REFEREED ARTICLE

DOI: 10.5836/ijam/2020-09-96

Encouraging farmer participation in agricultural education and training: A Northern Ireland perspective

AUSTEN ASHFIELD[1,*], CONALL MULLAN[1] and CLAIRE JACK[1]

ABSTRACT

Farmers are increasingly encountering complex challenges which require them to acquire in-depth knowledge of new technologies and best practices to bring about productive and sustainable farming systems. There is a need to update and improve knowledge and skills, particularly for those who have no or low levels of agricultural training. This study focuses on identifying existing and future skills gaps at farm-level and investigates how knowledge provision and training should be developed and delivered to meet industry needs. This research obtained the views of key stakeholders and farmers around agricultural education provision and future training needs. The methodology combined semi-structured interviews and a farm-level survey. The results identified an immediate need to develop a programme of continuous professional development. The key barriers to training were time, cost and the relevance of training to a farmer's particular farming system. Attitudes to training impact on the level of engagement with new practices and technologies; therefore the benefits of life-long learning within the sector need to be promoted. Agricultural education providers should develop stronger collaborations with other education providers and key stakeholders to ensure the sector needs are met.

KEYWORDS: Agricultural education, training, continuous professional development

1. Introduction

Farmers have always had to adapt their behaviour in response to changing market and policy environments. However, they are increasingly encountering more complex challenges which require the adoption of advanced technologies alongside developing sustainable farming systems to improve productivity, in response to world-wide population growth and climate change (Coomes *et al*., 2019). Farmers will require more in-depth knowledge of their production systems and related ecosystems; for example, soil management, land ecology, animal health and welfare and carbon sequestration (Schulte *et al*., 2014; Accatino *et al*., 2019). As highlighted by Lindblom *et al*. (2017), more sustainable agricultural systems are closely linked to a farmer's ability to interpret and make decisions around information and data which will necessitate a paradigm shift in production and management practices at farm-level. The industry's capacity to respond to these challenges will be dependent upon farmers' abilities to improve their skills base and to adopt farm-level innovations, improvements and best practice.

Northern Ireland (NI) is a small and largely rural region of the United Kingdom (UK), with a diverse farming structure. The average farm size in 2017 was 41.1ha with only eight percent of farmers farming 100ha or more (DAERA, 2018). The majority of NI farms are classified as cattle and sheep farms (80 percent), 10 percent are classified as dairy farms and the rest consists mainly of cropping (3 percent) and pig and poultry (3 percent) farms (DAERA, 2017). Ninety-six percent of farmers are male with 55 percent farming full-time (DAERA, 2018). As in other parts of Europe, over the past three decades the NI farming population has become older (Zagata and Sutherland 2015). The median age of farmers in NI in 2016 was 58 years; only six percent were under 35 years old, and there has been a limited flow of younger farmers into the sector, resulting in the number of farmer falling by some 12 percent between 2002 and 2017 to 25,000 (DAERA 2017; DARD, 2008; DAERA, 2018). This diverse farmer profile has contributed to an emerging skills gap in the NI farming sector with a higher percentage of farmers having no agricultural education (75 percent), compared to the UK as a whole (68 percent), and the EU average (68 percent) (Eurostat, 2016).

In Northern Ireland agriculture education falls under the remit of the Department of Agriculture, Environment and Rural Affairs (DAERA) and is delivered by

Original submitted November 25 2019; revision received November 24 2020; accepted December 03 2020.
[1] Agri-Food and Biosciences Institute, Newforge Lane, Belfast, BT9 5PX, United Kingdom.
*Corresponding author: Email: austen.ashfield@afbini.gov.uk

The College of Agriculture, Food and Rural Enterprise (CAFRE). CAFRE comprises of three campuses which provide training in agriculture, horticulture, food and equine. In agriculture CAFRE is responsible for the formal education programmes, including further education, higher education and short courses, and knowledge transfer.

Previous studies examining farmers' educational attainment have frequently highlighted low levels of uptake and completion of formal agricultural training, alongside limited participation in engaging in extension programmes around lifelong learning (Gasson, 1998; Huffman and Orazem, 2004; Sewell *et al*., 2014). This is despite research evidence indicating that the relationship between education and farm efficiency is positive (Lockheed, Jamison and Lau, 1980; Huffman, 2001; McDonald *et al*., 2016; O'Donoghue and Heanue, 2018). Furthermore, Kilpatrick and Johns (2003) identified that increased levels of educational attainment support farm-level decision-making through increasing a farmer's awareness of new practices and assisting farmers in their selection of and allocation of inputs between competing uses. Wallace and Jack (2011) and Heanue and O'Donoghue (2014) have shown positive returns to investing in education and training (beyond the minimum school leaving age) for farmers working both on and off-farm. The perceived barriers to training and skills development amongst farmers have been shown to be not country specific, but rather they are comparable between countries (Kilpatrick and Johns, 2003; Seymour and Barr, 2014). In addition, farmers are a heterogeneous group exhibiting a range of learning styles and different attitudes and approaches to implementing learning and new technology adoption (Black, 2000; Seymour and Barr, 2014; McKillop, Heanue and Kinsella *et al*., 2018). Furthermore, as identified by Sewell *et al*. (2017), learning in agriculture is moving away from people directed learning to a more independent approach particularly to encourage the adoption of new innovations at farm level.

Lifelong learning and continuous professional development (CPD) is about gaining new skills and competences, extending knowledge and obtaining qualifications. Other industries, such as veterinarians, have introduced the idea of lifelong learning and CPD which suggests that there is potential to apply the concepts to the agriculture industry. However, the unique circumstances and ingrained attitudes and behaviours to education and lifelong learning in farmers must be acknowledged as major challenges (Caskie, 2018). Learning, adoption and practice change is increasingly being viewed as a social process, influenced by a combination of personal, environmental and social factors (Hall, Turner and Kilpatrick, 2019). Previous studies have suggested these include individual characteristics such as education, social networks, farm business characteristics, and nature of the activity and learning environment (Fulton *et al*., 2003). For education to lead to adoption of practices the providers require a greater understanding of how farmers make decisions, and what factors influence their choice to engage with education. This understanding will allow education providers to encourage engagement and communicate more effectively to achieve greater improvements in farming practices (Turner, Wilkinson and Kilpatrick, 2017). Furthermore, it is understood that this is not a one off event and ongoing continued engagement with supported learning should result in farmers being more likely to develop the knowledge and skills required to undertake practice change (Turner and Irvine, 2017; Hall, Turner and Kilpatrick, 2019).

