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UNIVERSITY OF PLYMOUTH

THE IMPORTANCE OF KNOWLEDGE EXCHANGE AS A METHOD TO HELP FARMERS TRANSITION TO SUSTAINABLE FARMING METHODS AND MITIGATE CLIMATE CHANGE.

by

REBECCA WILLSON

A thesis submitted to the University of Plymouth in partial fulfilment for the degree of

RESEARCH MASTERS

School of Biological and Marine Sciences

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Finally, the research was undertaken as an opportunity to investigate some of the key opportunities that farming has in the future and the way that communication and knowledge exchange can help farmers embrace this challenge, I hope that it will contribute to a thriving industry that is sustained for generations.

Authors Declaration

At no time during the registration for the degree of Research Masters has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

Work submitted for this research degree at the University of Plymouth has not formed part of any other degree either at the University of Plymouth or at another establishment.

The author completed a Nuffield Farming scholarship, and contacts made through the Nuffield farming network were included as part of the key informant interviews. Responses that were analysed as part of this thesis was separate to the content included within the Nuffield report.

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Abstract

Climate change is among the world's greatest challenges in the 21st century. This research aimed to evaluate the opportunities for knowledge exchange to support farmers in the transition to more sustainable farming practices. This study used a mixed method analysis to understand current views on knowledge exchange and identify barriers and drivers for farmers to change practice specifically focused on the provision of advice. Key informant interviews were completed with a range of participants involved in sustainable agriculture. To complement opinions from the interviews, farmers were surveyed at three on-farm events and an online survey for farm advisors was completed. Thematic analysis using a realist approach was conducted and data coded and refined until key themes emerged. Key themes included the importance of framing technical information, the importance of trust and relationships, the use of demonstration and narrative, and the importance of sustaining projects over a long term to measure impact and support behavioural change. The on-farm events showed that farmers needed support to transition, and valued the demonstration and peer to peer learning brought about by the farmer hosts. Effective knowledge exchange is a crucial part of supporting farmers to achieve emissions reductions and improve sustainability and climate change mitigation and adaptation. Through understanding farmer motivations, framing the topics in a way which makes sense, using trusted advisors and tested dissemination

networks, and developing robust metrics that show impact, the industry can achieve real change.

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Chapter 1: Introduction

Climate change is among the world's greatest challenges in the 21st century. The contribution of agriculture to this challenge cannot be underestimated. Agriculture is of critical importance to sustainable development, but to achieve integration there is a need for the right mix of policies, technologies and projects that will drive change at the farm level. Farmers and growers are not just at the front line of climate change in terms of the impact of the changing weather patterns on their businesses and the need for adaptation, but also have a role in mitigating greenhouse gas emissions from the sector.

There is a need to develop an agriculture and food industry which is resilient, profitable, low carbon and sustainable. A key part of this is to communicate better with farmers and provide information in a way that will inspire and facilitate behavioural change.

In order to meet the emerging challenge of sustainability within agri-food systems various key attributes are required. These include system innovation and transition (Ingram *et a*l, 2015), and improved farmer technical competence, through the development of skills and knowledge (Hansen, 2014). Agriculture's environmental impact is also now being scrutinised widely in relation to environmental performance (Greiner *et al,* 2009). There is an increasing expectation for agricultural practices to change, yet the reasons behind decision making on-farm and the relative importance of sustainability as a key criteria for decision making is poorly understood. (Fleming and Vanclay, 2010).

Farming is seen as being complex; farmers need to be able to adapt and change their practices which requires continual development of new knowledge (Oreszczyn

et al, 2010). Knowledge and education, not necessarily in a 'formal' setting, but through attending technical events, seminars, workshops and discussion groups have been cited as key attributes to overcoming the current challenges. It has been suggested that knowledge can be "*even more important than physical resources*" (Rivers and Alex, 2008).

Learning and skills development, especially in agriculture, are multifaceted, as they are socially embedded and developmental (Wenger, 2001), and occur over a lifetime rather than a one off event (Kirkpatrick and Johns, 2003). Whilst the literature is prolific in terms of the value of information and knowledge transfer to the farming business (Kilpatrick and Rosenblatt, 1998), and the importance of understanding the socio-cultural approaches to farmer learning (Price and Leviston, 2014, Burton, 2004, Sheeder and Lynne, 2011, and Prokopy *et al*, 2008) there is little evidence on how that knowledge is acquired by the farmer.

The success of sustainable agriculture and the transition required to ensure production is balanced with environmental protection requires an understanding of the motivations, skills, current knowledge and learning needs of individual farmers as well as any collective activity or actions taking place (Roling and Pretty, 1997). To date, despite these recommendations being made almost 20 years ago, there is a paucity of knowledge on current learning needs and knowledge acquisition of farmers surrounding sustainable resource management. A synthesis of literature on adoption of best management practices within agriculture by Prokopy *et al* (2008) reinforced the importance of training events in increasing awareness and adoption rates of proposed management. However, in order to develop effective training for farmers in resource management there is a need to understand the mechanisms

through which farmers learn, including their preferential learning methods and what is effective in promoting an enabling learning environment (Kilpatrick & Johns, 2003).

1.1 Knowledge generation and the socio-economic characteristics of farmer learning

Knowledge can be comprehended as a "*collection of interconnected schemes of interpretation"* that can be called upon to provide meaning to a particular situation (Leeuwis and van de Ban, 2004).

The process by which a farmer gains new knowledge and adapts the knowledge into a behavioural change is complex and multifaceted (Mills *et al*, 2013). This is also described by Edwards – Jones (2006) who identified six factors that influenced a farmer's decision making including socio economic characteristics. It is important to also recognise that there can be a gap between obtaining new knowledge and having the skills, capacity or ability to adopt the recommended practice.

Researchers have examined the impact of socioeconomic characteristics on farmer training participation and adoption of environmental management practices on-farm (Marenya and Barrett, 2007, Darberkow and McBride 2003, Willson, 1997, Mwolo *et al,* 2019*)*. These and other studies have reported several determining factors that influence the likelihood that the farmer will try new things and be innovative. These factors include access to higher education and income. (Atari *et al*, 2009, Kolade and Harpham, 2014). The importance of education and training was confirmed by Kilpatrick (2000) who described a link between training and the ability of the farmer to learn and change. It is therefore clear that personal, social and situational characteristics of farmers are often important determinants of knowledge acquisition,

willingness to change and behaviour (including conservation behaviour), (Smithers and Furman, 2003).

1.2 Skills development policy

Skills development and training for farmers, growers and foresters has been a funding priority in UK Agricultural policy. The aim of skills training has been *"to equip professional farmers, growers and foresters with the skills, knowledge and experience to become the next generation of forward thinking business people and industry leaders." (*Defra, 2014).

Skills provision for improved knowledge of resource management skills has been explicitly highlighted. In 2011 Lantra, a training provider for land based industries including agriculture and forestry identified a emerging skills gap around climate change mitigation and the ability of our sector to respond to further land management and environmental requirements, including nutrient leaching and soil protection. Additionally, it has been shown that farming in a manner which is protecting natural resources or is environmentally restorative requires a wider skill set than farming conventionally (Mills, 2012).

1.3 Farmer information sources

There are a wide range of information sources available to farmers to access knowledge including advisors, agricultural media, other farmers, observations and training events (Muhammad and Garforth, 1999, Butler and Lobley, 2012). Although effective learning will differ depending on the individual in question and is a personal activity, it is also influenced by the social interactions that the individual experiences (Sligo and Massey, 2007). However research has indicated that farmers are not

heterogenous, they differ in their ability to respond to different types of information and methods of dissemination (Lanyon, 1994, Campbell, 1995).

Social learning theory revolves around the premise that knowledge is acquired through interaction (Moschitz *et al*, 2015). Literature based on farmer interviews across numerous papers support this statement (Greiner and Gregg, 2011, Schroeder *et al*, 2013, Reed *et al*, 2009, and Blackstock *et al,* 2007) and suggest that knowledge is valued when it is sourced in actual (and current) farming experiences (Wood *et al*, 2014). One advantage of interactive learning is an ability to gain immediate feedback from a group of like-minded producers and gain peer support and endorsement on proposed practice (Piercy *et al*, 2011).

Historical agricultural policy and research changes that occurred in the 1990s required advice provision to be substantially altered from the existing advice which was focussed on increased production, to the challenges of providing advice which addressed environmental concerns. However, the advice and knowledge system is becoming 'increasingly fragmented,' leading to 'information asymmetry' (Rivera and Sulaiman, 2009). Some research has expressed concern about the abundance of advice provision which can result in an uncoordinated and fragmented approach (Sutherland *et al*, 2013). This fragmentation can results in positive and negative experiences and outcomes. The drawbacks to the fragmentation of advice provision have been shown to cause duplication, gaps, conflict and confusion. Positive impacts have been shown by research including Rivera, 2000 and Garforth et al, 2003) who both suggested that with more advisors there is a diversity of approaches, providers and an enhanced ability for farmers to access advice.

Understanding and influencing behaviour change can be viewed as a complex and multi-faceted issue. Managing farmland requires multiple decisions to be made over

different temporal and spatial scales (LeGal *et al* 2011). There are a range of factors that could potentially influence farmer decision -making and behaviour including physical and economic constraints, socio – demographic issues and access to information (Toma *et al*, 2013). An overarching aspect is the farmers ability to access information and the subsequent trust in the information provided.

The heterogeneity of modern agriculture combined with the multifaceted nature of climate change suggests that there will not be one universal communication approach that will be sufficient. Results of a long-term study looking at the methods of communication on climate change adaptation (not specific to agriculture) indicated that behavioural intentions do not necessarily always translate into the required action (Howell, 2014), or may only result in short term change rather than the behaviour being sustained over a longer term (Howell et al, 2011).

1.4 Achieving behavioural change

"*Extension educators often are frustrated when farmers do not internalize, apply, or stick with the sustainable agricultural practices they recommend*" (Piercy *et al*, 2011, p. 822).

