	1	1	3	0	0	-1	2	0	1
Conservation of water	1	2	1	3	0	0	1	0	1	-1	0	2	0	0
Productivity	-1	1	1	1	1	1	1	2	1	0	2	1	2	2
Animal health	1	0	2	3	2	1	1	2	0	-2	0	2	-1	0
Animal Welfare	2	2	2	3	3	2	2	2	1	0	2	2	2	0
Plant species diversity	1	1	0	1	0	2	1	3	0	0	0	2	2	1
Animal species diversity	1	2	0	3	1	1	1	3	0	1	1	2	0	0
Weed control	0	-1	0	1	0	1	0	3	1	1	2	3	2	2
Plant disease control	0	0	1	0	1	0	0	1	0	1	1	1	2	2
Nutrient cycling	1	1	-1	2	2	1	0	2	3	3	2	2	2	2
Soil erosion	1	2	-2	3	0	1	1	2	2	-1	0	3	2	2
Soil carbon storage	1	1	0	3	0	1	1	2	2	1	0	3	2	1
Water purification	1	0	-1	3	0	1	1	0	2	-1	0	3	0	0
Flood prevention	1	0	0	3	0	1	2	0	1	-1	0	3	0	0

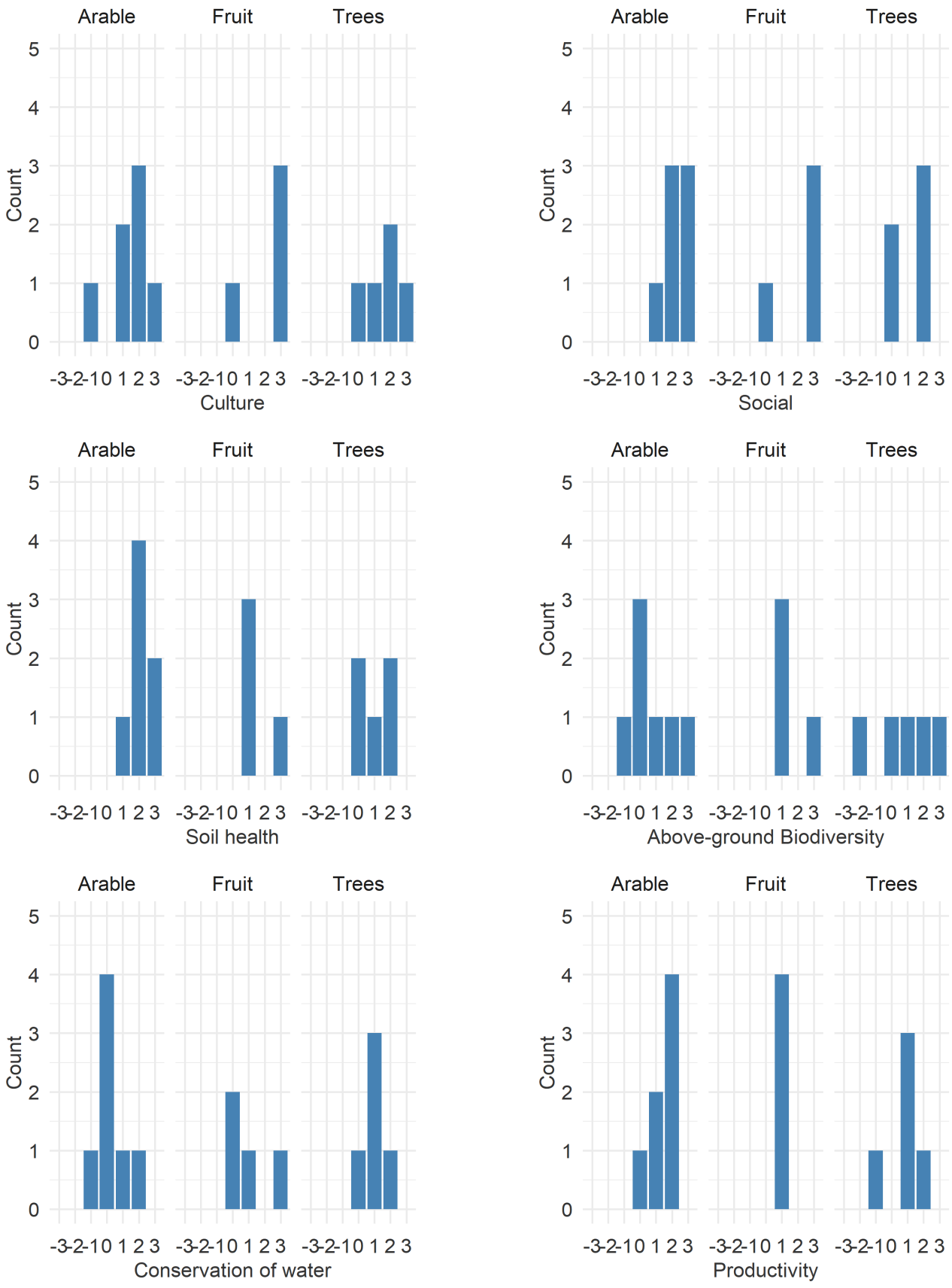

Figure 5: The frequency of scores by MiFAS type for each of the ecosystem services provided