While there has been considerable research undertaken in the area of agriculture education and how farmers can improve their skills, there have been limited studies focusing on a regional area with a large but diverse farming population characterised by very low levels of agricultural educational attainment. This study aims to examine the current and future skills requirements in the primary agriculture sector in NI and how knowledge provision should be adapted to best meet farmer's lifelong learning needs into the future. A conceptual framework for this study is shown in Figure 1.

2. Methodology

The research focused on obtaining the views of two specific groups, namely key stakeholders within the farming sector; and a cohort of farmers who had previously undertaken some form of agricultural training. A mixed methods research design was used with a combination of qualitative and quantitative approaches. Stakeholder interviews took place between March and June 2016. The interviews were semi-structured containing mainly open ended questions, designed to elicit the opinions of those interviewees. Each interview lasted between sixty to ninety minutes and focused on skills and training under three key themes:

1. The level/ type of training and skills needed in the industry overall
2. The level/type of training needed by individual farmers
3. Future development of training and delivery

Five main groups of stakeholders were identified namely:

1. Farming organisations/farmer representative groups (FO).
2. Senior representatives from agri-food processing companies (AP).
3. Main agricultural education provider - The main provider of agriculture training in NI (MP).
4. Professional services (PS) - individuals/organisations that provide professional services to farmers, they included banks, solicitors and accountants.
5. Learning, training and skills stakeholder (LTS) - other private sector organisations involved in providing agricultural training in NI.

Key stakeholders were selected on the basis of their profile and experience of working in, or their involvement with the NI farming and agri-food sector and their professional contribution to it. Overall twenty four individuals from a range of fifteen organisations were interviewed.

Two researchers attended each interview, taking detailed notes on the responses to each question. Once the interview was complete, the interview notes were written up and compared with the original notes to ensure accuracy and consistency in the documenting of the interview. When all the interviews had been completed and scripted, one researcher evaluated the data

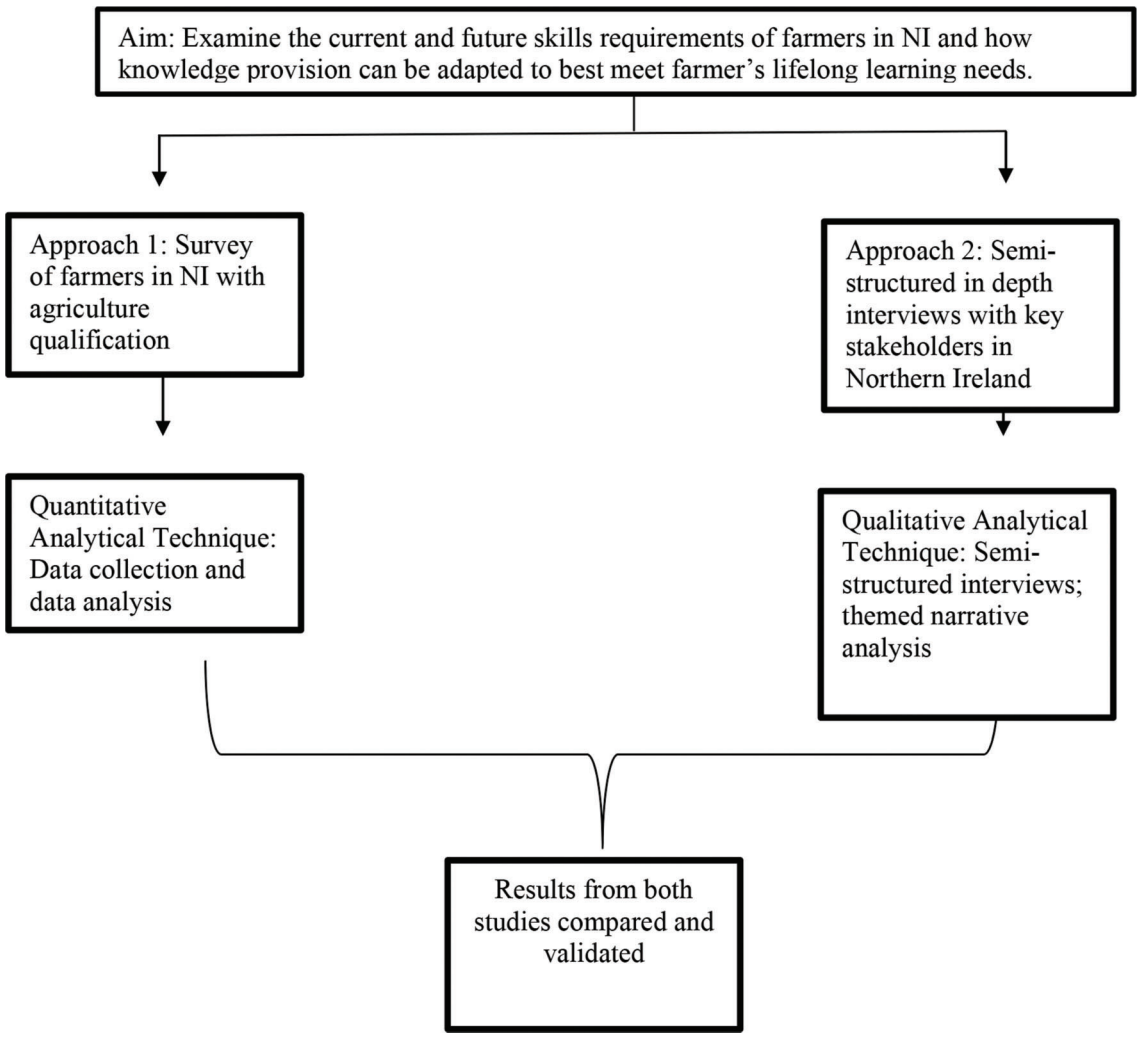

Figure 1: Study conceptual framework

thematically, a foundational method for qualitative analysis, (Holloway and Todres 2003), defined as 'a tool for identifying, analysing, and reporting patterns or themes within qualitative data' (Braun and Clarke 2006). Themes arising in the data were coded. Codes helped to index the themes providing a way to store and retrieve the data easily. Once the codes had been generated a second researcher read through the transcripts and codes to ensure it was accurate. Through discussions between the researchers a subsequent level of sub-coding was generated, which allowed the researchers to identify patterns in the scripting (Punch 2005). In reporting the results and key findings, respondents' answers have been combined and summarised.

Following on from the stakeholder consultation a survey of farmers who had previously undertaken agricultural training at a NI further education college or university was undertaken. This was an online survey, the link to which was emailed directly to farmers by farmers unions and education providers using there contact lists; it was also advertised in the local farming press. The themes around which the questionnaire was designed reflected the themes of the key stakeholder consultation and in addition included questions on the respondents own education level and their current farming activities. A range of Likert scale, ranking and open ended questions were used. The survey was administered online in August 2017 and in total there were 94 responses.