Achieving behavioural change may be viewed by knowledge providers as the 'ultimate aim' of training provision. However, as already highlighted there are many influencing factors that may all interact (Reddy *et al,* 2016). In order to achieve behavioural change, transition is needed from 'passive' to 'active' learning (Millar and Curtis, 1997), and a space for open discussion to explore implementation barriers and practical issues must be provided. Indeed, Sewell *et al* (2013) who focussed on knowledge around planting diverse grass leys and herbal mixes, found that farmer learning was promoted when farmers made connections with the evidence being

presented and their own farming system. In order to promote farmer learning, Sewell found that it was imperative that the diverse motivational needs of farmers were met, the content resonated with the audience, and was applicable to a commercial situation. Often there is a lack of understanding on the reasons that farmers engage with environmental management; if increased adoption of environmental management practices is to be sustained, this will need to be addressed (Dilling and Failey, 2013).

The process of change may start with the farmers' existing knowledge level. Literature looking at implementation of biosecurity measures on farms concerned with animal health, found that prior knowledge was a key determinant of behaviour (Toma *et al*, 2013). Indeed Raymond *et al* (2010) concluded that when designing new policy or research programmes, it is imperative to identify the current knowledge level of participants however to date there is little research on existing knowledge level specifically concerned with resource management.

1.5 The relationship between trust and behavioural change

The issue of trust in the information source and the connectedness of the information to their local situation has also been found to be important (Oliver *et al*, 2012).

Research has investigated the desires of farmers when receiving new knowledge and the factors that are important. Studies have identified the value that farmer place on information being independent and backed up by science (Oreszczyn, 2010). . Achieving behavioural change through advisory services has been shown to require trust by the farmer on two levels: personal or relationship trust (with the individual advisor) and institutional trust, which refers to the level of credibility which the farmer has for the source of the message (Mishler and Rose, 2001). Vanclay (2004)

evaluated the process by which advisors gain farmers trust, which has to be earned over time. This was confirmed by Sutherland *et al* (2013) which concluded that sustained advice which was provided over a long time period was the key to obtaining farmer trust.

When focussing on literature evaluating farmers adoption of climate change adaptation behaviour, research has found that there is a link between a behaviour response and risk perception (Artikov *et al*, 2006) as well as between behaviour change and beliefs (Arbuckle, Morton and Hobbs, 2015). Farmers who are fearful of the impacts of regulation or financial penalty for non-compliance have exhibited short term behaviour change to comply but this has often not facilitated this change over the long term (Smithers and Furman, 2003).

However, behavioural change can be difficult to measure, and many previous farmer education programmes that have been focusing on promoting environmental outcomes (such as biodiversity conservation) were never assessed as to their impact on long term behavioural change (Ferraro and Pattanayak, 2006). This may well have been due to the complexity of attributing behavioural change to a training interaction. This has been shown to be an overly simplistic approach (Stern, 2000) because in reality, behaviour change can be influenced by a multitude of factors rather than an isolated training event (Gifford, 2014).

"*Behaviour change is context and actor dependent, dynamic interactions between human behaviour and natural resources are relatively unexplored*" (Reddy *et al,* 2016, p. 255).

1.6 The use of farmer experience in the co-creation of knowledge

Farmers make use of a much wider information and knowledge network than just scientific research (Ford and Babb, 1989, Butler and Lobley, 2012). Farmer knowledge is extremely valuable and its use in association with scientific knowledge can provide insights into the practical value of research at farm level. It also allows the creation of solutions to problems that farmers actually want, rather than what we think they need (Dodunski, 2014). This leads to a shift from the traditional patterns of knowledge transfer, where knowledge was transferred from the research institution or trainer to the farmer to the co-creation of knowledge through social interactions, learning and knowledge exchange (Blackstock *et al*, 2007, Sturdy *et al*, 2008, Dogliotti *et al*, 2014).

Another theory that has meaning within this subject, has been explored by Riley (2008) and describes the 'knowledge – cultures' concept. This refers to the "*socially negotiated structures of meaning that enable and constrain actions."* By learning more about the characteristics of these structures, it may be possible to shed light on the links between famer understanding of a key concept and how that is then linked to the reasons why a practice is taken up or ignored. Understanding not just how knowledge and understanding influence management, but also what the justification is for that management, allows opportunities for framing and shaping of advice in a way which inspires action rather than just dictating management.

Effective knowledge exchange approaches also emphasise the need for farmers to problem solve and be part of the knowledge gaining experience. Knowledge exchange differs from knowledge transfer as farmers need to be actively involved in the discussions and contribute their own ideas which help them to develop their own solutions to problems through taking part (Blackstock *et al*, 2007). Farmers have

been shown to exchange knowledge within a range of networks that can shape how research is communicated (Wood *et al,* 2014). Peer to peer or group meetings are an important tool to enhance contextual learning. This includes making best use of the experiential knowledge of farmers to add local value and meaning to generic schemes and make them relevant. By taking small steps and carefully monitoring results, there is a potential to develop sustainable knowledge strategies, created by the farmers that has worth (Eshuis and Stuiver, 2005).

The use of farmer cooperatives as a mechanism to disseminate knowledge and innovation was shown as being effective in West Africa where being involved with the farmer cooperative provided not just new advice, but support with implementation (Kolade and Harpham 2014).

1.7 The farmer –expert interface

Literature highlights the importance of combining academic knowledge from researchers with integral knowledge held by farmers (Raymond *et al*, 2010, Wood *et al*, 2014,). Indeed, with the development of climate change, resource depletion and other environmental issues which are complex, understanding different sources and types of knowledge is important. One of the issues is that, in order to adapt to future challenges within agriculture, research, innovation and development are needed. However, conventional scientific knowledge has historically been developed and honed in a specific location, often a research institution or laboratory (Eshuis and Stuiver, 2005). Although scientific knowledge is incredibly important, often to be meaningful on-farm, the science needs interpreting into a form that has value to the farmer and is relevant to local conditions. Scientists and farmers need to meet and engage in dialogue and cooperate in order to create credible, useful and sustainable knowledge (Clark and Murdoch, 1997). Creating good relationships between

stakeholders, as well as involving farmers and scientists in the generation of knowledge, means that there is a higher likelihood of the knowledge being accepted (Eshius and Struiver, 2003). Historically farmers have been viewed as being '*unable to communicate with scientific experts'* (Riley, 2008), but perhaps as knowledge exchange evolves it is important for researchers to understand the value of farmer knowledge and accept that the combination of the two can produce a satisfactory result for both farmer and researcher. This highlights the importance of 'ground – truthing' the science and the value of local knowledge, not just from the view of the farmers, but also the researchers. It is suggested by Oliver *et al* (2012) that farmers and land managers are "*custodians not just of the countryside but of salient local knowledge*." This local knowledge should be valued as it can provide practical insight into the implantation of scientific theory at farm. Recommendations from work completed by Dilling and Failey (2013) included a need to focus on "*creating ongoing opportunities for researchers and decision makers to work together, rather than separating the process of knowledge generation from its use*." It can be difficult, however, to facilitate this interaction between scientists and 'end users' as it may conflict with traditional research goals. Predictive theory and core scientific concepts in isolation will not deliver solutions for practical problems, end users can add valuable insight and help deliver results which can be transformational. Including farmers and wider industry within research will help achieve this shift.

Valuing farmer knowledge is a key part of a move towards an integrated approach to land management which is multidisciplinary but centred in practice. With the complex environmental issues that are being tackled, there is a need to combine the efforts of many disciplines to understand the problems and interact actively with

farmers who ultimately have to implement the recommendations (Lemos and Morehouse, 2005).

1.8 Contextual learning

The literature suggests that farmers often prefer to learn and receive new information through experiential learning (Sewell, 2013, Dodunski, 2014, Wood *et al*, 2014). Including the ability for farmers to assess the relevance of the training to their own farm situation and where farmers and experts can work together to 'co-create' farm based solutions has been seen as valuable and a method through which behavioural change can occur (Kilpatrick and Rosenblatt, 1998). This interactive learning method includes the stages of dialogue, debate, questioning and reflection, which all help contextualise the theory and make it more relevant. Sutherland et al (2013) suggested that farmer knowledge can be classified into two types; formally acquired knowledge which can be important for some aspects of farming including compliance with legislation and long-term experiential learning which is developed through interaction with the farm environment. As experiential learning allows farmers to continue to manage their land on a daily basis, assessing the interactions between various parameters farmers may be more familiar and comfortable with this method of learning as it is rooted in practice (Morris, 2006, Roling and Wagemakers, 2000, Tsouvalis *et al,* 2000). This sort of learning is beneficial for agriculture as it allows an appreciation of the farm at a system level. When focussing on the opportunities for sustainable agriculture, and the acquisition of knowledge, this systems level is particularly important as climate change mitigation can be multifaceted, and include multiple and sometimes competing objectives. A systems perspective works for agriculture as it corresponds with the way that farmers view and manage their farm (Eshuis and Stuiver, 2005). Using a contextual framework allows for the core

principles to be refined using the farmers local knowledge and skill to develop management and environmental solutions in a consultative way which creates an end result which is in context and can provide value to the farm business.

Indeed, if we are to transform our farming practices and achieve “multi-functional agriculture” (Renting *et al*, 2009) we will need to all work together develop new forms of knowledge that respond to the emerging challenges. This offers opportunities to adapt knowledge exchange and create systems that respond to the objectives and enable farmers to feel part of the solution. Using a top down approach where technical information is developed and passed to farmers may not deliver the scale of change that is required (Wood *et al*, 2014). It is important to also consider how the information is communicated, and consider the preferred learning method of the audience in question (Smithers and Furman, 2003). This approach makes sense when focussing on farmer knowledge exchange. This ‘farmer centred’ approach has been well researched in the developing world through analysis of the ‘farmer field school’ programmes that have been run across Africa, Asia and South America and has shown to have a positive impact on environmental behaviour of farmers who have engaged (Larsen and Lilleor, 2014, Davis *et al*, 2012, Van de Berg and Jiggins, 2007, Huang *et al*, 2015, Guo *et a*l, 2015, Wood *et al*, 2014). Evaluating the use of a participatory approach in the UK in Farmer Field labs, the researchers found that through participation, farmers had developed confidence in their ability to try new things on-farm thus inspiring change (Reed *et al*, 2016).

The use of farmers’ ‘networks of practice’ is finding interesting results; as farming is evolving there is a wider network of people involved in management of the farm with varying interests: including these viewpoints in the discussions can enhance the learning and achieve long term benefits (Wood *et al*, 2014, Eastwood *et al*, 2012,

Oreszczyn *et al*, 2010, Dolinska and d'Aquino, 2016). There are also 'webs of influence' (Oreszczyn *et al*, 2010) which can govern how learning occurs and whether knowledge is transitioned into behavioural change.

