MIXED

EFFICIENT AND RESILIENT
MIXED FARMING & AGROFORESTRY

MIXED	
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Executive Summary

Labour is a complex resource to manage in any farming system due to its high cost, the fact that there are peaks and troughs of demand throughout the year, labour units are indivisible, labour cannot be stored and lastly, not all labour is equal. The EIP-AGRI Focus Group on Mixed Farming Systems (MFS) (2017), identified labour issues as one of the biggest challenges to the uptake of mixed farming in the EU, due in part to the complexity of these types of systems (Moraine *et al*., 2016) but also due to skills deficits, unattractiveness of farming as a career, lack of incentives for young people to enter farming and lack of motivation to keep livestock (Nicholas *et al*., 2021).

The primary purpose of this Deliverable was to utilise a workforce planning model framework to map labour requirements across a production cycle for a range of case studies of mixed farming system types, in selected European regions. Current labour requirements and availability were analysed to identify labour and skill pinch points, labour impacts of future business plans and challenges/solutions associated with addressing farm labour pinch points discussed with farmers. An exploratory analysis was also conducted, testing the ability of the COM-B constructs (Michie *et al*., 2011, 2014; West & Michie, 2020) (capability, opportunity, motivation) to explain farmers' goals, intentions, and behaviours around addressing labour issues.

Data showing labour requirements per enterprise and per labour type (management, general, casual) throughout the year is presented and labour pinch points identified for each case farms. Common pinch points included sowing in arable, harvesting in arable/fruit and the breeding season in livestock breeding enterprises. Pinch points most commonly affected general and casual labour and were exacerbated by increasingly variable climate and short sowing/harvest windows. The lack of transferability of skills between plant and livestock enterprises was identified as a contributor to labour pinch points. Labour productivity was highly variable between the farms – the large range may in part be due to socio-economic factors, as well as specifics of the different farm systems studied. No general conclusions regarding farm type and labour productivity can be made as the values appear to be more likely associated with region rather than farm type.

The results of the deductive analysis suggest that capability (psychological and physical), opportunity (physical and social), and motivation (automatic and reflective) are salient concepts for farmers as they pursue goals, implement their plans, and mitigate labour challenges along the way. The degree of ”mixedness” or integration between those enterprises was not mentioned explicitly as having an impact on the pinch points identified.

Lessons can be learned across case farms as to how individuals have, or plan to address labour issues, and some key recommendations from the study (also identified in D1.1) include:

- There is a need to address difficulties securing and administering large scale seasonal workforces. This requires political support as well as technological developments in routine tasks, and perhaps cropping system changes to reduce total labour demand.
- Training and upskilling (across a range of enterprise types), of future and existing staff is needed to provide a more flexible and effective workforce throughout the year. Both staff and employees need to be incentivised to engage with staff development – at present there are barriers in terms of cost, time and perceived security of investment from farmers.
- Improved co-operation between farmers could address a number of labour pinch points (e.g labour sharing to cover staff leave and holidays and working together to secure the services of arable contractors).
- Advisory support and modelling need to be developed to support farmers in cropping and labour planning in the context of increasing extreme and variable weather patterns.

Abbreviations

AACTT	Actor, Action, Context, Target, Time
CH	Switzerland
COM-B	Capability, Opportunity, Motivation, Behaviour
D	Deliverable
EC	European Commission
FTE	Full Time Equivalent
HR	Human Resources
ICL	Integrated crop and livestock systems
ICLF	Integrated crop, livestock and forestry systems
MFS	Mixed Farming System
NL	Netherlands
PO	Poland
PT	Portugal
SA	Specialist arable systems
SC	Scotland
WP	Work Package
WT	Work Task

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1 Introduction

Labour is a complex resource to manage in farming systems due to a number of factors (Barnard and Nix, 1979). It is also a high-cost input (monetary and administratively (McGuckian and Rickards, 2011), particularly when maintaining full time employees. Due to the nature of farming, there are peaks and troughs of work throughout the year, and as labour cannot be stored, and regular labour (as opposed to seasonal workers, contractors) comes in indivisible units, this can result in relatively poor labour productivity throughout the remainder of the farming year (Gil, Garrett and Berger, 2016). Another factor to consider is that not all labour is equal – some jobs require specialist skills whilst others are less skilled jobs - this means that labour is not always transferable between enterprises and activities. Finally, sourcing appropriately trained and reliable labour is becoming increasingly difficult due to the long working hours and relatively poor pay compared to other industries (McGuckian and Rickards, 2011).

All the challenges described above result in many farms relying on family labour. In a review of integrated crop-livestock systems for more sustainable agricultural production, Hendrickson (2020) found that increases in the number of family members involved in the farm business tended to improve adoption of integrated crop-livestock systems. A possible explanation is that family members play a key role in providing free and timely farming labour (Widadie and Agustono, 2015). Relying on family labour, however, does pose challenges, including increased complexity associated with having multiple decision makers, the inextricable link between business and family relationships (McGuckian and Rickards, 2011), often unclear or complicated business succession pathways and the opportunity cost of working on the farm compared to off farm jobs (Nicholas-Davies *et al*., 2021), amongst others.

The EIP-AGRI Focus Group on Mixed Farming Systems (MFS) (2017), identified labour issues as one of the biggest challenges to the uptake of mixed farming in the EU. Challenges related to labour organisation and skills to manage both livestock and cropping (and agroforestry) enterprises; often higher administrative burden in MFS; low remuneration of labour due to the generally low short-term profitability of MFS and current education and advisory systems (Moojen *et al*., 2023) not providing adequate tools for farmers in terms of labour management and managing complex MFS. Labour related challenges facing MFS were also identified in Nicholas-Davies *et al*. (2021) and included labour and skills shortages for complex MiFAS (and gender barriers to addressing this); the low attractiveness of farming as a career, especially for young people; a lack of entrance and exit schemes for farmers and a lack of motivation to keep livestock (as they are perceived as labour intensive and with low profitability).

Mixed farming systems have multiple enterprises that interact in complex ways which are often difficult to quantify (McGuckian and Roberts, 2011) and the complexity of management of these systems is often seen as a barrier to mixed farming uptake (Moraine *et al*., 2016). de Roest *et al*. (2018) stated that farmers may not perform as well managing complex systems, such as mixed farming systems, as managing multiple enterprises requires more skill and time. However, studies have suggested that overall labour productivity may be improved in mixed farming systems due to the more continuous demand for labour across diverse livestock, arable and forestry enterprises (Gil, Garrett and Berger, 2016). Mosnier *et al*. (2021) modelled the impact of mixing livestock enterprises (beef and dairy, beef and sheep) and livestock and crops (beef and crop) on labour requirements and peak workloads. They found that total working hours increased slightly in the mixed beef x crop farm (2%) and the beef x dairy farm (1%) but decreased in the beef x sheep farm (-1%) when compared to the enterprises managed separately. Mixed, compared to single enterprises tended to reduce peaks of workload, and assuming no part time workers were hired, resulted in decreased worker units over all – though higher working hours for the workers, often a particular challenge for family farming businesses. The reductions in peak workload were largest in systems with complementary enterprises (i.e. they had different peaks), however this modelling exercise did not consider the skills required to work in different enterprises. Thornton and Herrero (2015) in Gil, Garrett and Berger (2016) also stated that integrated crop and livestock systems (ICLS) result in greater, more continuous demands for labour throughout the year when compared to specialised

arable systems, however this may also result in increased labour use efficiency if permanent labour units on the farm are able to be better allocated to productive uses (Gil, Garrett and Berger, 2016) – something only possible if labour units are adequately skilled to work across multiple enterprises. Poffenbarger et al (2017) in a modelling study of cash crop arable, mixed ley arable and integrated crop livestock systems found that labour requirements increased with rotation diversity and the introduction of livestock, however livestock integration (in this case fattening cattle) did result in a more event distribution of labour throughout the year. The category of livestock (and the type of system) integrated into the cropping system would determine whether peaks of labour were complementary or not e.g. most UK sheep breeding systems would result in peaks of labour in the spring at lambing, coinciding with spring sowing activity in arable rotations.

The primary purpose of this Deliverable was to utilise a workforce planning model framework to map labour requirements across a production cycle for a range of case mixed farming system types in selected European regions. Based on collected data, current labour requirements and availability were analysed to identify labour and skill pinch points. The case farmers were also interviewed to identify the potential impacts of future business plans on labour pinch points, and challenges/solutions associated with addressing labour issues on their farms. The COM-B framework (Capability, Opportunity, Motivation – Behaviour; see figure 1; Michie *et al*., 2011, 2014; West & Michie, 2020) , extensively applied in the domain of healthcare, but proportionately less in agricultural contexts, has also been applied to the same interview data to identify necessary pre-cursors to behavioural change: 'capability' can be physical or psychological, and refers to an attribute of a person that makes a behaviour possible; capability relies on 'opportunity,' however, which are physical and social attributes of the environment surrounding the behaviour. Finally, 'motivation' is an "aggregate of mental processes which energise and direct behaviour," and can be reflective (involving conscious thought processes) and/or automatic (habitual, instinctive, and drive-related). This analysis was an exploratory test of the utility of the framework in this context and, specifically, a test of the ability of the COM-B constructs (capability, opportunity, motivation) to explain the farmers' goals, intentions, and ultimately, behaviours in relation or response to their labour issues.