The mixed methods approach employed combines quantitative analysis from the farm based survey with qualitative analysis from the stakeholder interviews. The approach provides a balanced analysis and the responses from the two separate groups helps improve our understanding around agriculture education and training. The mixed methods approach is fast gaining popularity in the literature as it provides a deeper analytical base for responses drawing on personal, social and psychological variables. Examples of studies that have applied similar approaches include Gittins, McElewee and Tipi (2020) in which they combined both interviews with farmers and a Discrete Event Simulation (DES) model to illustrates the benefits and challenges associated with farm technology and software adoption in Yorkshire, England. Similarly, Jack, Adenuga, Ashfield *et al.* (2020) employed the mixed method approach to examine and analyse the drivers of farmers' decisions in relation to joining and participating in a new approach to farm extension, learning and advisory service provision in Northern Ireland.

Seventy-seven percent of the respondents were male and 33 percent were female and the average age of

respondents was 44 years old. Forty-nine percent of respondents had employment outside of farming. Of those who had employment outside of farming, 74 percent worked full time (more than 30 hours per week), 22 percent worked part time (up to 30 hours per week) and four percent had seasonal/casual employment. Thirty-seven percent of the respondents indicated that they worked 30 hours or less per week and 38 percent of the respondents indicated that they worked 60 hours or more per week on the farm. The main enterprises of those surveyed (main enterprise being defined as the one which contributes most to farm business income) were beef cow herd (33 percent), dairying (30 percent), sheep (11 percent), arable (10 percent), beef finishing (8 percent), Poultry (3 percent), pigs (2 percent) and other (3 percent).

3. Results

Main Areas of Training

A need for higher levels of technical and business management skills were the main areas of training identified within the stakeholder consultation. Further training areas included business succession planning and Information Technology skills (IT); specifically how IT can be used to reduce workload and manage information. A recurrent theme from the stakeholder consultation exercise was the need for farmers to develop good information handling and analytical skills.

> "*Technical efficiency, business management and sustainability*". *(MP)*

> "*How to collect (proper) data and how to manage and interpret it, especially on beef and sheep farms*". *(AP)*

The main emphasis among the stakeholder responses was towards getting farmers to 'take ownership' of data aimed at improving key farm performance indicators. For example, undertaking their own analysis of costs of production and setting targets to improve profit margin per unit of output or per hectare of land.

> "*Training in collecting data and understanding performance indicators and costs on the farm; benchmarking against other similar farms and then using this data to make decisions*". *(AP)*

When asked to respond to the question, 'Over the next five to ten years, what areas do you consider should be a priority for training and skills development for the industry at farm-level', there was a common consensus across all the stakeholders that training should aim to improve farm technical efficiency and business management skills.

> "*Training gives the farmer the potential to make broader decisions around the farm business*". *(FO)*

Those who responded as part of the farmer survey identified management and business skills as the priority area, followed by technical agriculture and subsequently animal and plant health and welfare (Figure 2).

When asked, what an up-skilled agricultural sector would look like stakeholders indicated that,

> "*Farmers, from whatever farm size or system, would be more empowered to make broader decisions around the farm business, which may involve looking at off-farm opportunities, new markets, new innovations around the resources that they have and diversification opportunities*". *(LTS)*

> "*Farmers could speak from a position of knowledge rather than perception*". *(MP)*

Furthermore, focusing on the farm as a whole resource and identifying ways of maximising resource use was an important aspect of farming for the stakeholders; with a greater emphasis needed on developing skills which allow farmers to develop new opportunities through innovation and diversification.

> "*There needs to be an emphasis on innovation and exploring how farms can develop other income streams through diversification and innovation*". *(PS)*

Mandatory training

The majority of stakeholders indicated that training should be mandatory in areas such as first aid, manual handling, use of pesticides and medicines, basic IT, health and safety. However, some stakeholders were resistant to the idea of training being viewed as a "*licence to farm*" i.e. farmers must have a minimum level of agriculture education to farm. There was a general consensus that training should be incentivised, for example, completion of training could provide access to additional funding and subsidies.

> "*Not sure in legal sense, but conditional on receiving certain types of investment and support*". *(AP)*

> "*See the need for training, but want people to do it for themselves. It should be a carrot not a stick approach*". *(FO)*

Main methods of Training

The stakeholder consultation concluded that the main training methods for farmers should be practically orientated, allowing them to see the benefits of newly emerging techniques and best practice in an applied way. It was judged that this would be best achieved through a mixture of learning methods; from 'on the job' learning to farm visits aimed at showcasing new innovations and best practice. Stakeholders acknowledged that individual farmers do respond differently to different ways of learning hence a need to include a range of different training methods in lifelong learning for the agriculture sector.

> "*Practical vocational training not in a classroom*". *(AP)*

> "*Host farm visits - seeing from the experience of others*". *(MP)*

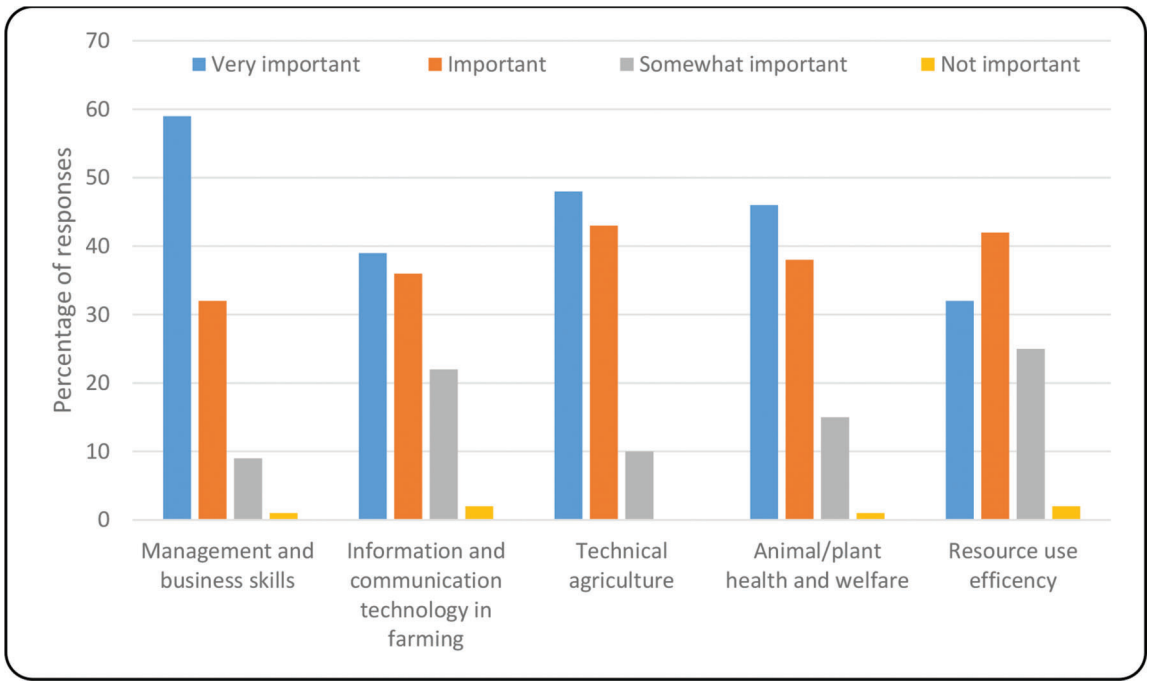

Figure 2: Percentage distribution of survey respondents by priority training areas over the next 5 years