1.9 Research into knowledge provision for agri – environmental management

Within Europe, Agri-Environment schemes are the main mechanism through which biodiversity and resource protection benefits are delivered across agricultural land (Mills 2012). Agri Environment schemes have evolved to be voluntary in nature, providing financial incentives for farmers to adopt certain practices that have been demonstrated to provide benefit to biodiversity, habitat creation or resource protection. The payments are structured to deliver the cost of 'income foregone' on the land that is now dedicated to environmental protection. This can lead to a segregation of landscapes and a division of objectives rather than an integration of environmental objectives within the overall farm management strategy. They programmes have also been developed and managed using a top down approach (Smithers and Furman, 2003). Indeed, Sutherland *et al* (2013) reveals that the low value that farmers can place on academic knowledge as well as a lack of trust can present an engagement problem as often knowledge is based on science rather than what works on-farm. As such, the mechanisms through which farmers are engaged in achieving improved environmental performance on-farm is incredibly relevant (Reimer *et al,* 2012).

Farmers can be seen as contributing to both issues and solution to environmental problems (Riley, 2008). Farmers have been viewed as lacking the knowledge in how to manage their land in a manner which is environmentally appropriate. As such agri – environment schemes provide this appropriate knowledge by incentivising the take

up of key management practices on-farm which have been designed by environmentalists, scientists and ecologists (Rollett *et al,* 2008).

However, there is a core question for social scientists that remains, namely *"what motivates farmers to act as long term stewards of their own farm?*" (Reimer et al, 2011).

Not surprisingly, given the value of public expenditure into them, numerous research papers have looked at the uptake of agri-environmental schemes and measures (Price and Leviston, 2014, van Herzele *et al*, 2013, Ingram *et al*, 2013) and the sociological and psychological reasons why farmers do or do not engage with them (Smithers and Furman 2003). One of the concepts defined here has been termed the '*cultural capital'* in farming practice and has been thoroughly researched by Burton. When looking at the adoption of environmental farm management, although financial incentives allow certain practices to be supported, often planning requires a long term commitment from farmers which isn't supported financially. This long term approach has little benefit to the farmer but multiple societal benefits (Atari *et al,* 2009). The approach in delivering agri-environment schemes in its simplest form implies a top down approach, where practices and policies are developed by experts in response to defined environmental issues. Programme managers and advisory services then seek to affect change in farmers' attitudes and behaviours that lead to the adoption of specific management practices and innovations (Smithers and Furman, 2003).

Burton's work (Burton 2004, Burton *et al*, 2008, Burton and Paragahawewa, 2011) argues that farmers are unlikely to develop positive attitudes towards the environment solely through adoption of agri – environment schemes. The work suggests that the reason for this disengaged is the removal of farmer skill and

ownership, which is valued for engagement. He argues that behavioural change would be more easily achieved if there was increased flexibility within environmental schemes, by focussing on environmental outcomes rather than dictating set management options that farmers have to comply with (Burton and Paragahawewa, 2011). This is a view that is further developed by Burton and Schwarz (2013), Schroeder *et al* (2013) and Sutherland *et al* (2013), which suggest that if schemes were 'results focussed' rather than 'practice driven' there would be enhanced co-production of knowledge between farmers and conservationists, and advice would be targeted at achieving required outcomes rather than simply management changes.

Co-production of science, policy and action has been described by Lemos and Morehouse (2005) as requiring three elements: interdisciplinarity, stakeholder participation and production of knowledge that is demonstrably usable. This view is shared by Dilling and Lemos (2011) which suggest that in order for new information to be useful on-farm, it is important to understand what is theoretically useful and what works in practice. Farmer perception of the outcomes has also been shown to be important in achieving uptake of the practice on-farm (Mills *et al,* 2013). Often, a challenge in linking science and practice exists, as there can be quite a distance between new science and the intended recipients of the results (Vogel and O'Brien, 2006). An ongoing challenge for programme managers is that as these programme have historically included this top down approach that can hinder adoption, any new approach will need to engage farmers, gain their trust and demonstrate that the advocated practices require farmer knowledge and skills and produce environmental outcomes that are relevant. When environmental benefits are spoken about

practically (i.e. by talking about the benefits of a certain practice) with farmers there can be significant potential for knowledge exchange to occur (Riley, 2008).

Smithers and Furman (2003) identify a strong desire for farmer involvement to allow the proposed environmental plan for an individual farm to be developed in partnership and made relevant to the individual farm in question, i.e. "*the principle investigator and final authority is the farmer*." Indeed, Atari *et al* (2009) concurs, finding that a lack of monitoring mechanisms in current environmental farm programmes compromises the credibility of environmental stewardship as the expected change in environmental outcomes is not documented. Monitoring of these environmental outcomes can be difficult and costly. There is little literature that has explored this concept of co-creation of solutions specifically with regards to farm resource management.

1.10 The 'good-farmer' concept

Having social standing is an important issue, as most farmers place value on the opinions of their farming neighbours (Hatch, 1992). Farmers as a sector place high value on social standing; one often cited reason for this is because they conduct 'over-the-hedge' farming to advertise their 'good farmer' credentials to their peers (Moran *et al*, 2013, Burton, 2004). The concept of 'good farming' gives farmers social standing; this is achieved by presenting their farm as complying with values and standards which are embedded in the culture of farming (Sutherland *et al*, 2012). This concept has often not included the efficient management of on-farm resources as a key principle. There is also great potential to harness good farming credentials and use them to aid social learning (Moran *et al*, 2013). Mills *et al* (2013) conducted a synthesis on a variety of research, regarding uptake of environmental schemes and the reasons behind the adoption of environmental management

practices. One of the key factors affecting farmers' willingness to manage their farm environment was found to be a cultural change where what was deemed as good included environmental management. When this change was analysed, it seemed to have originated from a greater level of farmer knowledge, and an increased sense of responsibility and accountability for the environment.

There is also potential to examine this 'good farming' concept, not just from other farmers, but also from a different audience, the general public. Currently the good farmer concept has been researched predominantly within the agricultural sector; there is little research to suggest whether the good farmer concept extends to the general public. Recent research has evaluated the concept as a motivator for protecting riparian environments (Thomas *et al*, 2019); the control of exotic livestock disease (Naylor *et al*, 2016) allowing new entrants into crofting in Scotland (Sutherland and Calo, 2020). As such, understanding whether being perceived as a good farmer is a motivator for undertaking conservation activities is an area which needs further research (Reimer *et al*, 2012). By understanding farmer motivations, it should be possible to target communications, monitoring and engagement activities in a manner which achieves environmental outcomes and is accepted by farmers.

What is clear is that there are a range of reasons why farmers engage in environmental activities. When considering how environmental outcomes can be achieved, it is therefore important to understand what is currently driving farmers to participate. Mills *et al* (2013) suggested that if the farmer is participating in programmes due to financial incentives they may not be sustained as much as if they are participating due to personal beliefs.

1.11 Designing effective knowledge exchange for resource management and adaptation to climate change

Thus far, agri-environment schemes have been predominantly focussed on environmental protection. Resource management has often been part of compliance schemes rather than incentive based options. In order to design programmes which engage farmers in resource management and climate change mitigation, it is important to evaluate the current reasons why farmers protect resources.

Farmers are the group "*on which the tasks of climate change adaptation and mitigation in agriculture will mainly fall*" (Berry *et al*, 2006). As such, they are a key attribute in the ability to achieve on-farm change (Feola *et al*, 2015). However, as previously mentioned the drivers and barriers to improved management of on-farm resources is relatively limited (Kirchhoff *et al*, 2013).

There has been a growing interest in the promotion of practices that reduce pollution from agriculture (European Commission, 2010). This has led to the development of various policies to help farmers understand the issues and to reduce inputs (European Commission 2013). Pollution policies are typically focussed on minimising water, air and diffuse pollution and are managed by a combination of legislation and advice. It cannot be underestimated though that climate and environmental issues can be difficult to address. They are complex because "*at the root of their causal chain are interactions between biological, physical and social systems*" (Lemos and Morehouse, 2005).

In order to achieve enhanced farmer understanding of the importance of mitigation and adaptation to climate change, there needs to be the development of infomraotn and support. Producers seem more open to new practices and ideas when they can

learn through observation, trials and a co-creation of solutions (OECD, 2012). Development of new knowledge takes time; research has shown that whether a farmer will take up proposed actions will depend on perceived risks and cost, so information should be targeted to address these concerns (Tarnoczi and Berkes, 2010). Through integration of research (to highlight risk), farmer knowledge (to highlight delivery mechanism) and funding (to provide cost), progress may be made in delivering the required outcomes (Chornesky, 2015).

1.12 Farmers and Climate Change

In order to engage farmers with the issues surrounding climate change and resource protection they need to be engaged in the topic and the messages need to be relevant to their farming system, location and current mangeement priorities.

However what compounds the issue when communicating climate change with farmers is the uncertainty of adaptation and mitigation and the potential conflict that can exist between competing farm and environmental objectives (Blackstock *et al*, 2007). This uncertainly has been reported by Helm (2008) which compounds the difficulty in providing consistent messages to farmers. These uncertainties are likely to persist due to the erratic nature of the climate and the unknown impact of these changes on ecology (Lawler *et al*, 2010) and in the ability to identify links between ecosystem processes and benefits (Daily and Matson, 2008).

There is a need to ensure that farmers are ready for the challenges that lie ahead. This will involve farmers gaining new knowledge and understanding and working collectively with multiple actors to create solutions that have worth and deliver impact.

Relevant, applied and usable scientific information will be important, as well as creating the links from the science to the identification of practical steps that can be taken at farm level (Chornesky, 2015). It is important to remember that farming systems are diverse and this will need to be refected in policy changes (Wall and Smit, 2005). These policy changes need to also include an understanding of the drivers behind farmer adoption, and this can then help to improve the uptake rates of any proposed changes (OECD, 2012).