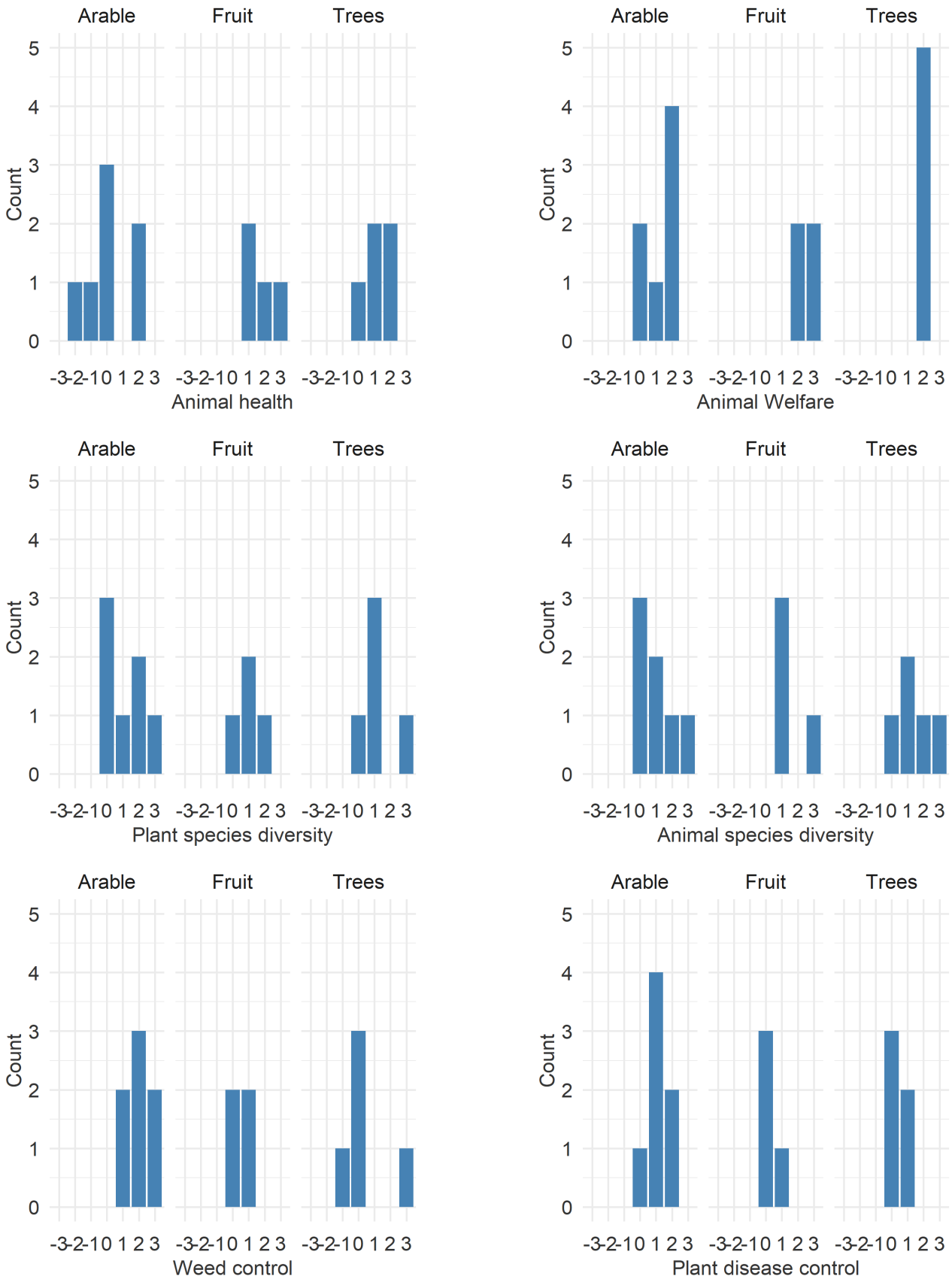

Figure 5 continued: The frequency of scores by MiFAS type for each of the ecosystem services provided