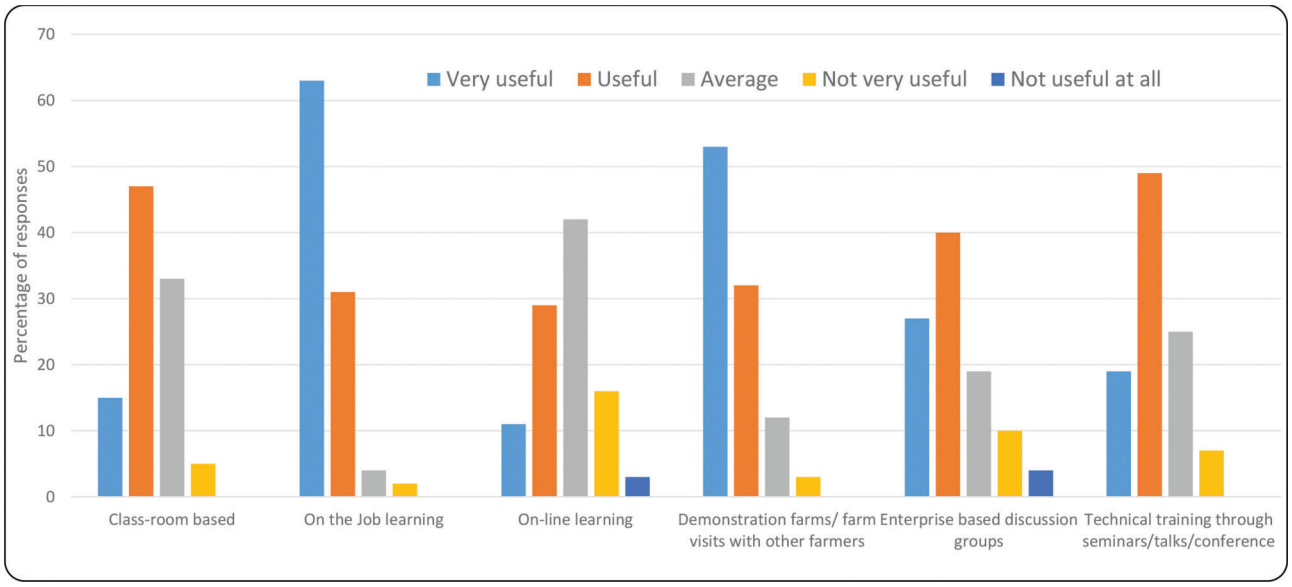

Figure 3: Percentage distribution of survey respondents rating of different training methods

The farmers responding to the survey also expressed an overall preference for non-formal training methods, such as on the job learning alongside demonstration farms and farm visits focused around specific technologies and practices (Figure 3). Stakeholders emphasised that colleges and universities needed to develop students' business management skills (understanding and interpreting business figures and data), their proficiency in IT skills and develop their problem solving and critical thinking skills by employing more problem-based leaning techniques and 'real-life' case study approaches. These should not be limited to decisions around farm production but should also explore medium term strategic management decisions. For example around decisions to introduce a new farm enterprise, on-farm diversification and succession planning.

> "*Need training through practical case studies as it is a better way of learning, not just desk bound learning*". *(PS)*

> "*Agriculture should be as innovative as any other sector - farmers have a wide range of resources and possible other incomes that can come from it*". *(LTS)*

Overall, farm discussion groups, a relatively new approach to advisory extension services in NI focused around peer to peer learning, were viewed as a positive mechanism in developing and delivering knowledge

transfer at farm-level. Discussion groups were deemed to provide a suitable forum for demonstrating new and improved technologies and best practice techniques, providing an opportunity for farmers to learn from each other and discuss business issues and relate this back to their own farming situation.

> *"They (discussion groups) are good because farmers pick up information more from other farmers, farmers like to see others doing it and if they see it working on another farm then it makes it easier for them to adopt new technologies". (FO)*

Furthermore the value and benefits of discussion groups beyond their aims around improved farm performance and knowledge transfer were also identified:

> *"They may help reduce the level of isolation that farmers can experience and allow social interaction; that is they could be seen as a mechanism for peer-to-peer support, which is important in times of financial pressures". (PS)*

Barriers to training

This study identified that the main barriers to training were cost, time, location (must be local), the availability of someone to look after the farm to allow participation, the relevance of courses offered; and the age and attitude of farmers themselves.

> *"Time – farms are busy places (releasing time to invest is a problem)". (AP)*

> *"Cost, time and accessibility". (LTS)*

Both the stakeholder consultation and the farmer survey indicated that for part-time farmers, who have off-farm jobs, finding the time to attend courses during the day can be difficult highlighting a need to explore other training delivery mechanisms and times.

> *"A lot of part time farmers have other commitments". (MP)*

A number of stakeholders expressed concern that a negative learning experience can impact on a farmer's future engagement in learning. That is, if farmers undertake courses which are too wide-ranging and lacking relevance to their farming situation this may result in them deciding not to participate in training in the future.

> *"Courses need to be relevant and have up to date information". (FO)*

> *"Relevance of training is important to get farmers to attend training". (PS)*

Farmers ranked improving farm business performance as the most important reason for them to participate in training (Figure 4) and the most important factor affecting their decision to undertake training was the perceived relevance of the training to their business (Figure 5). In general, a more 'business focused approach to farming' was identified as one of the biggest challenges facing the sector.