It is important to appreciate however that mitigation of greenhouse gas emissions and achieving carbon goals is not starting from a constant baseline. Indeed land is already managed to produce food, preserve ecosystems, safeguard biodiversity and provide amenity value. Current management of land in its various guises will be impacting on carbon performance and climate impact. As such it is important that proposed management options must take into account prior (and current) management (Dilling and Failey, 2013).

The Greenhouse Gas Action Plan (GHGAP) was the principle mechanism developed within the UK to delivering agriculture's carbon reduction commitments. The GHGAP was developed in response to the Climate Change Act in 2008, where agriculture, unlike other industries was given a voluntary emissions target of 3 million tonnes of CO2e by 2022. Since June 2019 this was superceded by the new Net Zero legislation. The GHGAP worked across the agricultural industry to help all sectors mitigate and adapt to climate change without adversely impacting domestic food production. Outputs of the GHGAP included roadmaps for different sectors highlighting the practices and scope for the sectors to reduce emissions and improve business resilience. Despite the aspirations of the GHGAP, it failed to demonstrate significant emissions reductions within the sector, a fact which has been noted by the

Committee on Climate Change (Committee on Climate Change, 2018). It is therefore apparent that within the new Net Zero targets for the UK, agriculture will have to play its part in both emissions reductions and carbon sequestration.

Globally the term climate smart agriculture has been used to group practices and techniques that farmers can use to mitigate emissions and improve business resilience. The term was first developed by the United Nations Food and Agricultural Organisation (UN FAO) and brings together the 'challenges of food security and climate change.' It is often used as the term to describe projects and initiatives that are tackling climate change and food security with farmers globally (FAO, 2017).

Agriculture is a significant sector when focussing on greenhouse gas mitigation as it is a source of emissions, but also can provide a climate solution through increasing carbon sequestration. Measures that are advocated to reduce emissions include management of soils, fertilisers and nutrients, improved management of ruminants, energy efficiency and a reduction in waste production. Many of these changes can result in improved efficiency and a reduction in cost as well as the required reduction in greenhouse gas emissions. However, despite all the positive benefits that can arise from farmers adapting management, farmers are providing surprisingly reluctant to implement them, (Wreford *et al*, 2010). This reinforces the importance of understanding the difference between the technical potential of recommended options and whether farmers actually implement them in the required manner (Moran *et al*, 2013).

Past experience has been found to influence farmer perceptions to climate-related risks (Arbuckle *et al*, 2014, Morton *et al*, 2015). As such, it may be important to take account of past experiences when interacting with farmers. For example, Morton *et al* (2015) found that personal experience with excess water and saturated soils was

significantly related to the farmer's utilisation of drainage and tillage management, the planting of cover crops and managing land based on erosion risk. However, as farmers, the weather and climate play a big part in day to day management decisions (Wilke and Morton, 2016). As such, one strategy to engage farmers in the debate is to aggregate weather and climate data and suggest management strategies to cope with changing conditions (Artikov *et al*, 2006). This strategy was also recommended by Haigh *et al* (2015) highlighting the potential for climate information to provide the base information for a more informed discussion.

Achieving a farm level transition to environmentally sustainable practices involves understanding the potential for improved technical as well as environmental efficiency. This is compounded by increasing concerns both socially and politically for agriculture's environmental impact. This concern means that it is important to provide robust data on the current carbon position and future projections. When discussing changing management it is important to communicate the benefits, there are many opportunities where improving technical efficiency will also improve environmental outcomes. As an example, if chemicals are used more effectively on-farm through uptake of technology and precision application, then the environmental performance is also improved (Guesmi and Serra, 2015).

Within agriculture, greenhouse gas mitigation is primarily concerned with reduction emissions of methane, nitrous oxide and carbon dioxide. Due to the complexity of multiple gases along with the biological nature of farming systems there can be conflicts to resolve. There can be trade – offs between practices which effectively reduce one gas, but increase another, or practices that may be good for reducing emissions but less good for environmental outcomes on-farm. There is also the need to balance emissions reductions with the production of food. Measuring greenhouse

gases from agriculture can be expensive, time consuming and error prone (Rosenstock *et al*, 2013), which is compounded by the heterogeneity of farming systems, landscapes and the diversity of methodologies used. Before being able to implement a range of management practices, it is important to be able to provide information on the practices that can be considered 'win-wins'. That is those which are beneficial for emission reduction and also contribute towards other environmental outcomes (Dawson and Smith, 2010). It is also important to be able to provide information that documents the potential impacts that are relevant to a farmer's location and business characteristics. This starts to transition advice from top down to co-creation where results and information are relevant, robust and can be acted on.

This use of the 'win-win' strategy to progress action against climate change is contested in the literature. Schwartz (1992) and Moran *et al* (2013) suggested that by using messages that appeal to a farmer's extrinsic values (for example financial gain) this could result in a displacement of intrinsic values (for example a sense of community, and altruism) in society. When focusing on climate change and mitigation opportunities, there is a need to look at collective action for public good, and as such it has been suggested that using a 'win-win' approach will not work. Evidence from Evans *et al* (2013) suggests that environmental messages are the most effective at impacting environmental behaviour change rather than focussing on 'win-wins' or economic benefits. One opportunity to move the agenda forward, when focussing on policy mechanisms, may be the development of a results based system where farmers are given the flexibility to choose practices and techniques which work for them and deliver emissions reductions. This may promote innovation and could be supported by carbon labelling or a certification scheme that would

encourage peer to peer learning (Moran *et al*, 2013). This may help contribute to a new and emerging vision of a 'good farmer' that incorporates carbon management and environmental protection.

1.13 The Soil Carbon narrative and its link to farmer interest

As stated by Campbell (2008), "*The time is ripe for refocusing on soil stewardship as a key to improving water productivity, energy productivity and food security while reducing net greenhouse gas emissions from agriculture*." There is a political desire to explore soil carbon at the European level as a 2010 communication from the European commission indicates:

"*Although GHG emissions from agriculture in the EU have decreased by 20% since 1990, further efforts are possible and will be required to meet the ambitious EU energy and climate agenda. It is important to further unlock the agricultural sector's potential to mitigate, adapt and make a positive contribution through GHG emission reduction, production of efficiency measures including improvements in energy efficiency, biomass and renewable energy production, carbon sequestration and protection of carbon in soils, based on innovation*" (European Commission 2010).

It is important that the potential for soil carbon is embedded as a key narrative within emerging policy and knowledge exchange activity. The potential will depend however on how management of carbon can be integrated into current environmental drivers and interests of both the private and public sectors (Dilling and Failey, 2013). There are many barriers to carbon management on-farm including competing objectives and limited resources, economics, carbon incentive programme payments, restrictions and record keeping requirements of carbon offset schemes, a lack of information and a lack of policy signals, although there is

currently discussions about the inclusion of carbon within new Environmental Land Management Scheme which will replace Agri Environment schemes in Britain. There are some key areas that will require further development to achiev a coherent policy that includes soil carbon, which include measurement, its scope as a climate solution, and the ability to use voluntary compliance and economic measures (Paustian *et al*, 2016). Research carried out in Australia documented some important co-benefits from improving soil carbon content, which included improved soil quality and reduced erosion, both of which help farmers to build resilience and be able to cope with changing weather patterns. Drawbacks identified included political uncertainty which can lead to inconsistencies in policy and the level of uncertainty around the impact of carbon farming practices on agronomic performance and farm profit (Dumbrell *et al*, 2016). This is an emerging area of research and activity on-farm as such it is likely that there will be more research in this space over the next 5-10 years. There is also a policy issue concerning identifying the synergies and trade-offs that exist with current EU soil management strategies and whether the proposed management has benefits for other foci, including energy security and water resources (Henriksen *et al*, 2011). There is potential for carbon sequestration through adopting practices on-farm that will sequester large amounts of carbon in soils and above ground biomass (including trees and hedges) (Dilling and Failey, 2013). The extent of different management practices to improve soil carbon sequestration is still being researched, but can include a reduction in tillage, the use of cover crops, a change in grazing management strategy and the application of manures and other organic materials. However, there need to be enhanced understanding of how on-farm decisions are made about managing carbon and the best way to frame research outcomes so they

can be used by decision makers. Indeed, Dumbrell *et al* (2016) concludes that policy makers and extension workers need to be able to "*communicate the potential co-benefits (rather than opportunities to earn carbon credits) to increase farmer engagement in carbon sequestration activities*."

The improvement of soil carbon levels can be implemented globally and will have different impacts depending on current soil conditions. An example where benefits may be large is in Sub – Saharan Africa where the loss of carbon and nutrients from soil has been cited as the main cause of reduced crop productivity (Lal, 2004). The ability to improve soil health and the increasing production gained from these soils has been cited as a key motivation for African smallholder communities (Kahiluoto *et al*, 2014). However, what is missing at the moment is the quantification of carbon sequestration at field level. This can be rectified by funding projects that develop research on-farm to collect targeted information that could help to bridge this knowledge gap, provide meaningful results that can foster funding mechanisms and give farmers the confidence to embrace carbon sequestration and achieve the benefits. By working on-farm this will also contribute results that are locally targetd and credible; these are both aspects of knowledge exchange which were cited as important by Ingram *et al* (2016). Developing the research on-farm could also provide the link from scientific research into meaningful behavioural change and enhanced farmer engagement.

The 4 per mille initiative is an initiative aimed at increasing global soil organic matter stocks by 4 per 1000 per year as a mechanism to address climate change. It was launched at COP21 (Minasny *et al*, 2017). While not providing the complete solution that soil carbon sequestration is often referred to, soil carbon sequestration may allows time for new technologies and innovations to be developed. As mentioned

above, there are advantages for farmers in improving soil carbon levels as through improving soil carbon, agronomic performance can also be enhanced. There is a need to develop cohesive approaches to understanding the potential for soil carbon sequestration and how this may be translated into policy and on-farm action (Rosenstock *et al*, 2013).