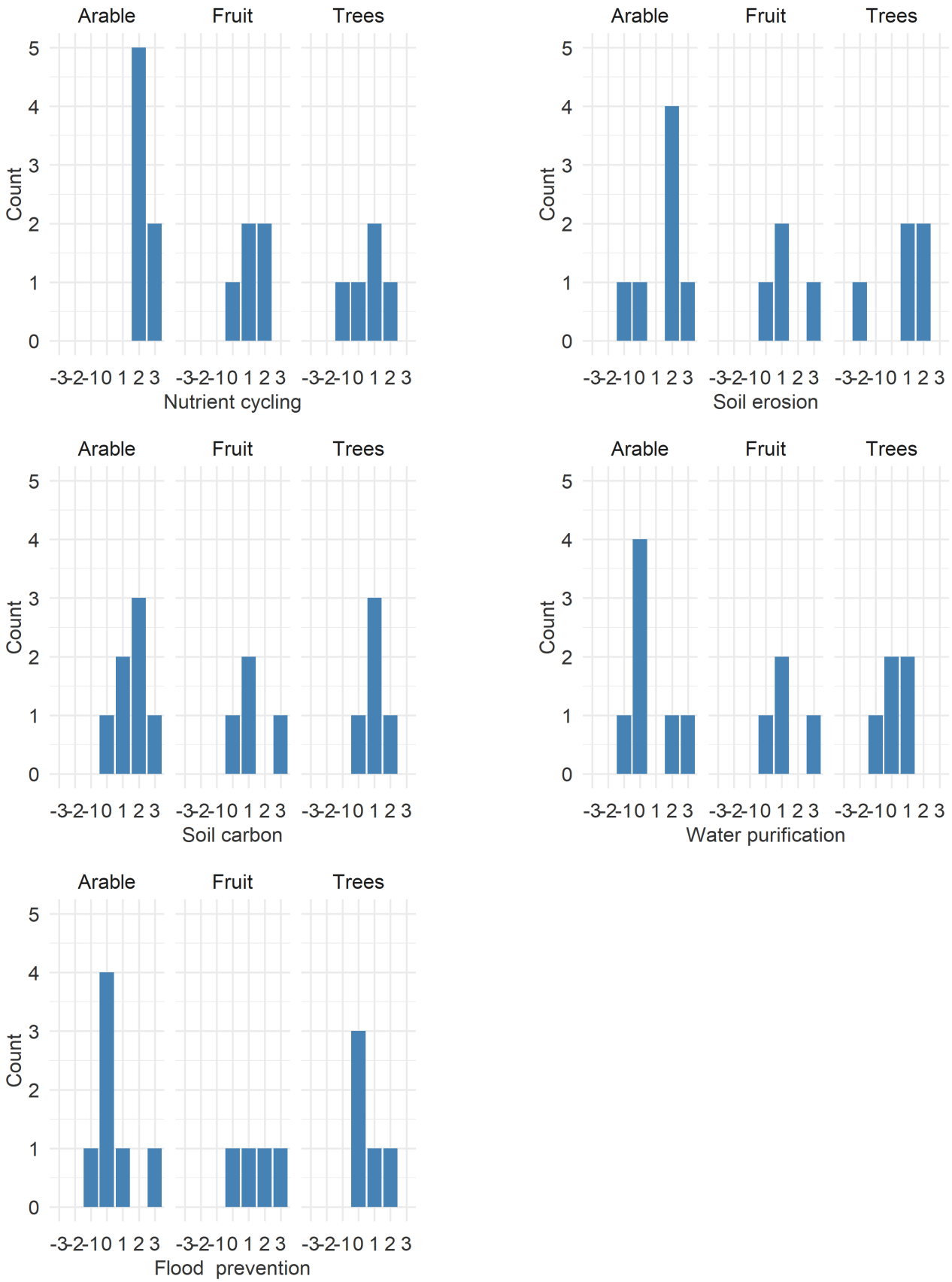

Figure 5 continued: The frequency of scores by MiFAS type for each of the ecosystem services provided

4 Discussion and Conclusion

The perception from our studies is that the adoption of MiFAS is largely beneficial for the delivery of ecosystems services. The social and cultural aspects were typically scored highly for all networks. The importance of the social benefits and the cultural aspects of reconnecting with family and traditions are major drivers for farmers reintegrating livestock into cropping systems (Meunier et al., 2024). Animal welfare, soil health and nutrient cycling also tended to score highly. This points towards the ability of these mixed systems to buffer against the social challenges due to climate change.

It is important to recognise that the supporting and regulating ecosystem service benefits arising from MiFAS systems may not be apparent in the short-term (Bernis-Fonteneau et al., 2024). The particular MiFAS adopted in any region must be appropriate to the environment and take into consideration the economic and cultural heritage of the region (Franzluebbers & Martin, 2022). MiFAS are more complex than specialised farms, and they create a system that improves the natural soil fertility and mimics the complexity of natural environments (de Faccio Carvalho et al., 2024). As well as the environmental benefits, integrated systems improve the economic resilience of the farms by diversifying the risk (de Faccio Carvalho et al., 2024; Meunier et al., 2024). These results thus suggest that these mixed systems can help to buffer the environmental impact of climate change and help to -improve resilience of the systems.

Although it is clear that there was a belief amongst participants that the MiFAS systems were largely positive in terms of ecosystem service delivery, these results were based on expert elicitation. Nevertheless, the wider literature does support that integrated systems offer financial, social and environmental benefits (Alderkamp et al., 2025; Meunier et al., 2024; Pinsard, 2025; Silva et al., 2024; Taube et al., 2024), and further research could provide more arguments supporting the long-term benefits of MiFAS systems.

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