> *"There is a need to move away from the idea of farming as a "way of life" and doing it the way it has always been done to a more business focused attitude". (AP)*

The majority of farmers surveyed recognised the need to improve their farming knowledge and indicated that they would need more training in the future in order to achieve this. Whilst acknowledging farmers' openness to training, the stakeholder consultation respondents perceived a greater need for farmers to engage in lifelong

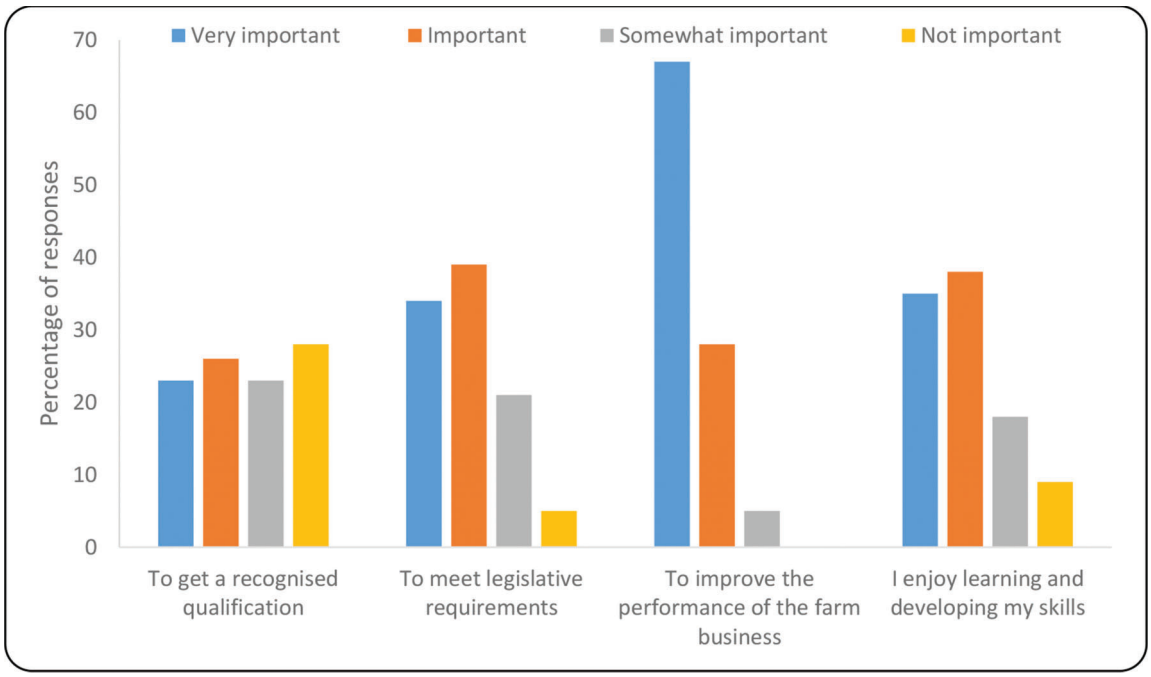

Figure 4: Percentage distribution of survey respondents rating of their reason to undertake training

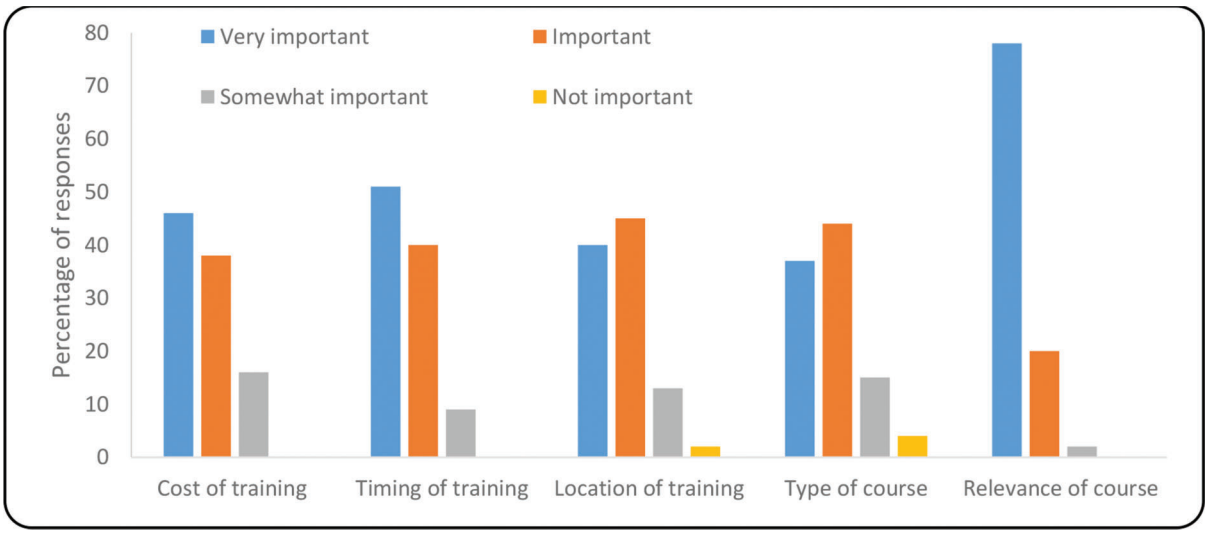

Figure 5: Percentage distribution of survey respondents rating of factors affecting their decision to undertake training

learning to bring about change and innovation in the sector and develop skills which would allow them to be more responsive and adaptable to markets, new technology and innovations, and wider policy changes.

> "*Need to change farmer's attitude and behaviour so they themselves want to seek out the further training they need*". *(LTS)*

Perceived Skills Gaps

The general conclusion emerging from all stakeholders was that there is considerable variation in the level of skills amongst farmers. A few stakeholders indicated that there was a perception that NI farmers' skills levels are lower than farmers in other parts of the UK and Ireland. In addition, it was perceived that skill levels differed between sectors, with the more intensive sectors (pigs and poultry), viewed as having a higher skills base, this was considered to be partly due to the supply chain within these sectors having a more vertically integrated structure.

> "*Most farmers are able to do most things, just not all at a high level*". *(MP)*

> "*Large gap on financial skills side, very low knowledge base*". *(PS)*

The stakeholders believed beef and sheep farmers had the lowest level of skills and training. However, it was acknowledged that this was probably reflective of the diversity within the sector, in terms of farm size, systems and structures and whether farms were operating on a part-time or full-time basis. Age was also identified by the stakeholders as a factor influencing skill levels, with the younger cohorts of farmers perceived as being more willing and prepared to engage in training and developing skills.

> "*Big gap especially in older generation*". *(FO)*

> "*Younger farmers have more of the necessary skills than older farmers because they have been taught them*". *(LTS)*

The pace of change within the sector, driven by increased globalisation, was seen as a factor that would have a significant impact in the future; not just on farmers but also on the wider agri-business supply chain and all the key actors involved within it. Stakeholders expressed a need for increased skills levels within the sector as the approach of '*It's been done that way before and it is how it will continue*' will not be sufficient to deliver improved performance and sustainability into the future.