1.14 The role of retailers and consumers

The focus of this review has been concentrated on the ability of policy and financial incentives to support farmer's transition to sustainable agricultural practices. However there is also significant scope to assess the role of retailers, supply chains and consumers to influence sustainability and farmer management practice. Consumers are often more aware of the environmental issues that can be attributed to agriculture, especially around GHG emissions, water and air pollution, due to increasing media and policy attention. There are emerging markets for farmers to access who are able to differentiate their production system, or 'prove' their environmental credentials, however the efficacy of these as a driver for practice change is not yet well documented. Examples of new accreditation systems include Regenerative, Pasture Fed, Carbon neutral, Climate conscious and Regenerative organic. All these marketing options are developing on the term sustainable. Whilst there is not a wide amount of literature for these emerging systems, there has been research into consumer attitudes and reasons for purchasing organic products, and some synergies may be drawn. Organic production has enjoyed a reputation that is linked to environmental credentials, and consumers often buy organic products due to the perceived environmental benefits of the production method (Oroian *et al*, 2017, Petrescu and Petrescu – Mag, 2015, Vitterso and Tangeland, 2014). If these new systems of production are going to provide economic benefits or new marketing

opportunities for farmers, then a clear narrative as to the environmental benefits of the production system will be required (Newton *et al*, 2020). The increasing media focus on the environmental impacts of agriculture are leading to consumers questioning food choices and the sustainability of some of our livestock based products. This has been reported as a change in consumer behaviour with a rise in 'flexitarianism' and plant based diets, however the reality is somewhat more nuanced and needs more research (Duckett *et al*, 2020).

Indeed a review by Joshi and Rahman which synthesised the results of 10 years of green purchase behaviour data found that one of the main determiners of green purchasing was the consumer's environmental concerns (Joshi and Rahman, 2015).

Retailers have an opportunity to influence farmer behaviour as they can exert pressure for certain management practices within their supply chains. This has been evident within dairy supply chains where milk processors are able to ask their suppliers to conform with new practices or environmental reporting as part of their contract. This is an easier process for supply chains which are well established and maintained (for example milk and some horticultural products), however for other farming systems like beef and lamb, where produce may reach retailers through a less direct route (i.e. through a market, abattoir or processor) it may be a more tenuous process to directly influence management practice on-farm.

1.15 The research focus

There has been a large volume of research that has focussed on farmer learning and knowledge acquisition; the knowledge to action process and how government incentive and compliance schemes have achieved engagement with environmental programmes designed to protect habitats, safeguard resources and improve

biodiversity on-farm. Farmers are a key partner in delivering environmental outcomes as they manage the land and can do so in a way which is environmentally restorative and regenerative, or in a way which can cause environmental harm. As farmers navigate new challenges brought on by climate change, new agricultural policies and an increasing consumer focus on the environmental impact of agriculture it is important to understand how to support farmers through these challenges and how knowledge exchange can be used to co-create sustainable farming systems that are fit for the future. Although the research cited here has provided valuable insights into the reasons why management change is required, and highlights good practice from work engaging with farmers on agri environment schemes, this research will focus specifically on how to engage farmers with the subject of climate change and how to develop knowledge exchange systems that will support farmers through the transition. Previous work has identified the value of co-creation of knowledge where technical information is combined with experiential learning; farmers and researchers work together to discover what is possible and what may work at a specific location for the farm in question. This has been used to address specific technical issues rather than evaluating whole farm sustainability. Whereas specific knowledge exchange mechanisms may have been looked at in isolation (for example discussion groups, one to one advice, training events), or targeted one particular group's experiences (for example farmers or advisors), it is important to consider how knowledge exchange can be used to help the agricultural industry transition to more sustainable practices which deliver environmental outcomes.

With the size of the challenge that agriculture is facing, and the potential for knowledge exchange to help facilitate the transition, this research is focussed on the

key question, what is the role of knowledge exchange as a mechanism to support farmers to deliver actions that mitigate the impacts of climate change? This question is multifaceted and requires an understanding of the potential role and scope of knowledge exchange from different stakeholders. This research will focus on views and opinions of farmers, researchers, farm advisors, knowledge exchange facilitators, and policy makers.

The research aim:

The aim of this research is to evaluate the opportunities for knowledge exchange to support farmers in adopting more sustainable farming practices.

Research objectives:

1. To understand how farmers lean new ideas and technical information specifically around sustainable farming practices.
2. To identify current barriers and drivers for farmers to change management practices
3. To analyse a current knowledge exchange method (on-farm demonstration) to evaluate its effectiveness at communicating key messages and changing farmer behaviour
4. To understand the current knowledge level of farm advisors concerning greenhouse gas mitigation options for farmers, and their potential role in supporting farmers with their transition.

Chapter 2: Methodology

2.1 The research approach

In order to fulfil the research aim of evaluating opportunities for knowledge exchange to support farmers in the transition to sustainable farming practices, it was necessary to design a method that allowed for an understanding of the current views of farmers, advisors and other industry representatives. This research project was therefore designed using a mixed method approach. Key informant interviews and the use of thematic analysis provided qualitative data to answer research objectives 1 and 2. This provided an opportunity to gain insights into farmer motivations for changing behaviour as well as gathering an understanding of experiences from a range of actors involved in sustainable agriculture. A quantitative approach from closed questions within the farm advisor survey and the farmer survey at the training events provided a method of identifying emerging patterns and trends which was instrumental in being able to answer research objectives 3 and 4. Some of the questions asked in the farmer advisor survey and at the farmer event were designed in open format, as such, a qualitative approach also contributed to the delivery of research objectives 3 and 4.

2.1.1 Key informant interviews

Key informant interviews were conducted with a range of participants including farmers, advisors, policy makers, funders, research organisations and government employees. These interviews examined the views and opinions of the different stakeholder groups and questioned participants on climate change, sustainability and the best way to inspire action and enable management change at farm level. The choice of a qualitative methodology was important to understand participants

views on which key messages were used when communicating about climate change and sustainability with farmers, and the best methods of delivery to ensure engagement. Open ended questions were used in order to allow participants the opportunity to express their views and opinions on projects, practices and policies for advancing sustainable agriculture. These questions can be found in section 2.3.1.

2.1.2: Farmer Surveys during training events

Farmers and their experiences, views and opinions on sustainability and resource protection also form a key component of this research. Farmers completed questionnaires examining key motivations for attending training events, as well as views on sustainability and resource protection during three events focussing on soil management in summer 2017.

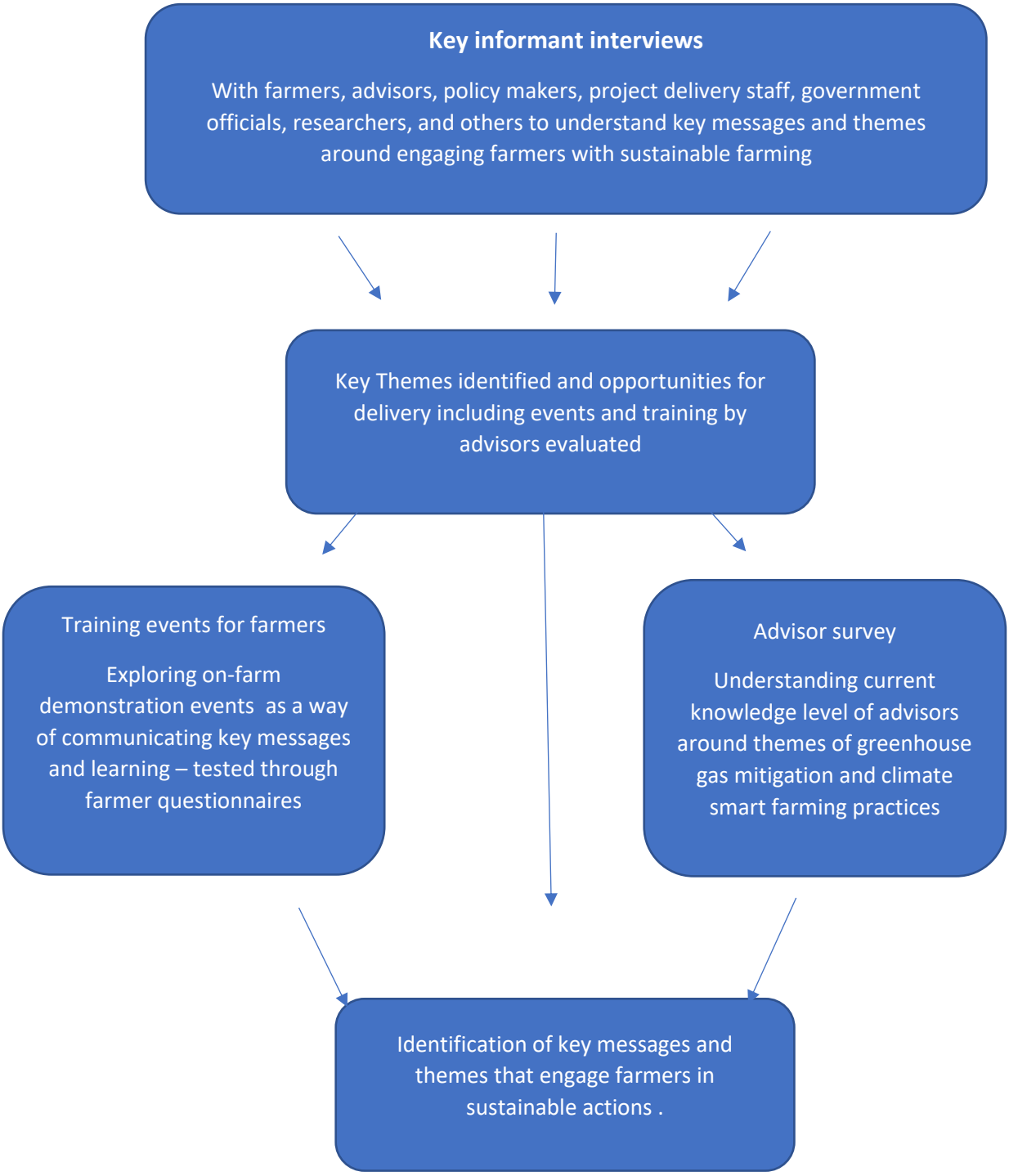
2.1.3: Farm Advisor knowledge through an online survey

Advisors were identified during the review of literature and initial interviews as a key group in terms of knowledge exchange to farmers. Often, farm advisors are involved in delivering training to farmers (both groups and one to one), and as such are able to recall experiences of farmer views, levels of engagement and understanding of the key issues. As well as gathering the experiences of those who have delivered at events, the main reason for inclusion of the farm advisors within the methodology was to look at the potential to use advisors to deliver information to farmers about resource management and greenhouse gas emissions. Farm advisors completed an online survey which evaluated their current skill and knowledge level around the topic of sustainable farming and gave them the opportunity to identify barriers or opportunities for their farm clients to undertake climate smart farming practices.