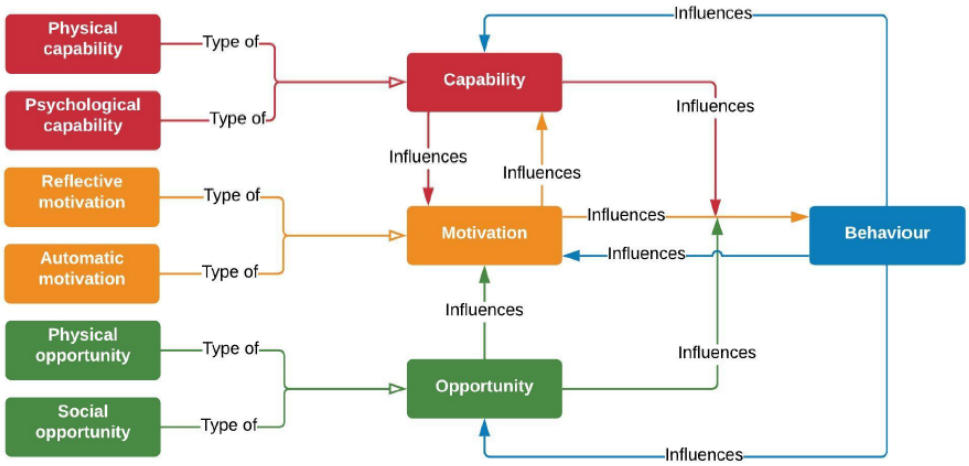

Figure 1. The COM-B model of behaviour (West & Michie, 2020).

2 Methodology

Utilising a typical human resources (HR) workforce planning model (CIPD, 2022), and based on quantitative and qualitative data collected through interview with farm managers, labour requirements were mapped across a production cycle for the various enterprises in case MFS in networks of the MIXED Project. They included examples for each of the different types of MFS being studied in the project including integrated crop/livestock (ICL), integrated crop/livestock/forestry (ICLF), collaborating specialised arable/crop (SA) and livestock systems (SL). Balancing current and potential future labour requirements with currently available labour allowed identification of labour and skill pinch points which were then used as a basis for discussion, such as how these pinch points might be overcome, and which external challenges might be hindering appropriate solutions. Partners participating in the Task included ABER (Lead), Consulai (PT), FiBL (CH), KST JUCHOW (PO), SAOS/SRUC (SC) and WU (NL). A summary of the MFS types interviewed in each partner country is presented in Table 1. All the interviews were conducted with the farm manager. In the case of JUCHOW, due to the size of the company, two farm managers were interviewed, one each representing arable/crop and livestock enterprises.

Table 1 Summary of the mixed farming systems included in the study from each country* and the unique codes used to identify them in the text.

Integrated crop and livestock (ICL)	Integrated crop, livestock and agro-forestry (ICLF)	Collaborating specialist livestock (SL) or cropping system (SA)
ICL- PO	ICLF-PT2	SA-SC1
ICL-SC3	ICLF-PT7	SA-SC2
ICL-SC6	ICLF-CH3	SA-SC4
ICL-SC7	ICLF-CH4	SA-SC5
ICL-SC8	ICLF-CH8	SL-NL1
ICL-NL3		SA-NL6

*CH=Switzerland, NL=Netherlands, PO=Poland, PT=Portugal, SC=Scotland

The interviews followed steps 1-5 of a standard workforce planning model (Figure 2.) (CIPD, 2022l), that is to understand the current organisation and its context, determine current staffing levels, forecast future staffing needs, identify the gaps between the two and identify solutions to labour challenges. Given Step 6 is longer term and beyond the time frame of this study, interviewees were instead asked to reflect on what solutions to labour challenges that have or have not worked (including barriers) in their farming systems.

Figure 2. The key steps in the process of workforce planning (CIPD, 2022)

2.1 Approach

The data collection for Task 5.2 required a semi-structured interview approach with farm managers. The interviewers gathered quantitative and qualitative information related to the farm business and current and potential future labour requirements, as outlined in the following steps based on the work force planning model in Figure 2.The interviews varied in length from 30 to 60 minutes.

2.1.1 Step 1 – Understanding the organisation

A general description of the farms that included the location, type of farm, the mix and relative importance of different enterprises, estimated physical output from the enterprises (to be able to calculate labour productivity indicators) and the labour used on the farm (including family, full and part time employed staff, seasonal workers, contractors) was gathered. The description provides a broad picture of the farming business. Templates (Appendix 1) were used to facilitate data collection.

2.1.2 Step 2 – Current workforce

A work force planning template (divided by meteorological season) was used to collect data on labour use within the farm business and across enterprises (Appendix 2). This data enabled pinch points in total labour use and labour type (management, general farm labour, contractors) across enterprises and seasons to be identified. It also allowed the identification of reliance on certain individuals, which might have implications in terms of the resilience of the business to accident, sickness or event mortality shocks (Nicholas-Davies *et al*., 2021).

The labour productivity for each farm was also calculated. In alignment with Task 5.1, standardised output prices per product type were applied to the estimated physical output for each farm. The standard price data was based on the German KTBL agricultural planning database (KTBL, 2024), for which output prices were assumed to be consistent across countries for comparative purposes. The total output value in Euros was then divided by the full time equivalent (FTE) workforce value to generate an output per FTE value, indicating the revenue generated by each worker (paid or unpaid).

2.1.3 Step 3 – Future workforce needs

Farm businesses are continually evolving to remain resilient in the face of social, environmental and economic changes. The interviewers asked participants to describe their future plans for the farm business and how these would impact the family and employed labour requirements of the business. Thus, participants were asked to establish their intentions, or goals, and elaborate on behaviours that would lead them there. When thinking about adoption of behaviours, or changes required of existing behaviours, the AACTT framework is useful (Presseau *et al*., 2019). AACTT stands for Action, Actor, Context, Target, and Time, encouraging us to consider who will enact the behaviour (*action*), where (*context*), and in what time frame (*time*); and when the person responding is a farm manager (*actor*), they can be reflecting on their own behaviour or the farm-level actions that others will carry out (*target*). A template was provided for interviewers which outlined key questions to ask the farmer and prompt questions to elicit more detailed responses, as well as space for recording qualitative data (Appendix 3).

2.1.4 Step 4 - Workforce gaps

Farmers were asked to reflect on the data collected in Step 2 (current labour) to establish where the pinch points might be in terms of labour and skill availability, and also the workloads of individuals. They were then asked to consider the impacts of futures plans (as outlined in Step 3) and how they might impact to alleviate, exacerbate or create new pinch points. Key questions and prompts to initiate discussion are again outlined in Appendix 3.

2.1.5 Step 5 and 6 - Addressing the gaps

In this step, the interviewer explored how the farmers have gone about addressing any pinch points identified in Step 4, and in doing so what challenges they faced. Challenges may include external challenges such as market, political or societal factors (e.g., low unemployment, immigration barriers) but also perhaps ingrained behavioural and attitudinal challenges. Thus, in this step we also explored the farm managers' perceptions of more internal barriers and enablers for behaviours associated with, for example, solving identified labour issues within their business. To meet this aim, participants were asked questions related to their capability, opportunity, and motivation (COM-B model of behavioural change; West & Michie, 2020) to make changes on the farm (Appendix 3).Also of interest were past success stories i.e., innovative ways they may have overcome previous labour challenges (e.g., introduction of a new technology, engagement with an apprenticeship scheme) that can be shared within and beyond the MIXED farmer networks.

3 Results

The aim of having a minimum of four interviews from each of the three mixed farming types was achieved (Table 1.) however not all participating networks were able to collect full datasets. In the Netherlands, whilst all quantitative data was provided, the farmers declined to complete the full interview as they did not view labour issues as a problem on their farms. Some insights were provided by the NL interviewer and contribute to the accrued knowledge in this deliverable but the contribution of NL qualitative data for Steps 3-6 is limited.

3.1.1 Step 1 – Farm business context

The size and main characteristics of each farm are presented in Table 2 below. The table indicates a large range in farm size, (20-6425 ha), reflecting the diversity of farm systems and the landscapes that they sit within. The largest farms were generally in Scotland, Portugal and Poland and the smallest farms within Switzerland. The Swiss farms were also the most diverse, with crops, livestock and agroforestry in the form of high-stemmed fruit trees common to all the farms. The larger farms in other countries tended to be more specialised and less integrated. The cropping and livestock enterprises tend to be highly specialised, such as dairying in the Netherlands, cropping in Scotland.

Table 2 Summary of the farm characteristics

Farm	Area (ha)	Crops	Fruit	Cattle / sheep	Pigs / poultry	Agro-Forestry	Other†
ICL_NL3	102	x		x			
ICL_PO	1936	x		x			
ICL_SC3	402	x		x			
ICL_SC6	365	x		x			
ICL_SC7	6425	x		x			
ICL_SC8	707	x		x			
ICLF_CH3	33	x	x	x		x	
ICLF_CH4	24	x	x	x	x	x	
ICLF_CH8	20	x	x	x		x	
ICLF_PT2	440			x		x	
ICLF_PT7	680			x		x	
SA_NL6	382	x					
SA_SC1	286	x					
SA_SC2	231	x	x				
SA_SC4	378	x					
SA_SC5	370	x					
SL_NL1	116			x			x

† Lawn grass

3.1.2 Step 2 – Current activities and staffing levels

Farmers were asked to indicate how the balance of work differs during the year. Table 3 highlights the variation in labour by season, as well as the average FTEs during the whole year.