4. Discussion and Policy Implications

Throughout European agriculture there is an increased awareness of the need to develop more efficient farming systems that are economically and environmentally sustainable (Coomes *et al*., 2019). Furthermore, UK farmers are facing potential challenges and opportunities from the impact of Brexit which has the potential to change the trajectory of many farming businesses (Davis *et al*., 2017). The post Brexit UK policy environment is orientating towards developing a whole farm approach which integrates efficient food production alongside incorporating more environmentally sustainable farming practices, (DEFRA, 2018; NFU, 2019). This will place new demands on farmers in terms of their need to adapt their production and management practices at farm-level. This inevitably will require farmers to improve their knowledge and skills base and to adopt farm-level innovations, improvements and best practice.

This will present particular challenges for the NI farming population as, in general, it is characterised by a low level of engagement and attainment of agricultural training compared to other regions, despite research highlighting that investment in skills and training provides positive returns (Jack and Wallace, 2011). The findings emerging from this mixed method approach of both the stakeholder consultation and the farmer survey identified a need to advance lifelong learning amongst farmers through a programme of continuous professional development. The study identified that such programmes need to provide for two distinct and discrete groups namely; those young people coming into farming with a view to becoming farm managers/work in the

industry in the future and a relatively older cohort of farmers with substantial farming experience.

Both the stakeholder consultation and farmer survey acknowledged that the pace of change within the sector, whether it be market, policy and/or legislative change, was an important factor in creating learning and skills gaps. This is supported by research undertaken in the US over the past 20 years looking at the educational and training needs of farmers, which has shown that the educational needs of farmers are continually evolving over time (Carter & Batte, 1993; Joerger, 2003; Eberspacher and Jose, 2005; Suvedi, Jeong and Coombs, 2010).

A strategy for delivering a programme of continuous professional development in agriculture should have a strong emphasis on training as an investment and the benefits that engaging in lifelong learning programmes can bring to the farm business. When making a capital investment on farm, whether it be a new piece of machinery or upgrading farm buildings, farmers recognise the benefits that the investment will bring to the farm business. In a similar way, the research results identified an increased need for this to be communicated to farmers in order to develop their understanding of why investing in their own development can lead to positive returns within a farm business. An important finding of the research was the need for increased collaboration among the key stakeholders within the agricultural skills development sector, i.e. industry, educators, researchers and government, to encourage cultural change that will develop a more positive attitude towards lifelong learning within the farming industry. Furthermore, the research identified the need for post qualification engagement between training providers and students, in order to help embed and encourage participation in lifelong learning throughout their farming career, which supports the research by Turner and Irvine, (2017) and Hall, Turner and Kilpatrick (2019).

This study identified that wider consideration needs to be given by agricultural education and training providers to the level of existing knowledge and the age profile of their student cohort groups. In general, younger farmers have higher levels of formal educational achievement compared to older farmers (Eurostat, 2013), and different age groups will prefer different methods of delivery. Failure to take account of this would impact on farmers' engagement and uptake within a professional development programme. This is further emphasised by a previous study conducted by Ota *et al.* (2006) who highlighted that in order to deliver effective lifelong learning a combination of teaching strategies (lectures, problem based learning, case studies, and role play) have the greatest impact. Furthermore, Kilpatrick (1996), Hansen (2015) and Hall, Turner, Irvine *et al.* (2017) have found that a farmer's level of formal educational attainment can influence their perceived motivation to participate in learning. Those who have low levels of formal learning find it more difficult to engage in further lifelong learning while those farmers with higher levels of formal education are more likely to seek further opportunities for learning. The results from this study have shown that farm and research demonstration visits aimed at showcasing new techniques and best practice are the most popular. For those farmers coming from a less formal educational background these methods make training and learning more accessible. The challenge from an educational delivery perspective is to ensure that, improvements in knowledge, skills and competencies are achieved through a range of formal and in-formal techniques which provides for a range of individual preferences and requirements.

Survey respondents expressed an overall preference for non-formal training methods which are short in duration and relevant to farm business needs. This supports the findings of Hall, Turner and Kilpatrick (2019) who found that farmers were more likely to attend non formal training on a topic that was relevant to their farm. The research identified a range of barriers that contributed to farmers nonparticipation in training, these were similar to those widely identified in the international literature (Kilpatrick and Johns, 2003; Seymour and Barr, 2014). From the current study the convenience of both location and timing of training is important but added to this in terms of encouraging engagement is the relevance to a farmer's particular farming system. The overall design and implementation of agricultural training and skills provision, needs to ensure that progression along a 'learning and skills pathway' is visible and accessible, as non-formal training and skills programmes were seen as a gateway for younger farmers to move into a more formal qualification.

The survey and stakeholder feedback identified the important role that technically capable advisors bring to the farming sector which supports the findings of Hall, Turner and Kilpatrick (2019). An important aspect of that relationship is their ability to build trust and employ their professional knowledge in assisting the farmer to identify what training would be relevant to their farm business. There is a role for the advisors to identify with farmers what skills they need and assist them to navigate their training needs. However, in the context of a more complex farming environment which is becoming more technology and data driven (Wolfert *et al.*, 2017) there is an increased need for advisors to be provided with the time and resources to engage in their own continuous professional development and keep their specialist knowledge up to date and aligned with best practice.

A recurrent theme from the stakeholder consultation was the need for farmers to develop business-oriented skills and strategies. Developing analytical skills was seen as relatively more important in the current farming environment compared to the past. An increased emphasis is needed in getting farmers to 'take ownership' of data in order to improve the key performance indicators of their own farm business. It was also highlighted that there was a need for farmers to recognise that in order to be sustainably competitive they must engage with those innovations and technologies which will improve their business performance alongside developing technical and business management skills. These findings concur and support evidence from a recent study undertaken in the Republic of Ireland examining training for dairy farm managers (Deming *et al.*, 2019).

The implementation of an upskilling programme which emphasises developing business orientated skills and best practice adoption will provide challenges as it represents a major change for all those involved in the industry; farmers, agri-food processors, educators, researchers and government. Due to the pace of change that the industry is facing, technological advancements

and wider societal demands, there is a greater need for the main agriculture educational providers to engage more with other education providers (universities and research institutes), farmers and agri-food processors in order to keep pace with changes in the sector and to ensure that the resulting programmes and curricula are meeting industry requirements. This engagement could take the form of establishing a wider industry consultative body to oversee the strategic development of an agriculture and land based training and skills development programme.

A limitation of this study was the small number of farmers who responded to the survey. There was no database of farmers with agricultural qualifications available, therefore, the authors went to considerable effort to ensure the survey was advertised widely through the farming press, knowledge transfer newsletters and by the farming unions. The authors have come to the conclusion that the limited response reflects a certain level of disengagement in formal agricultural training amongst the farming sector in NI. This in itself provides a basis for undertaking further research in this area to gain a better understanding of why there is a low level of participation in formal agricultural training.