2.1.4 Ethical approval

Ethical approval for the key informant interviews, farmer questionnaires and advisor surveys was sought and granted in 2016. The ethics application documented how consent would be sought from participants, and how their data would be used for the purposes of the research. It also allowed the participants to withdraw at any time from the study.

2.2: Representative schematic of research design



2.3 Strategy and research design

2.3.1 Key informant interviews

Key informant interviews were completed with a range of participants between August 2016 and March 2017. A variety of techniques were used to recruit stakeholders. The researcher was involved in completing a Nuffield Farming scholarship between 2016 and 2018, focussed on communicating carbon reduction schemes to farmers . A requirement of the scholarship is global travel to investigate agricultural practices and policies around the world. Key trips to Australia, USA, Ireland, and Scotland were used to recruit and interview relevant individuals and organisations that were working within agriculture. In additional to the global participants, researchers, advisors and farmers from England were also recruited for interview. A key requirement for selection was that the individual was involved in sustainable agriculture, and participants were classified as to their role within sustainable agriculture during analysis. Prior to the interview, the aims of the research were explained and consent was obtained. 60% of the respondents were recruited by the researcher and 40% were recommended during interviews as pivotal people to include and were then recruited and included in the research.

Interviews took place during global travel and interactions with a range of stakeholders which included:

- Project managers working on sustainability or environmental projects aimed at helping farmers;
- Project staff involved in running training events or advising farmers on management practices that will improve sustainability;
- Farm advisors;

- Researchers working on sustainability, greenhouse gas emissions reduction or knowledge transfer to farmers;
- Farmers engaged in projects or working to improve sustainability on-farm
- Policy makers working to embed sustainability and carbon reduction into agricultural policy.

Prior to undertaking global travel, key points for discussion were developed to ensure that there was clarity and consistency for all interviews and that the responses would address the research objectives. Key areas to be discussed during interviews were developed and refined. These included:

1. Key messages and topics when communicating with farmers about climate change.

This allows a focus on how to discuss technical information about sustainable farming practices, and the best way to communicate it to enhance farmer learning.

2. The best methods to engage farmers on climate change

This was focussed on the method of farmer engagement, including one to one advice, the time period of support, the use of on-farm demonstration and other training events, developing farmer networks.

3. Key lessons learned about engaging farmers in sustainable farm management

This area of questioning enabled an understanding of successful initiatives and projects, and an understanding of what were the key attributes that made them successful and achieved farmer engagement.

4. The way to achieve mass behavioural change and a more sustainable agricultural sector

Based on responses to earlier questions, this question was focussed on how to scale up successful activities that participants may have been involved with and also an understanding of any key research, policy or funding requirements to achieve change.

5. Any future opportunities to get more farmer engagement.

This built on participants past experience and learning to highlight any future development that could be integrated into future projects or schemes.

During the period August 2016 to March 2017, a total of 45 interviews were completed. 41 of these were conducted face to face, and 4 took place via Skype. During interview, detailed notes were taken which were written up post interview. The majority of participants responded to an email invitation for a meeting to participate in the research, however a few participants were recruited to the project as a recommendation from a participating individual and in these situations initial contact was made by telephone. On these occasions the purpose of the interview and the research aims were explained and the rights of the participants to withdraw. For those recruited by email, this information was sent by email with the confirmation of the interview timing. Interviews were completed with participants in a range of locations including work places, homes and social spaces. Participants confidentiality was maintained by anonymising any identifiable responses.

Interviews took place in 5 countries; Australia, America, England, Scotland and Ireland and were completed by farmers, advisors, government officials,

representatives of the agricultural industry, policy makers and researchers. Table 2.1 shows the final number of interviews by country and respondent type.

Country	England	Ireland	Scotland	Australia	America	Total
Advisor	2	-	1	3	5	11
Farmer	-	-	2	3	2	7
Government	-	-	-	1	3	4
Industry	1	1	-	4	3	9
Policy maker	2	-	-	1	-	3
Researcher	2	1	3	3	2	11
Total	7	2	6	15	16	45

Table 2.1: The breakdown of the participants in the key informant interviews broken down by sector and country

Key informant interviews: Participant selection

In order to achieve the research objectives, it was necessary to select participants that had the required level of experience in working with farmers, running projects focussed on sustainable practices or climate change mitigation or being involved in sustainable agriculture. As such this provided a recruitment bias so that their experiences could be obtained and documented. Certain projects and personnel that were focussed on working with farmers on greenhouse gas mitigation were selected for interview as well as key policy makers and funders that represented a range of support mechanisms for farmers under existing schemes. As mentioned above, the initial interview list was expanded due to recommendations from interview candidates of additional people working in this area. It is acknowledged that this selection of participants for the key informant interviews may well have led to a biased response.

Following the development of the FAO dataset (explained in more detail in section 2.3.2 below), the information that was gathered during the key informant interviews was refocussed to match the questions that were asked during the online discussion. This process involved examination of the individual interview responses and sorting the responses to match the questions that were asked during the FAO forum. There were synergies between key interview topics and the questions that were posed during the Forum which allowed for the datasets to be combined. It is acknowledged that this may have led to some small inaccuracies in the data, however efforts were made to avoid this. Future research would be aligned from the outset to ensure questioning was consistent throughout.

2.3.2 Key informant interviews – online discussion forum

To complement these results and represent a global picture, data was also collected from an online learning event on climate smart agriculture facilitated by the Food and Agricultural Organisation (FAO). During the online event which took place over a two week period, facilitators from the FAO posed questions around the theme of delivery of climate smart agriculture. Three questions were asked during the online event that were the same questions that were asked during the key informant interviews that were collected face to face. These were:

1. Based on your experiences what would be the three key messages or topics when communicating about climate change with farmers?
2. What is the best way to engage farmers through rural advisory services on climate change?
3. What are the key lessons that you have learnt about engaging farmers in sustainable farm management through your experiences?

These questions were posed from the moderators of the online group from FAO headquarters in Rome and then participants fed comments and suggestions back through an online forum which was visible to all members of the forum.

At the close of the event, all of the responses to the questions were collated by the researcher. along with the respondent's location and classified according to their work (whether they were farmers, advisors, policy makers or researchers). This was collated by collecting the responses from forum participants to the questions, and aligning it with the respondent's location and work status (farmer, advisor, policy maker or researcher). This information was brought together on a spreadsheet to collect all of the online responses in one place. On collation of this data it was felt that it complemented the data that was collected during key informant interviews as it represented views and opinions from a wider geographical location than the key informant interviews, and may provide insights into the challenges and opportunities for farmer engagement from global experiences.

Permission was sought from the FAO to use the data within this research and responses were collated and included in analysis alongside the key informant interviews.

During the two week online discussion which took part from the 28th November until 23rd December 2016, 72 responses were collected. Table 2.2 below shows the location and respondent type of the FAO discussion forum.

	Africa	N America	S America	Asia	Europe	Global	Oceania	TOTAL
Advisor	12	1	-	6	2	4	-	25
Farmer	2	1	1	2	-	3	-	9
Government	3	-	-	-	-	-	1	4
Policy	2	-	-	2	1	1	-	6
Researcher	9	1	-	7	-	2	1	20
Industry	1	-	1	2	2	2	-	8
TOTAL	29	3	2	19	5	12	2	72

Table 2.2: A table showing the location and respondent type of the participants in the FAO online forum focussing on climate smart agriculture

2.3.3 Data analysis key informant interviews

The responses to the three common questions that were answered by all face to face interviews and through the online forum were analysed to look for similarities between responses. Answers were noted, collated and subdivided into common themes, which allowed for an understanding of key areas to investigate in more detail.

The data from the key informant interviews and the online discussions were analysed using thematic analysis. The thematic analysis was carried out using a realist approach, to provide reporting of experiences and language in a straightforward way rather than taking a constructivist approach.

Thematic analysis provides a methodology for working with qualitative data by sorting it and grouping the data around themes and has been adapted from Braun and Clarke (2006). The reflexive approach used by Braun and Clarke mean that this method can be used to answer a range of research questions. It has been used to analyse agricultural research most commonly around understanding farmers' opinions and attitudes towards new management practices (Rois – Diaz *et al* 2018) or belief systems (Stanley Clarke, 2019).

Questions within the key informant interviews were of an open format, and provided a wealth of information from which to develop the themes. Initial responses were categorised into respondent type; this included whether the respondent was a Farmer or Non -farmer.

Responses were then coded to identify initial patterns. This process was completed through studying all of the responses and identifying the frequency of which certain terms, phrases or ideas were being discussed These frequent terms became the initial themes were developed. The initial themes were then defined in broad terms, and evaluated for repetition or similarities to ensure that the themes were well defined. The coding process was then repeated to further refine the themes and revisit the responses to check for relevance to the research question.

The process then evaluated the link between theme definition and responder type. The initial coding included Farmer responder (FR) and non-farmer responder (NFR). However it was clear in the early stages that additional non-farmer categories were required to understand the difference in responses per sector. Further categories were then added (that can be seen in Table 2).

The data was then checked against the theme to ensure that it was coded correctly to the defined theme.

Once the themes were defined, and connections between themes were understood, the process was repeated for a third time to check for any errors or discrepancies. It is acknowledged that due to the researcher completing the whole process from interview, to analysis, there will be a degree of researcher bias, however the repetition of the process and the gradual refinement of the themes was an attempt to minimise this.

The final themes were then summarised with their narrative and supportive quotes.

2.3.4 Focussed research on farmer knowledge transfer events

During the initial collation of the data from the online learning event and the key informant interviews, it was evident that on-farm knowledge exchange was a key part of disseminating technical information on relevant management practices that contribute to sustainable agriculture. This was evidenced from responses to questions 2 and 3 that focused on the best way to engage farmers and the key lessons that had been learnt through engagement. Responses were grouped around the importance of on-farm events and the use of demonstration to showcase management practices. Respondents in the key informant interviews and the online forum were primarily non-farmers; as such to explore this in more detail and to gain the opinions and thoughts of farmers three events were chosen to evaluate farmer's learning experiences and hear their views on effective knowledge exchange and the role of on-farm demonstration as a tool to change practice.