For ICL type systems, labour use tended to peak in the autumn and winter. This pattern is similar for the ICLF farms, whilst the specialist arable farm labour peak is more in the summer/autumn. The only specialist livestock farm indicated labour peaks in spring and autumn which is probably dependent upon the calving season.

Labour productivity was highly variable between the farms, ranging from <€10k/FTE (ICL_PO through to >€180k/FTE (ICL_SC6 and ICL_SC7). This very large range may in part be due to socio-economic factors, as well as specifics of the different farm systems studied. It seems no general conclusions regarding farm type and labour productivity can be made as the values appear to be more likely associated with region rather than farm type. However, the two farms with the highest labour input also exhibit amongst the lowest labour productivity (ICL_PO and SA_SC2).

Table 3 Summary of the farm labour per season (FTE), average for the year (FTE), annual production value (€), and labour productivity (€/FTE).

Farm	Spring FTE	Summer FTE	Autumn FTE	Winter FTE	Average FTE	Production value Euro	Labour productivity Euro/FTE
ICL_NL3	4.00	1.95	4.25	1.75	2.99	526984	176396
ICL_PO	145.70	149.20	151.50	143.40	147.45	1424146	9659
ICL_SC3	6.00	6.67	6.00	6.00	6.17	1108090	179690
ICL_SC6	3.20	3.20	5.52	3.20	3.78	691510	182939
ICL_SC7	8.88	8.88	9.10	8.88	8.94	1627712	182173
ICL_SC8	4.75	4.75	16.75	22.75	12.25	1905113	155519
ICLF_CH3	0.90	1.70	2.20	1.70	1.63	71435	43960
ICLF_CH4	1.65	1.95	2.45	2.10	2.04	166924	81926
ICLF_CH8	1.50	1.50	1.50	0.80	1.33	18445	13920
ICLF_PT2	4.30	4.30	4.30	4.30	4.30	135448	31499
ICLF_PT7	2.15	2.15	2.15	2.15	2.15	102180	47526
SA_NL6	17.00	12.00	17.00	8.00	13.50	2358240	174684
SA_SC1	2.00	2.00	2.67	2.33	2.25	320406	142402
SA_SC2	36.33	386.33	553.00	553.00	382.17	5684774	14875
SA_SC4	4.42	6.42	6.25	6.42	5.88	695856	118444
SA_SC5	4.00	4.00	4.00	4.00	4.00	626130	156533
SL_NL1	3.70	2.93	3.60	1.75	3.00	494524	165116

In addition to identifying the total labour force, the interviews aimed to understand how labour needs were split between enterprises, as shown in Figure 3 below. For the ICL farms, there were mixed results - whilst some farms maintained a consistent labour requirement, others showed strong seasonal patterns. However, the farms that saw strong differences were usually linked to specific enterprises, such as vegetable crops, or in the case of ICL_SC2, fruit production. For the ICLF systems the Swiss farms observed variable labour requirements due to fruit production and livestock, such as calving. The Portuguese farms showed a flat labour pattern, whilst the four Scottish arable farms (SA), showed increased labour demand in the autumn for sowing, with lower demands in the spring. The farm SA_SC2 had exceptionally strong labour demand as the year progressed - a similar, though proportionally smaller pattern was observed on ICL_SC8, both of which were reliant on autumn/winter casual labour for harvesting vegetables and soft fruit crops (Figure 4).

Figure 3 Summary of the farm labour per season (FTE) per enterprise or work type (y-axis=FTEs). Farms are sorted by type (starting top left-hand corner).

Figure 4 shows the labour demand per season and labour type and shows that for most farms the majority of labour is supplied as management or general workers. However, for some farms, casual or contractor labour forms a large proportion of their labour input, at least at certain times of the year. These peak workloads seem to be primarily related to specialist crops of fruit (e.g. SA_SC2, ICLF_CH3) and vegetables (ICL_SC8), either as labour for harvesting or winter maintenance.

Figure 4 Summary of the farm labour type per season (FTEs)

3.1.3 Step 3 – Future staffing requirements

Interviewers explored the future plans of the farm businesses and how those plans might impact on both the family and employed labour requirements of the business. A summary of these plans, demonstrated by direct quotes, is presented in Table 4.

Table 4 Future plans (5-year time frame) of case study farms demonstrated by direct quotes

Integrated crop and livestock (ICL)	Integrated crop, livestock and agro-forestry (ICLF)	Collaborating specialist livestock (SL) or cropping system (SA)
"*introduce maize to our crop rotation*" (ICL_PO)	"*convert to organic farming*" (ICLF_PT7)	exchange knowledge with arable farmers about crop management (SA_NL1)
"*Reducing spring barley area*" (ICL_SC6)	"*Try to keep the value chain on the farm*" [do direct marketing] (ICLF_CH3)	more exchange of land (SA_NL1)
"*the hope is to cut out x 1 spray pass*" (ICL_SC7)	"*maintain suckler cow husbandry in combination with ecology as the main branch of business*" (ICLF_CH8)	joint optimisation of crop rotations (SL_NL6)
"*expand by increasing livestock stock numbers*" (ICL_SC3)	"*introduce other fruit trees like plums, apples, pears, mirabelles*" (ICLF_CH3)	*"Reduction of labour requirements overall, able to farm same amount of area with less people*" (SA_SC2)
"*Using winter grazing as a method to control crop growth going into winter months, i.e., not having to worry about sowing winter cereals too early*" (ICL_SC6)	"*more autumn and winter work [harvest, pruning]*" (ICLF_CH8)	"*Getting bussier (sic) with the fruit side of the business*" (SA_SC2)
"*reduce inorganic fertilisers and livestock concentrates*" (ICL_SC7)		"*The farm wants to take on new technology when feasible*" (SA_SC4)
More sheep grazing, more cover crops, more regen approach to farming" (ICL_SC8)		

Enterprise changes were identified on 8 farms, some changes requiring more or less labour and others having a neutral impact on labour. In Portugal (ICLF_PT7) the aim was to make incremental changes to pasture and herd management that will ultimately result in a reduction of labour from 2 to 1 shepherd. In Switzerland (ICLF_CH4), an aging father who will no longer be able to help in the pig fattening business, meant that that enterprise was likely to disappear, and available labour focussed on the remaining dairy enterprise. In Scotland the enterprise changes were about reducing the need for full time labour in favour of using seasonal labour at busy times. The introduction of maize growing to become more self-sufficient in livestock feed (ICL_PO) and fruit growing trees reaching harvest maturing in 10-15 years (ICLF_CH8) were both identified as requiring more labour (in the longer-term future for ICLF-CH8). Other changes such as increasing livestock numbers, using winter grazing of arable crops to control growth (managed by collaborating sheep farmer) and instigating a regenerative approach to farming (ICL_SC3, ICL_SC6, ICL_SC8) were thought to have a neutral impact on future labour requirements. In ICL_PO the introduction of a home grown and mixed diet for the dairy herd was thought to increase workload whilst everyone learnt the new system but in the longer term, would have a neutral impact on labour requirements.

Some farms had planned social goals that they wanted to achieve/develop in the short to medium term. SA_SC5 was planning for the retirement of the senior partners. The junior partner planned to take over managing the business on their own, though support from paid labour or an additional employee might be needed. Other social goals such as increasing cooperation and exchange of

knowledge about crop management with arable farmers in the region (NL farmer network) were thought to have a neutral impact on labour.

Several of the farms mentioned business goals they had in the next 5 years that had varying impacts on labour requirements. SA_SC2 in Scotland, for example had the aim of reducing labour requirements overall, effectively farming the same area with fewer people. In ICL_PO, new goals were planned for the dairy component of the mixed farming system - to breed animals suited to the existing organic farming system but with higher yields and capable of producing A2 milk. Whilst this was not identified as increasing total labour, the skills required to achieve such goals were new so there was an element of training/reallocation of labour required. In ICLF_PT7 and ICL_SC8 there were plans to shift towards organic and regenerative agricultural practices, respectively, which again was not expected to change total labour requirements but retraining of existing staff would be necessary. ICL_SC3 and SA_SC4 were focussed on the expanding their businesses (e.g. by increasing livestock numbers) to be able to continue to employ existing staff.

Business investments were not specifically mentioned other than SA_SC4 wanting to take on new technologies related to crop production when feasible.

ICLF_PT2 and ICLF_PT7 and ICLF_CH8 could not see any changes in labour requirements in the next 5 years.