5. Conclusion

This research focused on examining the current and future skills requirements within the primary agriculture sector in NI and how knowledge provision should be adapted to best meet farmer and industry needs. A mixed methods approach, combining structured interviews of key stakeholders and a survey of farmers was employed. The results from this study have offered a number of recommendations around the future provision of agricultural training which are considered relevant to NI and other regions, with similar farming structures, both nationally and internationally.

Embedding key professional skills, both business and technical, into the more practical aspects of farming through a programme of Continuous Professional Development (CPD) should be a priority. Delivery will require improved collaboration between education providers and the wider industry as this study has identified a 'mixed methods approach' as the most appropriate way of securing farmers' engagement and adoption of new practices. The main training providers should explore the possibility of widening delivery of courses, in conjunction with local Further Education Colleges, particularly with a view to facilitating access to provision for part-time farmers. Teaching and advisory staff should be provided with the time and resources to engage in their own CPD, keeping their specialist knowledge up-to-date and increasing their knowledge of new technologies together with new approaches to learning, as they arise.

In general, the study identified that there was a need to encourage a more positive attitude towards qualifications, training and lifelong learning in the primary agriculture sector. The wider industry needs to lead on promoting a positive image of farming as a career, focusing on the technological and scientific nature of modern agriculture and the role of farmers in managing sustainable rural businesses. Moreover, the findings indicate a requirement for greater partnership among the key players; researchers, extension services and educators due to the pace of change in relation to new innovations, technologies and practices within the sector. This would allow for a more timely transfer of new science and innovations to be translated into farmer learning and innovation, resulting in behavioural and practice changes at farm level.

About the authors

Austen Ashfield is a Senior Agricultural Economist at the Agri-Food and Biosciences Institute (AFBI), Belfast, Northern Ireland.

Conall Mullan is an Agricultural Economist at the Agri-Food and Biosciences Institute (AFBI), Belfast, Northern Ireland.

Claire Jack is a Principal Agricultural Economist at the Agri-Food and Biosciences Institute (AFBI), Belfast, Northern Ireland

Acknowledgement

The authors are grateful to the Department of Agriculture, Environment and Rural Affairs, who funded the research on which this article is based. The authors are grateful to the anonymous reviewers for their constructive comments on the original manuscript.

REFERENCES

Accatino, F., Tondab, A., Drossa, C., Légerc, F. and Tichit, M. (2019). Trade-offs and synergies between livestock production and other ecosystem services. *Agricultural Systems* 168, pp. 58-72. DOI: 10.1016/j.agsy.2018.08.002.

Black, A.W. (2000). Extension theory and practice: a review. *Australian Journal of Experimental Agriculture* 40(4), pp. 493-502. DOI: 10.1071/EA99083.

Braun, V. and Clarke, V. (2006). Using Thematic Analysis in Psychology. *Qualitative Research in Psychology* 3(2), pp. 77–101. DOI: 10.1191/1478088706qp063oa.

Carter, B.R. and Batte, M.T. (1993). Identifying needs and audiences in farm management outreach education. *Review of Agricultural Economics* 15(3), pp. 403-415. DOI: 10.2307/1349477.

Coomes, O.T., Barham, B.L., MacDonald, G.K., Ramankutty, N. and Chavas, J.P. (2019). Leveraging total factor productivity growth for sustainable and resilient farming. *Nature Sustainability* 2, pp. 22–28. DOI: 10.1038/s41893-018-0200-3.

Caskie, P. (2018). Human capital and the CAP: A case for radical policy reform. *Eurochoices* 17(3), pp. 31-36. DOI: 10.1111/1746-692X.12205.

DAERA. (2017). EU Farm Structure Survey 2016 Northern Ireland. Department of Agriculture and Rural Development, Dundonald House, Upper Newtownards Road, Belfast, Northern Ireland.

DAERA. (2018). Statistical Review of Northern Ireland Agriculture 2017. Policy and Economics Division, Department of Agriculture and Rural Development, Dundonald House, Upper Newtownards Road, Belfast, Northern Ireland.

DARD. (2008). Statistical Review of Northern Ireland Agriculture 2007. Policy and Economics Division, Department of Agriculture and Rural Development, Dundonald House, Upper Newtownards Road, Belfast, Northern Ireland.

Davis, J., Feng, S., Patton, M. and Binfield, J. (2017). Impacts of Alternative Post-Brexit Trade Agreements on UK Agriculture: Sector Analyses using the FAPRI-UK Model. FAPRI-UK project report, Agri-Food and Biosciences Institute, Belfast, Northern Ireland.

DEFRA. (2018). Health and Harmony: the future for food, farming and the environment in a Green Brexit. Department for the Environment, Food & Rural Affairs, Westminster, London, UK.

Deming, J., Macken-Walsh, A., O'Brien, B. and Kinsella, J. (2019). Entering the occupational category of 'Farmer': new pathways through professional agricultural education in Ireland. *The Journal of Agricultural Education and Extension* 25(1), pp. 63-78. DOI: 10.1080/1389224X.2018.1529605.

Eberspacher, B. and Jose, H.D. (2005). Determining educational needs: A focus group approach. Paper presented at the meeting of *15th Congress of International Farm Management Association*, Campinas, Brazil.

Eurostat. (2013). http://ec.europa.eu/eurostat/ accessed November 2020.

Eurostat. (2016). http://ec.europa.eu/eurostat/ accessed November 2020.

Fulton, A., Fulton, D., Tabart, T., Ball, B., Champion, S., Weatherley, J. and Heinjus, D. (2003). Agricultural Extension, Learning and Change. No. 03/032, Rural Industries Research and Development Corporation, Barton, Australian Capital Territory.

Gasson, R. (1998). Educational Qualifications of UK Farmers: A Review. *Journal of Rural Studies* 14(4), pp. 487-498. DOI: 10.1016/S0743-0167(98)00028-X.

Gittins, P., McElwee, G. and Tipi, N. (2020). Discrete event simulation in livestock management. *Journal of Rural Studies* 78, pp. 387-398. DOI: 10.1016/j.jrurstud.2020.06.039.

Hall, A., Turner, L., Irvine, L. and Kilpatrick, S. (2017). Pasture management and extension on Tasmanian dairy farms – who measures up? *Rural Extension & Innovation Systems Journal* 13(2), pp. 32.40.

Hall, A., Turner, L. and Kilpatrick, S. (2019). Using the theory of planned behaviour framework to understand Tasmanian dairy farmer engagement with extension activities to inform future delivery. *The Journal of Agricultural Education and Extension* 25(3), pp. 195-210. DOI: 10.1080/1389224X.2019.1571422.

Hansen, B.G. (2015). Financial extension that challenges farmers' thinking in discussion clubs helps farmers improve their problem solving abilities. *Agricultural Systems* 132, pp. 85-92. DOI: 10.1016/j.agsy.2014.09.009.