The events that were selected were all based around soil management and were farm walks that were run by farmers who had been recognised as winners in the 2017 Soil Farmer of the Year Competition that was run by the Farm Carbon Cutting Toolkit (FCCT) and Innovation for Agriculture. The Farm Carbon Cutting Toolkit is a farmer-led UK based organisation that works with farmers to help reduce greenhouse gas emissions and improve resilience. These events were chosen as they were being run by the researcher in collaboration with the soil farmer winners.

The competition was developed in 2016 and aimed to showcase farmers who were passionate about soil and had changed their practices to improve soil health and performance.

Soil Farmer events have been historically well attended by farmers and as such these events were chosen to allow a large number of farmers to participate. It is recognised that the farmer views that were collected during these events will not represent all farmer's views.

The three farms walks were as follows:

- Farm Walk with runner – up Soil Farmer of the Year Goole, Yorkshire, 28th June 2017.
- Farm Walk with Soil Farmer of the Year, County Durham, 5th July 2017.
- Farm Walk with Soil Farmer of the Year, Wolverhampton, 6th July 2017.

The events all followed a similar format; the walks were introduced by the researcher with a brief explanation of the competition and the link between soil management and sustainable farm management. Then the walks were conducted by the winning farmers who explained their farming systems, focussing on cultivation techniques, cropping and input choices, managing soil biology, and the transition from their previous management to their current activities. Attending farmers were able to ask questions on a range of topics from detailed agronomic technical advice to sharing views on how to transition their management and practical implications of changing system. The events contained a small amount of technical information from the researcher on the impact of soil management on greenhouse gas emissions and how different management practices impact carbon sequestration.

2.3.5 Questionnaire design for farmer events

A questionnaire survey of participants was conducted at each event. The aim of the farmer feedback was to understand in more detail the motivations for coming to the

event and the expectations pre-event of what they were going to learn during the event.

The second aim was to understand in more detail what farmers value in a training event, and explore their experiences and opinions concerning climate change impacts on their farm. There was also the opportunity for farmers to identify what was stopping them taking action on their farm, and also detail topics that they wanted more information on, that would facilitate behavioural change.

The questionnaire was set up to be completed in two phases. A short introductory section was completed by all delegates at the event before it began. Farmers were given the questionnaire on registration at the farm. This collected some introductory details about their location, farm type and size. There were then questions asking where they had heard about the event and then two questions that asked them why they had attended the event and what they wanted to learn during the event (the questionnaire is included in the Appendix B).

The questionnaire was then revisited at the end of the event to ascertain whether their preliminary expectations had been fulfilled, and also to allow them to document what had been positive and negative about the event. There was also an opportunity for them to indicate whether attendance at the training event would influence their soil management and to explain any proposed changes.

The questionnaire then proceeded to ask a series of questions which explored the participating farmer's views on climate change, the impacts that they are seeing on-farm, and what the barriers are that are preventing action currently. Finally there was an opportunity for farmers to share any key areas of concern on their farm

focussed on resource use and sustainability that they would value more information on, and future training events.

A week after the event, each participant was emailed to enquire whether there was any additional feedback that they would like to give, and, where additional feedback was received, this was added to the form.

All farmer delegates that attended each event were invited to complete the questionnaire and completion rate at all events was 100%. The responses from the questionnaires were then collated and recorded post event. Any non-farmers who attended the events (for example advisors, agronomists) were not questioned.

The numbers of responses that were gathered at each event are detailed in table 2.3 below.

Farm Walk	28.06.17	5.07.17	06.07.17
Number of farmer respondents	6*	16	13

Table 2.3: The number of farmer attendees that responded to the surveys that were conducted at three on-farm events held in June 2017

*This walk only included 6 farmers, due to appalling weather conditions.

This gave a total of 35 responses from the three events which were then collated and analysed.

Farmers attending these events had varying knowledge and experience of sustainable soil management practices. Some were already implementing practices on-farm (such as direct drilling and cover cropping) and in some cases they were managing the farm ‘conventionally’ and were seeking out information as to how to change management.

2.3.6 Survey of Farm Advisors

A key theme that emerged from the key informant interviews was the important role of farm advisors, both in the knowledge transfer process but also in the change of management at the farm level, providing support and knowledge over a longer term than a training event. To explore this in more detail, a survey was developed to understand farm advisors views on current management options for their farm clients as well as their own skill and knowledge level on mitigating greenhouse gas emissions at the farm level.

The Greenhouse Gas Action plan is an industry-wide initiative working towards achieving the Greenhouse Gas emissions reduction targets that have been set for UK agriculture. The main outputs of the Action Plan are the production of environmental roadmaps for different sectors of agriculture and the bringing together of key partners in the industry to understand how to achieve the targets.

The Action plan has focussed on upskilling advisors in the latest research and knowledge surrounding resource protection, sustainability and greenhouse gas emissions and then allowing the advisors to disseminate that information to their farmer clients as there is an existing trusted relationship built up with the farmers. An important aim of the questions that were asked to the farm advisors was to understand how frequently discussions were being had on-farm around the topics of sustainability, resource protection and greenhouse gas emissions and what the opportunities were to achieve the required reductions with their clients. The Action plan also has a list of key management practices that have been shown to deliver emission reductions on-farm.

2.3.7 Farm Advisor Survey design

The survey was designed and piloted with the support of the key delivery organisation of the Greenhouse Gas Action Plan, the National Farmers Union. It was completed by advisors online using Survey Monkey (www.surveymonkey.com).

The survey was designed to understand the views of advisors on several key topics:

- their current knowledge level on GHG emissions from agriculture and the opportunities for reduction
- Current levels of uptake of the recommended 'best management practices' that are advocated by the GHG action plan at farm level by their clients.
- Where the knowledge gaps were in terms of applied research, tools or literature on these key action areas
- Whether the key action areas were the right ones that would achieve the targets and were applicable at farm level
- The integration of advice on resource management to farmers with business management advice
- The current knowledge level of their farmer clients on management practices to reduce greenhouse gas emissions from farms.
- The views of their farmer clients on greenhouse gas emissions reductions
- The potential for mass uptake of these recommendations by the farmers
- How these recommendations should be delivered (what is the most effective way)

After pilot testing with project staff at the NFU the survey was refined and was open for respondents from the 3rd February until the 3rd June 2017. The survey was designed with a combination of defined answers to select from and free text boxes where respondents were able to explain their views in more detail (see survey in Appendix B).

2.3.8 Survey Dissemination and promotion

The survey was disseminated to advisors by the members of the Greenhouse Gas Action Plan steering group which includes the NFU, the Agricultural and Horticultural Development Board (AHDB), ADAS, AEA, the British Poultry Council (BPC), the Country Landowners Association (CLA), the Farming Wildlife Advisory Group (FWAG), Linked Environment and Farming (LEAF), the National Institute of the Association of Botany Arable Group (NIAB TAG), the Organic Research Centre (ORC) and the Royal Agricultural Society for England (RASE), All members were sent the survey and the rationale for its development and asked to promote it to their contacts. The survey was also advertised on the NFU environmental electronic newsletter in February 2017. By the end of February 2017, the response rate was very low. The low response rate could have been due to a lack of interest in the subject, timing of the survey (February is often a busy time for farm advice for arable farms), and the use of existing networks rather than direct recruitment of participants. Due to the low number of responses, a wider promotion strategy was employed, including sending the survey out through the Farm Carbon Cutting Toolkit and the network of advisors associated with Duchy College, as well as promotion through social media. It is recognised that advisors that chose to respond to the survey may well have had strong feelings about the Greenhouse Gas Action plan and so may have created a bias from responses.

The survey was open to advisors working across all sectors. At the close of the survey online, on the 3rd June 2017, 25 completed responses had been collected.

2.3.9 Advisor Survey data analysis

Data from the survey was collated and analysed. The initial questions on location and type of advice and farm enterprise were described and then the management options and their feasibility both at the farm level and the mitigation potential were evaluated to understand advisors' views on the mitigation options available for farmers. Methods of knowledge transfer were analysed by collating responses for their effectiveness (in the opinion of the survey respondents) in changing management practice for a key set of practices that have been shown to reduce greenhouse gas emissions.

Chapter 3: Results

3.1 Key informant interviews.

The responses analysed in this section combine the data from the key informant interviews with the responses given by the participants in the FAO online forum. Table 3.1 shows the breakdown of the location and respondent type when these two datasets are combined.

	Africa	N America	S America	Asia	Europe	Global	Oceania	TOTAL
Advisor	12	6	-	6	5	4	3	36
Farmer	2	3	1	2	2	3	3	16
Government	3	3	-	-	-	-	2	8
Industry	2	3	-	2	3	1	3	14
Policy maker	9	1	-	7	2	2	2	23
Academic Research	1	3	1	2	8	2	3	20
Total	29	19	2	19	20	12	16	117

Table 3.1 Table showing the location and respondent type from participants completing key informant interviews and FAO online discussions.

Questions that were posed to both groups of respondents were focussed on the issues surrounding sustainable agriculture and identifying some of the opportunities and barriers to engaging farmers more deeply with adaptation and mitigation practices. It should be noted that many of the respondents highlighted the complexity of the subject, and the multifaceted nature of climate smart agriculture. A key need which was identified was the targeting of information to local conditions and the use of drivers that were relevant. The first question requested that participants focus on the three key messages or topics that they felt were important when communicating about climate change with farmers, fishers and foresters. Responses either focussed on different topics or key messages. The responses were summarised into key topic

groups depending on frequency of words within responses. The topics ranged from broad subject areas including climate change mitigation, adaptation, and managing climate risk to more focussed technical topics, for example managing natural resources including water, soil and cropping. The number of responses in each topic is listed in the table 3.2 below.

Topic	Number of responses
Weather variability and adapting the farming business to changing weather patterns	46
What is climate change?	23
Resource use efficiency	22
Climate change mitigation opportunities	17
Agroforestry and the role of trees	12
Water management	11
The economic benefits of farming sustainably	11
Soil management and soil carbon	9
Cropping management	9
Carbon accounting and tool use	8
Nutrient management	3
Diversification opportunities	3
Waste management	1
Livestock management	1
TOTAL	176

Table 3.2: Responses given from key informant interviews and during the online learning event in answer to the question on the three key topics that were important when communicating about climate change

In order to evaluate whether there was a difference in topic choice for those who were participating in the key informant interviews and those that were taking part in the online discussions, the results from table 3.2 were split into the two audience groups. The graph below shows the breakdown of responses for the first question that come from the Nuffield interviews and the FAO online event.