The COM-B constructs of capability, opportunity, and motivation were observed in how participants reflected on past experiences to respond to these questions on future plans and likely impacts on labour. For example, ICL_PO recounted the preceding year and how they had: "*changed the feeding system for our dairy cows in the autumn and winter season, we changed from feeding them only hay to feeding a mixture of hay and silage. We took this decision to keep up our mixed farming system and keep up fodder sovereignty, because feeding a mixture of hay and silage lowers costs when compared to feeding only hay. We produced and fed silage for the first time ever, so everybody had to learn how it works, which took some additional time at the beginning, but by now everybody got used to it*." This is an example of how **psychological capability enablers**, in the form of new understandings, as well as **physical opportunity enablers**, in term of cost savings, helped them manage the labour implications of making progress towards their stated goals. Moreover, the Polish farm's experience embodied physical opportunity in terms of the hiring and harvesting behaviours required to become more self-sufficient:

> *"In the coming season we will introduce maize to our crop rotation to get more self-sufficient in terms of animal fodder. Until now we buy in maize, but this in very expensive, much more expensive than growing it ourselves, and sometimes it's also complicated if you need to buy organic maize. For the maize we will need to hire at least some seasonal worker(s) for weeding the maize fields, because this will be due when a lot of other work needs to be done. Probably we will also need to hire someone for the harvesting, because maize is due in autumn, which is a time when a lot of other field work needs to be done. Keeping up fodder sovereignty by growing maize has a huge impact on the crop rotation and the rhythm of the field work because of the late sowing and harvesting times for maize".* ICL_PO

In farm ICLF_CH4, we see a **physical opportunity barrier** implicated in the labour requirements of implementing their future plans, in the form of an ageing employee: "*At the moment he runs the business without employees, but they have 3 standard workers. His father helps with the stable work. Unfortunately, he is already 75 years old. If he can no longer help the farmer, he will probably give up the pig fattening business*"; and similarly, in farm SA_SC5, their future plans are impacted by **physical opportunity barriers** in terms of lost worker resources (also **reflective motivation** on the part of the staff members in question): "*The senior partners of the business would be planning to*

look towards retirement and slowing down/go part time in next 5 yrs, but the junior partner (next generation) plans to run business on own, or with continued paid labour/employee." Farm ICLF_CH3 report similar **psychological capability barriers** (skill) associated with retirement: "*Previous helpers have reached retirement age [making their cherry harvest problematic]. It is more and more difficult to find available and competent workers*" (ICLF_CH3). On the other hand, in their quest to reduce inorganic fertilisers and livestock concentrates, farm ICL_SC7 aims to "*Work to improve how [their] enterprise's complement one another*," which are **physical** and **social opportunity enablers**.

3.1.4 Step 4 - Where are the pinch points?

Farmers were asked to reflect on current labour to identify pinch points (labour and skill availability, workloads of individuals) and consider how futures plans might impact to alleviate, exacerbate existing or create new pinch points.

Arable and fruit cropping enterprises dominated the discussion around labour pinch points. Spring sowing of field crops and autumn harvesting of field and fruit crops were the main pinch points, with field activities such as crop spraying and pruning also mentioned. Most of these pinch points were discussed in the context of small and changeable weather windows making it very difficult to plan labour availability in advance. It was the availability of skilled labour (e.g. tractor/combine harvester operators) that was the main challenge in the arable enterprise context. In some instances, this specialised labour requirement was fulfilled by contractors with their own farm machinery.

"Hard to find labour during the spring and harvest times, and a lot of potential staff lack skills". SA-SC1

Farms that had fruit enterprises as part of their mixed systems (SA_SC2 and all CH farms) highlighted the availability of seasonal staff for fruit harvest (and planting and pruning in some examples) as a pinch point. Total numbers available was identified as an industry wide issue in Scotland (SA-SC2, ICL-SC3 and ICL-SC8) and the flexibility of labour availability when weather patterns influence harvest dates and volumes in CH (ICLF-CH3, ICLF-CH4 and ICLF-CH8). In Portugal, the availability of cork harvesting crews was identified as a pinch point – these highly skilled teams of harvesters are usually employed as contractors and are in high demand, so they need to be booked well in advance of the harvest.

Spring lambing, often coinciding with spring sowing, was identified as a pinch point in ICL-SC3 and ICL-SC7 – this again required skilled labour that was likely to be in high demand on other farms at the same time. Another time/weather critical activity related to the livestock element of mixed farming systems was hay/silage harvesting in the summer (ICL-PO, ICLF-CH3 and ICLF-CH8).

Two farms specifically mentioned the absence of labour pinch points in their livestock enterprises (ICL-PO and ICLF-PT7). In the Polish dairy enterprise, the same volume (hours) of work was required throughout the year but the tasks undertaken varied depending on the season. This suggests that skills are transferable within this dairy enterprise.

With respect to labour flexibility in general, in the Polish example, the following comment was made:

"We try to get along with our own labour force. If needed, additional working hours are required, or people change positions/move to other tasks". ICL-PO

Flexibility of labour was mentioned by seven farms in the context of labour pinch points, some stating that there was flexibility in their workforce and others not. ICLF-PT2 indicated that their workforce receives ongoing training in multiple labour tasks (forage and livestock) and that the time the workers spend on the farm is flexible depending on the time of year and what tasks need doing. ICL-SC8 indicated that their staff are fully competent in both arable and livestock tasks. Conversely, ICL-SC3

indicated that there was little flexibility of labour between livestock and arable enterprises. In the case of ICL-SC5 - staff were highly skilled specialists in some tasks (e.g. spraying) which no other staff were able to do. Hence the identified need by the farmer to train a further member of staff in some tasks to reduce risk.

"*The junior partner is the only person that can do the spraying at present, but there are plans to get the paid employee through his spraying tickets. One senior partner drives the combine, and the other senior partner drives the drill machine, but the paid employee can drive both*". ICL-SC5.

Fruit harvesting was mentioned by ICL-SC2, who stated that soft fruit picking was a highly skilled task but was somewhat transferable between fruit crops. This was in relation to the 500 seasonally employed staff brought on the farm for harvest.

Labour to cover farmer and farm worker holidays was identified as a pinch point on two farms (ICLF-CH4 and ICL-SC4). Both farms commented that it was almost impossible to find suitable temporary workers, at all skill levels (unskilled, skilled and managerial).

When asked where they think the main pinch-points reside, in terms of labour, skills, and individual workloads, across enterprises and throughout the year, farmers responses suggested that the COM constructs were present in their thinking. For example, in the following quote 'time' represents a **physical opportunity barrier**: "*In spring we need to prepare and repair the fences for the meadows, and accompanying the cows to the pastures takes additional time. But in autumn and winter, when the cows stay inside the barns, we have more work with keeping the boxes clean, e.g.*" (ICL_PO). Here, too: *"…for the cork extraction, there is only a 15-day gap for this work to be executed. Thus, there is a high demand for skilled workers during this specific time, which requires anticipated management and early requisition for these services*" (ICLF_PT2). In the following quotes, time is present as both a **physical opportunity barrier** and **enabler**, depending on unfolding circumstances: "*Also seasonal labour needs to be coordinated to be on farm in time for harvesting, which due to overseas staff can be stressful getting staff on farm. Full time staff are fully competent in range of tractor and stock work*" (ICL_SC8); seasonal labourers lack **psychological capability** (knowledge of the job role), which creates a **physical opportunity barrier** for the farmer (time). On the other hand, keeping full-time staff offers a **physical opportunity enabler** precisely because it reduces demand on time. It is also implied that full-time staff are more committed (**reflective motivation enabler)** and skilled (**psychological capability enabler**).

Moreover, time can be a **physical opportunity barrier** in the short-term but should at least lead to **psychological capability enablers** in the longer-term: "*limiting factors such as finding time to train staff, as the all current time is required to keep the business running*" (SA_SC4). These interpretations are supported by a quote from SA_SC5, when discussing their employee's skill-set (**psychological capability)**: "*The junior partner is the only person that can do the spraying at present, but there are plans to get the paid employee through his spraying tickets. One senior partner drives the combine, and the other senior partner drives the drill machine, but the paid employee can drive both.*" Indeed, SA_SC4 suggests that a lack of practical experience or support to acquire it is a **social opportunity barrier** – "*And there isn't enough training in practical experience. For example, someone can train to be a farm manager but not get the practical farming experience*" – which is also, certainly, a **physical opportunity barrier** too. Conversely, and in support of the point, **psychological capability enablers** (knowledge and skills) were present in ICLF_PT2: "*Individual skills are well managed as every worker has several workshops and qualification programmes to improve their skills*."

ICLF_CH3 describes inclement weather as a **physical opportunity barrier**, and not wanting to work with seasonal workers is a **social opportunity barrier**: "*Bottleneck when there are only few good weather periods for haymaking. To alleviate this, the farmer would try to improve productivity, possibly enter cooperations with others. However, he does not want to work with seasonal workers.*"

Physical opportunity enablers are also present in the data, such as this quote from ICL_SC6, where bigger machinery predicts better efficiency: "*Don't plough as too slow – use reduced tillage systems also using bigger machines – including bigger combine. Direct drill a possibility in the future.*"

Finally, returning to **psychological capability enablers** and **barriers**, many farms have experienced related issues, including SA_SC1 ("*Hard to find labour during the spring and harvest times, and a lot of potential staff lack skills. The skills are transferable between each of the cropping enterprises*"), SA_SC2 ("*Seasonal workers are the current pinch point for this farm, these are needed during planting and harvesting in particular. Experience with fruit is the major skill required*"), ICL_SC3 ("*seasonal skilled labour, spring lambing and sowing, harvest. Livestock and cropping enterprises are not interchangeable skills unless the employee has experience in both... It will probably get worse as it's a core industry issue*"), and SA_SC4 ("*Sowing and harvest. All leaves (sic?) of staff are needed but there is lack of trained skilled labour at all skill set levels: low, medium and high. Yes, it is an industry wide issue, staff in the industry are underpaid for the demands that are required of them*."