Heanue, K. and O'Donoghue, C. (2014). The economic returns to formal agriculture education. Teagasc, Ireland. ISBN: 978-1-84170-613-9.

Holloway, I. and Todres, L. (2003). The Status of Method: Flexibility, Consistency and Coherence. *Qualitative Research* 3(3), pp. 345–357. DOI: 10.1177/1468794103033004.

Huffman, W.E. (2001). Human Capital: Education and Agriculture. In Gardner, B.L. and Rausser, G.C., (Eds.). *Handbook of Agricultural Economics, Volume 1A*. Elsevier Science, Amsterdam, Netherlands, pp. 333-381.

Huffman, W. and Orazem, P. (2004). The Role of Agriculture and Human Capital in Economic Growth: Farmers, Schooling, and Health. Economics Working Papers (2002–2016). 244. http://lib.dr.iastate.edu/econ_las_workingpapers/244, accessed November 2020.

Jack, C. and Wallace, M. (2011). On-Farm and Off-Farm Returns to Education among Farm Operators in Northern Ireland. A Non-Technical Summary and Policy Discussion Document, Belfast. https://www.daera-ni.gov.uk/sites/default/files/publications/dard/returns-to-education-report.pdf, accessed November 2020.

Jack, C., Adenuga, A.H., Ashfield, A. and Wallace, M. (2020) Investigating the Drivers of Farmers' Engagement in a Participatory Extension Programme: The Case of Northern Ireland Business Development Groups. *Sustainability* 12, pp. 4510. DOI: 10.3390/su12114510.

Joerger, R.M. (2003). Student perspectives of the nature, effectiveness, and value of the Minnesota farm business management education program. *Journal of Agriculture Education* 44(1), pp. 56-69.

Kilpatrick, S. (1996). Change, Training and Farm Profitability. Canberra, National Farmers' Federation, Australia.

Kilpatrick, S. and Johns, S. (2003). How farmers learn: Different approaches to change. *The Journal of Agricultural Education and Extension* 9(4), pp. 151-164. DOI: 10.1080/13892240385300231.

Lindblom, J., Lundström, C., Ljung, M. and Jonsson, A. (2017). Promoting sustainable intensification in precision agriculture: review of decision support systems development and strategies. *Precision Agriculture* 18(3), pp. 309-331. DOI: 10.1007/s11119-016-9491-4.

Lockheed, M.E., Jamison, D.T. and Lau, L.J. (1980). Farmer Education and Farm Efficiency: A Survey. *American Journal of Agricultural Economics* 29(1), pp. 37-76. DOI: 10.1086/451231.

McDonald, R., Heanue, K., Pierce, K. and Horan, B. (2016). Factors Influencing New Entrant Dairy Farmer's Decision-making Process around Technology Adoption. *Journal of Agricultural Education and Extension* 22(2), pp. 163-177. DOI: 10.1080/1389224X.2015.1026364.

McKillop, J., Heanue, K. and Kinsella, J. (2018). Are all young farmers the same? An exploratory analysis of on-farm innovation on dairy and drystock farms in the Republic of Ireland.*The Journal of Agricultural Education and Extension* 24(2), pp.137-151. DOI: 10.1080/1389224X.2018.1432494.

NFU. (2019). The future of food 2040. National Farmers Union, Agriculture House, Stoneleigh Park, UK.

O'Donoghue, C. and Heanue, K. (2018). The impact of formal agricultural education on farm level innovation and management practices. *The Journal of Technology Transfer* 43(4), pp. 844-863. DOI: 10.1007/s10961-016-9529-9.

Ota, C., DiCarlo, C.F., Burts, D.C., Laird, R. and Gioe, C. (2006). Training and the needs of adult learners. *Journal of Extension* 44 (6), Article No.TOT5.

Punch, K., F. (2005). Introduction to Social Research Quantitative and Qualitative Approaches, 2nd edition, Sage, London, UK.

Seymour, E. and Barr, N. (2014). Farmer preferences for formal learning: A review of current data and literature. Rural and Resources Policy, Victorian Government of Environment and Primary Industries, Melbourne, Australia.

Sewell, A.M., Gray, D.I., Blair, H.T., Kemp, P.D., Kenyon, P.R., Morris, S.T. and Wood, B.A. (2014). Hatching new ideas about herb pastures: Learning together in a community of New Zealand farmers and agricultural scientists. *Agricultural Systems* 125, pp. 63-73. DOI: 10.1016/j.agsy.2013.12.002.

Sewell, A.M., Hartnett, M.K., Gray, D.I., Blair, H.T., Kemp, P.D., Kenyon, P.R., Morris, S.T. and Wood, B.A. (2017). Using educational theory and research to refine agricultural extension: affordances and barriers for farmers' learning and practice change. *The Journal of Agricultural Education and Extension* 23(4), pp. 313-333. DOI: 10.1080/1389224X.2017.1314861.

Schulte, R.P.O., Creamer, R.E., Donnellan, T., Farrelly, N., Fealy, R., O'Donoghue, C. and O'Huallachain, D. (2014). Functional land management: a framework for managing soil-based ecosystem services for the sustainable intensification of agriculture. *Environmental Science & Policy* 38, pp. 45-58. DOI: 10.1016/j.envsci.2013.10.002.

Suvedi, M., Jeong, E. and Coombs, J. (2010). Education Needs of Michigan Farmers. *Journal of Extension* 48(3), Article No. 3RIB3.

Turner, L. and Irvine, L. (2017). Tasmanian Dairy Farmers and the Pasture Management Process: Case Study Findings on the Role of Coaching in Achieving Practice Change. *Rural Extension & Innovations Systems Journal* 13(1), pp. 31–40.

Turner, L., Wilkinson, R. and Kilpatrick, S. (2017). Boundaries to Change: Insights into the Change Process of Beef and Sheep Farmers. *Rural Extension and Innovation Systems Journal* 13(1), pp. 9.

Wallace, M.T. and Jack, C.G. (2011). On-Farm and Off-Farm Returns to Education among Farm Operators in Northern Ireland. Paper presented to *85th Annual Conference of the*

Agricultural Economics Society, Warwick University, Warwick, UK.

Wolfert, S., Ge, L., Verdouw, C. and Bogaardt, M. (2017). Big data in smart farming – a review. *Agricultural Systems* 153, pp. 69–80. DOI: 10.1016/j.agsy.2017.01.023.

Zagata, L. and Sutherland, L. (2015). Deconstructing the young farmer problem in Europe: towards a research agenda. *Journal of Rural Studies* 38, pp. 39-51. DOI: 10.1016/j.jrurstud.2015.01.003.