3.1.5 Step 5 - Resolving pinch points

In this step, the interviewer explored how the farmers have gone about addressing any pinch points identified in Step 4, and in doing so what challenges they faced. Approaches to addressing pinch points are presented below and the challenges are fully explored in Section 3.1.6 below.

Solutions proposed to address current and future potential labour pinch points can be categorised into business expansion, enterprise change, investment in technology, upskilling staff, cooperation/collaboration, increased sub-contracting/part-time workers (Appendix 1, Tables A1.1, A1.2 and A1.3). In Scotland (ICL-SC3, SA-SC1, SA-SC2 and SA-SC4) business expansion of existing enterprises was planned, primarily to secure the employment of existing staff but also as a way of employing staff in key areas (e.g. livestock, tractor operations) to reduce labour pinch points. SA-SC4, SA-SC5 and ICL-SC6 in Scotland also emphasised the need for accompanying investment in technology (e.g. GPS, modern cultivation equipment) to make more efficient use of employed labour around peak labour times of sowing and harvest. In ICLF-CH3, the recent retirement of the father from the business left two options, to reduce the size of the dairy herd or to collaborate with a friend to maintain cow numbers. ICLF-CH3 also had plans to increase the diversity of enterprises on the farm to develop winter work so employees could be retained year-round. ICLF-CH3 did, however recognise that any new enterprise would have to complement rather than conflict with existing enterprises in terms of labour use peaks. Upskilling of staff was specifically mentioned in ICLF-PT2 and ICL-SC5. In the latter, the junior partner and full-time employee were to be upskilled in all tractor operations to help reduce short term labour pinch points around sowing and harvest, but with this approach alone, labour issues (and pinch points) were likely to worsen with the retirement of senior partners in the next 5 years. Farm ICL-SC8 in Scotland, which is reliant on seasonal labour for fruit harvesting, recognised that greater cooperation is needed with the Government to secure a supply of overseas seasonal workers in the future.

The farmers told stories that exemplified various COM constructs as influential in the implementation of plans to resolve labour pinch-points. For example: *"[The farmers'] children can already take on some tasks. Especially work that they love to do, e.g. watering the calves, picking up apples with the machine and working on the cider apple sorting belt*" (ICLF_CH4; **reflective motivation** enabler– enjoyment is a strong motivator of behaviour); "*Possible improvements with sharing knowledge*" (SA_NL1; **psychological capability enabler**); "*The pinch points are avoided through the constant programmes which enable each worker to be autonomous and more valuable to the business*" (ICLF_PT2; the programmes provide a **physical opportunity enabler** which also reduces time constraints and the need to manage staff [**physical opportunity enablers**], likely increasing **reflective motivation** of staff, too). Educational programmes, like sharing knowledge, mentioned by

SA_NL1, above – especially when elaborated on as cooperation "based on mutual trust and help; it is not primarily driven by commercial interests" – are also a **social opportunity enabler**, sharing commonalities with what farmer ICL_SC8 says about how rules change the ways in which people work: "*More cooperation with Government to aid supply of overseas workers*." Education (or present lack thereof) is a **psychological capability barrier/enabler** and will rely on said cooperation between multiple stakeholders and levels in the system: "*industry wide changes needed not in the business, education is going to be a major key to getting the issues fixed on industry level*" (ICL_SC3).

Physical opportunity enablers were frequently cited, in the form of:

- financial investment – "*We want to subcontract more (even in herd management), invest in more fences to create parks in the farm, and reduce the number of cows to facilitate management and decrease the acquisition of feed outside the farm*" (ICLF_PT7); "[to improve on pinch points] *The business would require more investment into people and technology*" (SA_SC4); "… *we need to invest in fences, subcontract some herd support, and possibly reduce the number of cows. But we need to reduce labour costs, so we are investing towards this aim*" (ICLF_PT7);
- expansion – "*If new farm branches are established (e.g. direct marketing, introduction of other fruit trees), the new work peaks may overlap with previous work peaks (fodder production)*" (ICLF_CH3) – bigger machinery and new technologies – "*Bigger machinery, [and] GPS guidance allows workmen to do longer days and marginal improvement in efficiency (5%?)*" (ICL_SC6); "*Possibly go for shakeable industrial cherries. In the long term, move away from large-scale cherry cultivation and towards other fruit trees (plums, apples, pears, mirabelles, etc.), plant only a few young cherry trees. Use of lifting platform so that father can be used as a picking helper for even longer (accident-wise)*" (ICLF_CH3),
- better staffing and upskilled workers – "*The plan would be that the junior partner would learn to use the combine or drill [also a* **psychological capability enabler***], so they can help/provide relief to the paid employee. Additional harvest help/apprentice or agri-student would help to do some less skilled jobs, e.g. carting grain*" (SA_SC5).

Physical opportunity barriers were also cited, however, in the form of lost labour and resultant downsizing – "*More issues with the dairy cows if his father gives up (because no pigs anymore) or cannot work anymore. Unfortunately, replacing his father is not possible, so he would probably reduce the number of dairy cows as well*…" – albeit with a resultant **physical opportunity enabler**: "… *or consider working with a friend and colleague*" (ICLF_CH4).

Data reported and interpreted above speak as much to barriers as they do enablers, of course, but the following narrative from ICL_PO exemplifies many COM constructs "in action" simultaneously:

> "*We need to employ people who live close nearby, but it's extremely difficult to find appropriate workers in our region. In general, there are very few people living here, and many of them are not qualified. We tried to focus on young men from the surrounding villages, but this doesn't work out, that's what we can say now after trying it for several years. It seems that the young people have a different attitude towards work than older ones. Sometimes they come to work, sometimes they don't. Sometimes they are drunken or have taken other stuff. You can't do this if you work with animals. We tried to qualify them, give them some training, and gave them several opportunities to get out of their trouble. But if it doesn't work after quite some time, we just need to watch out for other workers. Working in the stables is exhausting and demanding, this is also part of the story, that's why some people quit the job get employed somewhere else. That's why we have quite a high rotation in parts of our section, and at the same time we are limited in finding new workers by the above-mentioned reasons*." ICL_PO

Specifically, **physical opportunity barriers** and possibly **social opportunity barriers** are present in the need and difficulty employing local staff, and certainly there is a **psychological capability barrier** (knowledge, skill) in the statement, 'many of them are not qualified,' and a **physical capability barrier** presented by the 'exhausting and demanding' stable work'. A **social opportunity barrier** is present in the 'norms' related to worth ethic, and also a probably **automatic motivation barrier** in the individuals they are referring to. "Sometimes they come to work, sometimes they don't" suggests a **reflective motivation barrier** in the workers, and there appears to be some **automatic motivation barriers** at play in the form of prevailing social identities in that population and location. (See Figure 1 for the elements of COM-B, including pathways donating direction of influence between them and definitions of these constructs.)

Not surprisingly, when asked if they have sufficient resources to make changes to their business to address current or future labour challenges, and whether they believe the benefits will outweigh those costs, financial cost itself was a prohibitive **physical opportunity barrier** cited many times by farmers. For example, affordability as a barrier to making progress: (1) "*We've been thinking about hiring an additional animal breeder already one year ago, because we do not do everything that is useful to do (e.g. weighing the cows, checking the body condition score every month), but we just couldn't afford it*" (ICL_PO); (2) "*Financial is main issue, as risk is that you train staff and that they don't stay, and currently business does not need to employ staff, due to senior partners currently being fit and able to do the work*" (SA_SC5); and the unavoidable cost of time (3) "*limiting factors such as finding time to train staff, as the all current time is required to keep the business running*" (SA_SC4) and "*time to upskill staff*" (SA_SC5). However, cost, it seems, is easier to "stomach" under certain circumstances, as with ICL_SC3: "*The farmer thinks it is worthwhile to invest people if they have the right attitude*"; a few participating farms intimated as much. Also, the "right attitude" is equally a **psychological capability enabler** in a COM-B sense. **Physical opportunity barriers** such as cost are often intricately linked with **reflective motivation barriers** (intentions) and **automatic motivation barriers** (identity as a farmer and what he is "used to doing"), as this quote illustrates: "*At the moment, the farmer is still a little hesitant about the exact direction he should take with the farm. So, the change is taking place rather slowly and in stages. And the resources are limited, especially financially if all areas (house, machinery, wages and quality of work) are to be weighted equally*" (ICLF_CH3). On the other hand, **reflective motivation** can be an **enabler**, as is the case for ICLF_PT7, who are being proactive rather than hesitant: [If they do not address their labour challenges] "*It will get to a point in which the economic margin of the farm will be negative. We must act and reduce labour costs*." So, they are "*acting slowly but steadily. No major risks involved. And being careful because the two full time employees are there for more than 30 years. They will retire and the changes will happen. We are just preparing the farm and doing incremental changes over the years*" (ICLF_PT7).

Past experiences in addressing labour challenges that the participants wanted to share with other farmers

This set of responses, too, demonstrates that capability (psychological, physical), opportunity (social, physical), and motivation (reflective, automatic) are present in how farmers articulate their advice for other farmers facing/anticipating similar labour challenges. For example:

- **Physical opportunity enablers**:
  - "*They purchased their own powerful mechanization for the fruit harvest in order to save working hours*" (ICLF_CH4).
  - "Larger machinery, employing worker with tractor, rather than worker alone, GPS guidance where possible" (ICL_SC6).
  -
- **Physical opportunity** and **social opportunity enablers**:

- "*Organise some flexibility in terms of contract labour and 'labour from neighbours*" (SA_NL1).
- "*Organise flexibility through contract workers - and maintain good relationships with them*" (SA_NL6).
- "*In times of the highest workloads we make maximum use of the labour forces we have, which means additional working hours for the workers*" (ICL_PO).
- "Introduce flexible working hours for employees, make part-time employment possible, allow short-term private appointments (as long as seasonal work somehow allows it, of course), make it possible to work with employees' children so that parents do not need full day childcare" (ICLF_CH3).
- "Participant in Machinery ring apprentice scheme - onto 4th apprentice now" (ICL_SC8).

- **Physical opportunity** and **social opportunity enablers** and **barriers**, as well as **automatic motivation enablers** (work identity and work ethic):
  - "*The local labour force supply is very limited, that's why we try to offer the (potential) workers as good conditions as possible…… Every new employee requires time, training, permissions for machines which is costly, that's why we try not to lose workers. We also try not to make experiments and ask current workers and acquaintances if they know somebody who would like to join, since we want to avoid situations like those with "the young men". Now we will focus on more adult workers, they seem to be more stable. If we know of someone looking for a job we also contact him/her actively, so we don't miss the opportunity of getting/potentially hiring this person. In the summertime the workers of the farming section sometimes are overloaded with work. If workers from the animal breeding section have the skills that are needed in the farming section they help. It's important to plan the annual leaves in advance, so that we don't have too many people being absent at one time. This requires planning within the sections (farming, animal breeding) as well as between the sections*" (ICL_PO).
- **Physical opportunity** and **social opportunity enablers**, and **psychological** and **physical capability enablers***:*
  - "*Mechanization adopted, workforce training*" (ICLF_CH8).
  - "*Take the time to show the younger people the ropes*" (ICL_SC3); "*Take on people under 16 and train them into the industry, all from non-farming backgrounds, they will potentially staff in the business for longer*" (SA_SC4); "*Have taken on staff as young members of team, e.g. current employee started after leaving school and have trained him up to do work to senior partners standards, so that the employee does not come to the farm with bad habits or poor skills*" (SA_SC5).
  - "*Invest in the labour skill improvement and knowledge*" (ICLF_PT2). There are similar quotes from the Scottish farmers about investing in people for the future, perhaps related to raising the **psychological capability** for the desired behaviours.

4 Discussion and Recommendations

We conducted a labour survey within a sample of MIXED farm networks to enable an assessment of current labour productivity levels and identify labour challenges and potential solutions in these mixed farming systems. The case study networks represent only a small sample of mixed farming system types and therefore it is difficult to scale results up beyond this work. However, useful insights are given to labour solutions previously implemented or proposed by the network farms that have value in sharing beyond the project. The results of the deductive COM-B analysis are discussed in the context of farmers as they pursue goals, implement their plans, and mitigate labour challenges along the way. There were labour pinch points in all the systems regardless of whether they were mixed or specialised, and, in most cases, it was general farm or seasonal work force, rather than management time, that was limited. In a mixed farming system, it is typically the manager that is responsible for overseeing the integration between systems and who requires the skills to deal with the complexity that comes with that (EIP-Agri, 2017). Farmer discussions on labour pinch points tended to have an enterprise focus, and because of this, it was the number of enterprises, rather than the level of mixedness or integration *per se* that appeared to contribute to labour complexity.

The analysis of these case farms has identified where pinch points occur in specific enterprises. In farming systems with arable crops there are pinch points at harvest (late summer/early autumn) and at sowing (autumn or spring depending on cropping system). Those with fruit crops, had labour pinch points at fruit harvest (usually in late summer/early autumn) and these systems were heavily reliant on large scale, seasonal work forces. The introduction of livestock to an arable farming system posed a skill pinch-point on many farms, with the specialist skills for livestock not commonly being transferable from arable or harvest workforces. Furthermore, the type of livestock system and farm practices determined if there were additional or increased pinch-points - e.g. lambing in a sheep breeding enterprise coinciding with heavy arable workload in spring compared to dairying/pig enterprises which had labour spread more evenly throughout the year.

The pinch points described by those interviewed were often caused by multiple factors including total labour availability, the skills of the labour force and difficulties with work force planning due to climate variation (see summary tables A-1.1, A-1.2 and A-1.3 in Appendix 1). Total labour availability pinch points related to administrative difficulties securing and managing seasonal work forces (identified as an industry wide issue particularly in Scotland but also mentioned in Switzerland), competition with other farms to secure contractors to conduct time sensitive field/harvest activities and the need to allow workers to take holidays. Skill pinch points related to lack of transferability of skills between enterprises (particularly livestock and cropping) and difficulties sourcing and retaining seasonal and permanent staff with the necessary skills e.g. to harvest or conduct field operations. Pinch points resulting from difficulties planning labour requirements were frequently mentioned in the context of increasingly unpredictable weather patterns and shorter weather windows in which to conduct time sensitive activities such as planting and harvesting. This was a particular issue when external labour such as seasonal workers (e.g. to harvest short shelf-life soft fruit) or contractors were needed for time sensitive operations.

Observations (both the farmers and the authors) on the impacts of implementing future plans in the context of existing labour pinch points are summarised in Appendix 1 (tables A-1.1, A-1.2 and A-1.3). The diversity of farming systems and wide variety of future plans (e.g. enterprise change, business expansion, change of farming approach to organic or regenerative, retirement, labour force reduction) meant there were an equally wide variety of predicted impacts of those plans on labour – some positive and others negative. These included no change, increases in labour productivity, increases/decreases in the number of permanent employees maintained, increases/decreases in the amount of contract labour required, increased need for labour collaboration and potentially new labour pinch points being created.

Business expansion and enterprise change were the most identified actions/plans to address labour issues. Implementing such changes was not always simple however, with some plans (e.g. ICLF_CH3 increasing diversity of enterprises) having the potential to make existing pinch points

worse. The highlights the importance of considering trade-offs , including for labour, when developing future business plans. Upskilling staff across multiple enterprises was identified in interviews as having the potential to reduce labour pinch points, however some farmers raised concerns about the cost of doing so and the risk of investing in staff training, for them to then leave their job. Nicholas *et al*., (2021) also identified structural issues (e.g. lack of training availability and continuing professional development pathways) and limited opportunities for upskilling staff and new recruits to the industry. An alternative solution is to use contracted labour who bring their own machinery. The benefits include the highly skilled nature of this labour and that they utilise their own machinery, which is often large and with the latest technology (efficiency per tonne harvested). Disadvantages however include that they are in high demand and securing their services can be difficult with increasing short and unpredictable weather windows for operations. Cooperation between local farms to secure contracting services (i.e. effectively increasing the hectares to harvest in a single locality) may be more attractive to contractors, however, Nicholas *et al*., (2021) identified trust and cooperation between farmers as challenging, especially in the context of crop and soil management.

One challenge for which no solution was forthcoming was that of securing skilled seasonal labour, particularly for the harvest of high value fruit and vegetable crops. The short shelf life and unpredictability of growing seasons and harvest windows make planning and securing this form of labour very difficult. Government policy in the UK has made it less easy for EU workers to travel, therefore labour is having to be sourced from further afield (e.g. Asia) and the need for work visas increases administrative burdens. The availability of seasonal labour was not just a UK issue, as problems were identified in Switzerland as well. Meuwissen *et al*. (2021) discussed responsive action in case study fruit and vegetable farm systems in Mazovia during the COVID pandemic, where the crisis triggered fundamental discussions about how the systems were reliant of migrant labour and the need to build resilience strategies more generally in these systems. This triggered a shift in cropping to increased mechanisation and the growing of less labour-intensive crops. The relatively low labour productivity of systems with very high seasonal labour input (e.g. SA_SC2) in this study combined with a lack of resilience to external labour markets may require a fundamental system shift such as that discussed by Meuwissen *et al*. (2021) to ensure long term sustainability of the business.

The results of the COM-B analysis suggest that capability (psychological and physical), opportunity (physical and social), and motivation (automatic and reflective) are salient concepts for farmers as they pursue goals, implement their plans, and mitigate labour challenges along the way. Theoretically interpreting their own words, **motivation** can be strengthened by techniques that improve staff commitment, maximise any enjoyment and satisfaction that staff get from particular work tasks (and match staff to their preferred work), promote autonomy and perceived value, boost adaptive intentions, and harness contemporary thinking on social and professional identity, though the farmers' stories attested more to the importance of **capability** and **opportunity**.

To this point, **capability** can be improved through on-farm and off-farm activities (overtly experimental, or second-hand knowledge-seeking) that provide new understandings; farm businesses need to prioritise time and support for these experiences, for trainees, apprentices, and young staff in particular. Training and skill development, especially in terms of variety, comprehensiveness, and innovative practices, also need to be emphasised as enablers of **psychological** and **physical capability**. To an extent, industry- and labour market issues will need to be overcome if seasonal staff are to be available, sufficiently skilled, and adequately compensated in pay for the role demands. Similarly, there are barriers in the agricultural education system as presently constructed (which need to be tackled), but knowledge-sharing (accompanying continued professional development experiences), when done well, can help overcome this.

The perception of **opportunity** (often theorised as the antithesis of *threat*) can be enhanced predominantly by supporting farmers to conceptualise the cost savings and time efficiencies to be gained, and then prepare for and execute, good management of the labour implications of goal-striving. Judicious investment of time (e.g., to train staff, to engage in knowledge sharing) and money (e.g., subcontracting, innovative technologies) were omnipresent suggestions from farmers in the present study. Furthermore, strategizing ways to improve how a business' enterprises complement

one another, including in labour terms, seems prudent, as does seeking cooperative arrangements with other farms. Succession plans too, need to be carefully considered, both for retirement and seasonal fluctuations/availability. Finally, many participants attested to the importance of flexibility in contract labour, cooperation with neighbours, maintenance of good relationships with contract workers, provision of good conditions for all staff, and these *opportunistic* approaches could thus be built into agricultural education and extension work. As can be seen in this summary, participants' stories often spoke to more than one of the enablers of behaviour simultaneously, particularly **psychological capability** and **reflective motivation**, and **physical opportunity** and **psychological capability**. This means that interventions targeting one of the drivers might have positive spillover effects to others, thereby increasing their efficacy.

It should be acknowledged that interviewing is a relatively time-intensive method for collecting data from farmers, who often can ill-afford time away from their management tasks. It is possible to tap into the COM constructs via alternative means, such as questionnaires (allowing quantification) and open-ended surveys, if interviews are not possible due to contextual factors, but such methods arguably result in less rich data and limited interpretation possibilities. Therefore, it is prudent, as was the case in the present study, to collect this qualitative data at the same time as other study activities are taking place on-farm with the participant (e.g., obtaining farm labour and productivity data from their data management systems).

In conclusion, the analysis has demonstrated that the behaviours required to realise a farmer's plans for the future of their business can be construed through the COM-B lens. In future studies, the line of questioning and interviewer's probing questions should delve deeper into this promising way of conceptualising farmer behaviour. Indeed, in other realms of human life and work, the constructs of capability, opportunity and motivation have proven to explain and predict both adaptive and maladaptive behaviours and their attendant outcomes, and theoretically, the farming context should be no different.

Methodologically, to further capitalise on the insights provided by participants in the present study – and with the help of the Theory and Technique Tool from the Human Behaviour Change Project (www.theoryandtechniquetool.humanbehaviourchange.org/tool) - a behaviour change scientist would identify a set of behaviour change techniques (BCTs) that target the COM constructs as 'mechanisms of change,' such as: (a) instruction on how to perform the behaviour, information about social and environmental consequences, verbal persuasion about capability, and (all targeting **capability**); (b) social support (practical), prompts/cues, social comparison, and subjective norms (all **opportunity**); and (c) goal-setting for the behaviour, feedback on the behaviour, identification of self as a role model, and self-talk (all **motivation**). 'Mechanism of change' refers to a known ability (via empirical research) of the BCT to influence a psychological process in the recipient that would explain *how* the technique *works* to alter behaviour. For example, instructions on how to perform a relevant behaviour manipulate knowledge, skills, and beliefs about capabilities, and these are known to focus attention and catalyse effort towards the task. Next, depending on who desires to deliver this behavioural intervention (e.g., extension agencies, farmers unions, charities, scientists), different levers or "tools" would be at their disposal; accordingly, the selected BCTs would be embedded in an intervention that might take the form of a communication campaign, provision of a service, environmental planning, provision of a service, guidelines, even a fiscal measure (see the outer rim of the Behaviour Change Wheel for descriptions (www.behaviourchangewheel.com; Michie *et al*., 2014). All of the preceding decisions would be taken in collaborative discussion with a project advisory group made up of representatives from the target population; hence, the intervention would be co-designed for maximum effectiveness. It is outside the scope of this MIXED Task/Deliverable to act on this particular recommendation, but the study has demonstrated the utility of COM-B to explain farmers labour-focused intentions and behaviours, and opened up potential routes for intervention – such as this – in the future.

5 Conclusions

This analysis indicates that in these case farms, general and seasonal labour pinch points are the biggest problem and become increasingly so in farm systems with multiple and diverse enterprises (particularly with the introduction of a livestock breeding enterprise). The degree of ”mixedness” or integration between those enterprises was not mentioned explicitly as having an impact on the pinch points identified. Pinch points around sowing, harvesting and lambing/calving were common across all systems with one of the biggest barriers to labour sharing across plant and livestock enterprises being the specialist skills required for livestock farming. Lessons can be learned across case farms as to how individuals have, or plan to address labour issues, and some key recommendations from the study (also identified in D1.1) include:

- There is a need to address difficulties securing and administering large scale seasonal workforces. This requires political support as well as technological developments (e.g. for mechanised harvesting of fruit), and perhaps cropping system changes to reduce total labour demand.
- Training and upskilling (across a range of enterprise types), of future and existing staff is needed to provide a more flexible and effective workforce throughout the year. Both staff and employees need to be incentivised to engage with staff development – at present there are barriers in terms of cost, time and perceived security of investment from farmers.
- Improved co-operation between farmers could address a number of labour pinch points (e.g labour sharing to cover staff leave and holidays and working together to secure the services of arable contractors).
- Advisory support and modelling need to be developed to support farmers in cropping and labour planning in the context of increasing extreme and variable weather patterns.

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Appendix 1 – Workforce analysis and planning.

Table A-1.1

Integrated Crop and Livestock				
Case Farm	Timing of pinch point	Issue	Future plans	Observations (F = farmer comment, A = Author comment)
ICL_PO Livestock	None identified	The work activities change but the total amount of work is relatively constant	Developing two new dairy herd breeding programmes – additional animal breeder will be employed to manage these.	(F) No livestock pinchpoints but issue in arable system. (F) Upskilling staff across enterprises could reduce arable pinch points. (A) Labour productivity low – social enterprise an important element of system which is not valued monetarily.
ICL_PO Arable	Mowing early forage, arable harvest	No outsourced labour, climate variability makes planning harvest difficult – workers hours have to increase or workers moved from other tasks,	Introduction of maize into the rotation to become more self-sufficient in feed for the dairy herd	
ICL_SC3	Spring lambing and sowing, arable harvest	Staff on livestock and cropping enterprises not all interchangeable	Increase livestock numbers.	(F) Enterprise expansion could increase FTE employment – reducing pressure points. (A) Upskilling staff across enterprises could reduce harvest pressure point?
ICL_SC6	Arable harvest	Time/weather critical, often insufficient labour/machinery to harvest	Reducing spring barley (SB) area in favour of grazed winter barley – SB more reliant on seasonal workers than full time. Invest in further technology.	(F) Tractor technology and altered crop rotation to reduce pinchpoints. (A) Increase contracted field labour with machinery (latest technology)?
ICL_SC7	Spring lambing and sowing, arable harvest	Limited transferability of skills between livestock and arable, peak activities occurring together in spring.	Reduce inorganic fertilisers and livestock concentrates through greater crop/livestock integration. Grazing winter cereals. Reduce chemical reliance.	(F) Proposed increased integration will not improve pinch points. Some activities (e.g. grazing winter cereals) will negatively affect winter holiday opportunities. (A) Increased upskilling of existing workforce across enterprises or need for contracted field labour?

ICL_SC8	Vegetable harvest	Time critical for optimal quality. Seasonal labour difficult to obtain and coordinate.	More sheep grazing, more cover crops – regenerative farming approach.	(F) Future plans unlikely to impact total labour, upskilling across enterprises may be needed. (F) Heavily reliant on migrant labour – policy support needed to facilitate.

Table A-1.2

Integrated crop, livestock and agro-forestry				
Case Farm	Timing of pinch point	Issue	Future plans	Observations (F = farmer comment, A = Author comment)
ICLF_PT2	Cork extraction (every 3-4 yrs)	Time/weather critical and highly skilled – high demand.	No changes planned.	(F) Efficient planning needed to secure cork extractors. (F) Livestock/forage pinch points are avoided through employed staff skills development focus - resulting in flexible labour force.
ICLF_PT7	Sowing and fertilising pastures (Autumn), Cork extraction (every 3-4 yrs)	Time/weather critical, cork harvest highly skilled – high demand.	Incremental changes to pasture and herd management to reduce labour to 1 shepherd. Conversion to organic farming practices.	(F) Move to reduce permanent farm labour will require specific tasks to be contracted out. (A)Labour productivity could be improved by making more efficient use of permanent staff member.
ICLF_CH3	Hay making and cherry harvest	Time/weather critical, difficult to plan, flexibility of local pickers, low wages.	Maintain or even increase diverse range of enterprises and keep the value chain on the farm. Develop winter work so that part time employees can be employed year round. Retired father as a flexible worker to facilitate more free time for the farmer.	(F) Workload peaks of new enterprises may overlap with existing pinch points. (A) Employing part time staff over winter will only improve productivity if output increases. (A) Flexible parental labour only a short-medium term solution for a better work/life balance for farmer.
ICLF_CH4	Pruning and fruit harvest, covering holidays	Temporary, qualified labour impossible to find.	Planned retirement of father from the business likely to lead to loss of the pig enterprise for which he is responsible.	(F) Parental retirement will have knock on impacts to dairy as well as pig enterprise. (F) Reduce dairy numbers if utilising remaining labour or collaborating with a friend/colleague.
ICLF_CH8	Forage harvest (May/June) and arable harvest (August)	Time/weather critical – reliant on family labour.	Planted fruit trees will reach maturity in 10-15 years – labour will increase siginficantly with requirement to harvest crop.	(F) When apple enterprise comes on stream – peaks of labour in Sept/Oct. (A) Climate change/variability may result in new pinch point with arable.

Table A-1.3

Collaborating specialist livestock and cropping system				
	Timing of pinch point	Issue	Future plans	Observations (F = farmer comment, A = Author comment)
SA_SC1	Spring sowing, autumn harvest	Difficult to find seasonal workers with required skills (tractor operations).	Expand if the opportunity arises but important to keep the same work/life balance.	(A) Expansion could enable more permanent labour to be employed. (A) Reduced reliance on seasonal workers who are difficult to find.
SA_SC2	Planting and fruit harvest	500 skilled seasonal workers required for planting and harvest annually, industry wide shortage.	Reduce labour overall – farm same area of land with fewer people. Fruit business will continue to expand.	(A) Expansion of fruit business will require more seasonal labour unless technological solutions can be implemented.
SA_SC4	Spring sowing, autumn harvest	Difficult to find seasonal workers with required skills (tractor operations).	Grow the business where possible to continue to employ current staff. Take on new technology where possible.	(F) Labour productivity improvements through expansion with existing labour and technology. (A) Reduced need for seasonal contractors?
SA_SC5	Arable harvest and sowing of winter crops	Crop sowing and harvesting, machinery operation skills not transferable at present (spray, drill and combine done by different individuals).	Senior partners to retire in next 5 years. Junior partner to run business solo or with continued paid labour/employee.	(F) Skilled contracted labour, or multi-skilled employee required. (A) Upskilling planned - still reliant on individuals for specific tasks, high risk?

Appendix 2 – Labour input summary

Table A-2 Labour input per farm and by enterprise per season

			Spring FTE	Summer FTE	Autumn FTE	Winter FTE	Average FTE
CH07_03	ICLF_CH3	Farm total	0.9	1.7	2.2	1.7	1.625
		General work	0.235	0.21	0.16	0.17	0.19375
		Cattle	0.625	0.26	0.28	0.18	0.33625
		Forage	0.02	0.655	0.6	0.015	0.3225
		Crops	0.02	0.335	0.84	0.295	0.3725
		Fruit trees	0	0.24	0.32	1.04	0.4
CH07_04	ICLF_CH4	Farm total	1.65	1.95	2.45	2.1	2.0375
		General work	0.3675	0.225	0.16	0.45	0.300625
		Pigs	0.2175	0.2565	0.3215	0.275	0.267625
		Cattle	0.2775	0.3285	0.4135	0.355	0.343625
		Forage	0.27	0.321	0.475	0.205	0.31775
		Crops	0.27	0.429	0.475	0.205	0.34475
		Fruit trees	0.2475	0.39	0.605	0.61	0.463125
CH07_08	ICLF_CH5	Farm total	1.5	1.5	1.5	0.8	1.325
		General work	0.31	0.24	0.38	0.38	0.3275
		Cattle	0.14	0.14	0.14	0.07	0.1225
		Forage	0.84	0.56	0.42	0.07	0.4725
		Arable crops	0.14	0.42	0.28	0.07	0.2275
		Fruit trees	0.07	0.14	0.28	0.21	0.175
NL12_01	SL_NL1	Farm total	3.7	2.93	3.6	1.75	2.995
		Farm management	0.444	0.3516	0.432	0.21	0.3594
		Dairy	1.184	0.9376	1.152	0.42	0.9234
		Lawn grass	1.48	1.172	1.44	0.28	1.093
		Silage	0.592	0.4688	0.576	0.14	0.4442
NL12_03	ICL_NL2	Farm total	4	1.95	4.25	1.75	2.9875
		Farm management	0.48	0.234	0.51	0.21	0.3585
		Dairy	1.6	0.78	1.7	0.7	1.195
		Starch	1.04	0.507	1.105	0.455	0.77675
		Wheat and beans	0.88	0.429	0.935	0.385	0.65725
NL12_06	SA_NL3	Farm total	17	12	17	8	13.5
		Farm management	2.04	1.44	2.04	0.96	1.62
		Potatoes	11.9	8.4	11.9	5.6	9.45
		Sugar beet	2.55	1.8	2.55	1.2	2.025
		Barley	2.55	1.8	2.55	1.2	2.025
PL13_01	ICL_PO	Farm total	145.7	149.2	151.5	143.4	147.45
		Farm management	33.6605	31.254	36.4738	37.8217	34.8025
		Dairy cattle	51.1367	50.195	53.486	52.5474	51.84128
		Crops/forage	60.9415	67.751	61.5402	53.0309	60.8159

PT14_01	ICLF_PT2	Farm	4.3	4.3	4.3	4.3	4.3
		General farm management	1	1	1	1	1
		Finance and bureaucracy assistance	0.27	0.3	0.27	0.3	0.285
		Veterinary	0.03	0	0.03	0	0.015
		Farming activities	3	3	3	3	3
PT14_02	ICLF_PT7	Farm total	2.15	2.15	2.15	2.15	2.15
		General farm technical coordination	0.15	0.15	0.15	0.15	0.15
		Herd management	2	2	2	2	2
UK04_01	SA_SC1	Farm total	2	2	2.666667	2.333333	2.25
		Farm management	0.475	0.475	0.6125	0.8875	0.6125
		Crop enterprise	1.525	1.525	1.831944	1.223611	1.526389
UK04_02	ICL_SC2	Farm total	36.33333	386.3333	553	553	382.1667
		Farm management	7.816667	7.4	5.6	9.216667	7.508333
		Crop and fruit	28.51667	267.8222	547.4	543.7833	346.8806
UK04_03	ICL_SC3	Farm total	6	6.666667	6	6	6.166667
		Farm management	3.2	1.6	2	2	2.2
		Crops enterprise	1.4	2.744444	2.5	2.5	2.286111
		Livestock enterprise	1.4	2.1	1.5	1.5	1.625
UK04_04	SA_SC4	Farm total	4.416667	6.416667	6.25	6.416667	5.875
		Farm management	1.854167	1.316667	1.4	1.727778	1.574653
		Cropping enterprises	2.5625	4.877778	4.85	4.466667	4.189236
UK04_05	ICL_SC5	Farm total	4	4	4	4	4
		Excavation/Contracting	2.1375	1.5525	1.920833	1.595833	1.801667
		Rental Properties	0.34	0.34	0.34	0.34	0.34
		Arable	1.5225	2.1075	1.739167	2.064167	1.858333
UK04_06	ICL_SC6	Farm total	3.2	3.2	5.52	3.2	3.78
		Farm management	0	0	0	0	0
		Grassland and Forage	0.32	0.32	0.32	0.32	0.32
		Field Cropping	2.24	2.24	4.56	2.24	2.82
		Livestock	0.64	0.64	0.64	0.64	0.64
UK04_07	ICL_SC7	Farm total	8.88	8.88	9.1	8.88	8.935
		Farm management	0.072	0.072	0.072	0.072	0.072
		Grassland and Forage	0.288	1.032	1.054	0.288	0.6655
		Field Cropping	4.152	3.408	3.496	4.152	3.802
		Livestock	4.368	4.368	4.478	4.368	4.3955
UK04_08	ICL_SC8	Farm total	4.75	4.75	16.75	22.75	12.25
		Farm management	0.3	0.133333	0.1	0.133333	0.166667
		Cattle	2.008333	1.791667	1.225	1.45	1.61875
		Crops	2.208333	2.025	1.3	1.391667	1.73125
		Veg	0.133333	0.766667	14.125	19.775	8.7

Appendix 3 – COM-B deductive analysis questions

Questions included in the interview guide to explore farmers' drivers (barriers and enablers) of the behaviours needed to meet labour demands and challenges.

Capability

- Would you like to make changes? If so, what changes would you like to make? Is there anything stopping you making the changes? If so, what?
- If you don't want to make changes, what is the reason for that? (e.g. happy with existing situation, don't see the need to change, don't have the time/resources at the moment to change, etc.).
- If you think that changes are necessary to address pinch points, do you think they are achievable with the current workforce? If no, what not? (e.g. right skill sets might not be present, the staff are already working very hard, can expect them to do any more etc.). If yes, can you see any long-term implications for the existing workforce in terms of working conditions (hours), staff retention etc.

Opportunity

- Does the farmer/farm manager feel like they have the time to sit down and think about how labour challenges can be resolved and implement changes or are there too many competing tasks and time constraints?
- Does the farm have the financial resources in the business to make changes to resolve labour challenges e.g. by employing more people, paying for training and development of existing staff in skills that might be needed, using contractors for some specialist tasks.
- Does the farm have the physical resources in the business to make changes to resolve labour challenges e.g. housing for permanent or seasonally employed staff?
- Are social influences, such as what others in the farming community/peers are doing likely to facilitate or hinder decision making in relation to solving labour challenges?
- Does the farming family support and trust the farmer/farm manager to make the right decision in relation to solving labour challenges?

Motivation

- Does the farmer/farm manager think the benefits of addressing labour issues outweighs the costs, in time, effort and money, of doing so?
- Does the farmer/farm manager think the business, and the people in it, will suffer in the long run if they don't do anything about labour challenges?
- Is the farmer/farm manager likely to feel good/bad if they do/don't do anything about labour challenges?