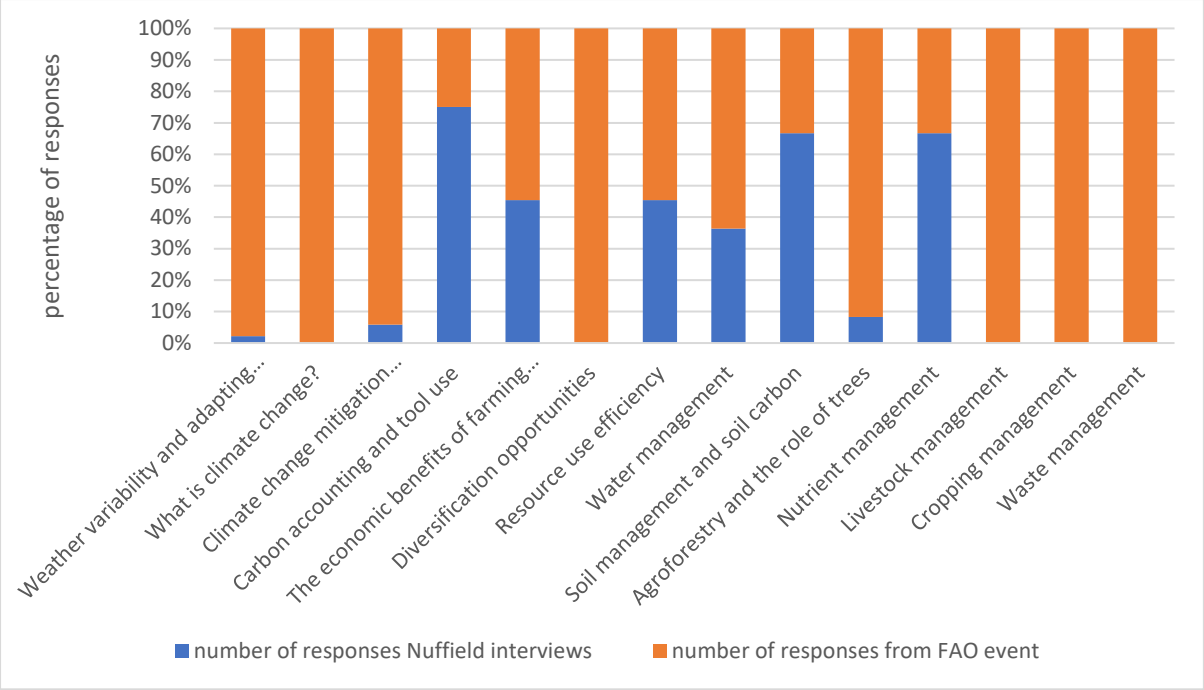


Figure 3.1: A graph showing the key topics that advisors thought were important when talking to farmers about climate change, broken down into the two different research groups, Nuffield interviews and the FAO event.

3.1.2 Interview responses

There was a clear distinction in the responses from those who were farming or working in areas that have seen more direct impacts from climate change in terms of changing weather patterns and therefore used this change in weather to frame the discussions about climate change and agriculture's impact and those who were working in areas more sheltered from extreme weather where discussions were more about increasing awareness and 'future proofing' the business. However, across all participants, there was a consensus of a pressing need to inform farmers about climate change, the impacts on agriculture and the steps that agriculture would need to take to lessen its impact on greenhouse gas emissions. One advisor from Asia commented "*Climate change really does mean change. Initially small, but increasingly large changes in weather patterns will lead to changes in the structure and function of every biological system on the planet requiring change in agricultural management practices, not just coping until things return to how they used to be*."

This illustrates the need to develop farming systems that are resilient to the changing weather patterns and are fit for the future. Developing and delivering these systems will involve everyone in the industry as well as consumers and the wider supply chains, a challenge which was noted by various interviewees. One participant commented "*This challenge involves everyone, not just farmers; however, in order to support farmers to transition then there needs to be robust data, enabling policies, emerging markets and a concerted effort by all to change*." Advice provision was therefore thought to be incredibly important in this transition to a more sustainable agriculture. A policy maker explained, "*Farmers need the skills, knowledge and understanding to get these systems to work*."

It was noted by various respondents that many farmers have preconceived ideas and views on climate change that may span from previous political campaigns or personal views on the validity of the science and this can cause challenges for inspiring farmers to change practices. One advisor commented "*There is a need to break through common perceptions on climate change to break it down into messages that motivate farmers to act*." This is where trusted advisors who have a long term relationship with farmers and who can frame the messages in ways which elicit action are key. One advisor, who works with farmers in America, explained how he talks to farmers about climate change, "*How do we approach it? Climate change is highly political, so we choose not to even go there and mention it. Water is huge in this area and gets the farmer's attention especially when you look at the cost of that water that could be going into their soil. By talking about organic matter and its impact on infiltration rates, we get the same results without having an argument about climate change."*

This concept of framing was identified as a key theme for successful knowledge exchange which is discussed in more detail below in section 3.2.2.

3.2 Results from Thematic analysis

When considering the challenges of the research aim, specifically around the opportunities to utilise knowledge exchange to support farmers, it was important to first evaluate current advice provision for farmers.

3.2.1 Advice provision for farmers for climate change mitigation

As knowledge exchange plays such a crucial role in supporting the transition of farmers to sustainable practices, it is important that the knowledge exchange is undertaken in a way which maximises impact, both for the farmers involved and also the project being completed. For projects there is a need to deliver long lasting impact, both in terms of the numbers of farmers trained but also whether, by taking part in the knowledge exchange event, the farmer will change practice or behaviour on-farm. The development of new technologies and methods of knowledge exchange including farmer networks, demonstration farms, farm clusters, online learning through webinars and social media mean that there has never been as much information available as there is now. However, in this age of ‘information overload’, the way in which information, research and technical information are shared is incredibly important.

Through the key informant interviews and by questioning participatory farmers at the farmer events, the value of the knowledge exchange was stated by the different responder groups. Many advisors identified the importance of advice provision specifically for this topic, although not all advisors surveyed within the advisor survey confirmed that they had the base technical knowledge to provide advice on climate change mitigation.

When focussing on knowledge exchange and advice provision for farmers specifically concerning climate change mitigation, it was acknowledged as a complex and multifaceted issue with a range of potential management options available that need to be locally targeted and specific. There is a level of interpretation required to take mitigation options from concept to on-farm implementation.

"*Climate change impacts are context specific; so are strategies, practices and techniques that we can use to help farmers adapt."*

Because of the lack of simple solutions, there was a consensus from advisors and project managers that advice was crucial. It was felt that advisors were "*a key attribute in delivering practice change.*"

Although the value of the advice provision was clear; the aspects of knowledge exchange which made it valuable needed more clarity. Results showed that the value of knowledge exchange differed depending on the class of respondent. Farmers valued events as an opportunity to share ideas and experiences, learn from their peers and see the suggested practices 'in action'. Researchers valued events as an opportunity to reduce the time between research being available, and it being used by farmers. Project managers and staff involved in running climate change mitigation options valued advice provision and knowledge exchange as a way to make the sometimes abstract concepts more real and grounded. Further exploration into aspects of knowledge exchange which were valuable provided some key themes.

3.2.2 Drivers for achieving behavioural change.

The key informant interviews aimed to identify current drivers that allow farmers to implement management change, specifically around climate change mitigation. Four

main drivers were observed, which were longevity of advice provision and support, the use of demonstration, the level of trust in advice provision and how the topic was framed.

Longevity of advice provision

Results from interviews with project managers and advisors highlighted the importance of being able to support farmer's transition over a sustained time period. One manager from Australia explained "*these changes don't take place overnight, and our support systems need to reflect that, completing a training course for three days isn't going to cut it, we need to move from one -off training to continuous coaching and improvements*." This need to maintain a relationship with farmers was echoed by project workers in America, and was seen to be especially valuable when looking at monitoring the impact of projects. "*Longer term mentoring and monitoring means that you can support the farmer to make changes and see the impact on the farm, which provides valuable data that you can use to inspire other farmers to change*."

The length of time of training was seen as important by interview respondents. An example of the importance of sustained engagement was cited from a trainer in Australia explained their methods; "*The courses take place over 7 days which locks them into practice change. However after the week course, they continue to be mentored for two years intensively and then for a further three years extensively. Farmers can't change everything in one go, it has to be staged and we have to support them along that process*."

This sentiment was echoed from participants in the FAO online discussion which included the need to sustain support after projects have finished, moving to a "*softer*

and longer term approach." Within the interview cohort, the importance of sustained farmer engagement was highlighted by project staff, advisors, and farmers. Farmers saw the benefits of the long term engagement as a mechanism to build trusted relationships with advisors.

The use of demonstration and narrative

Providing practical demonstrations of concepts and techniques being advocated for climate change mitigation was seen as an important characteristic of successful projects. This was evident when questioning the key informant interviews about the best mechanism to deliver advice and was endorsed widely by respondents as well as being seen as valuable during the on-farm events. The mechanism by which the advice is delivered had a great impact on whether farmers engaged. One farmer interviewed commented "*A key barrier to change is a lack of visible success. Show me it working and I'm much more likely to get it*."

This was echoed by numerous respondents who suggested a move was needed from telling to showing. When interviewees were asked about the best way to exchange on climate change with farmers then the most commonly cited engagement method was the use of on-farm demonstration activity. A farm manager from a research farm had seen the value of demonstration in increasing farmer engagement; "*Taking farmers out and showing them the different options in the field is much more effective than showing them a graph or telling them why it works.*"

Through the use of demonstration it is possible to achieve practice change. The process of demonstration and allowing farmers that have implemented changes to share their experiences was valued immensely by farmers involved in the research, both in the interview cohort, and farmers attending the on-farm events. The main

motivations to attend the events was to ‘see it work’ and to ‘see good farming.’ Post event when the farmers were asked again what the most valuable aspect of the training was, the ability to see the concepts working was highlighted, alongside the ability to talk to the practitioner and gain not just technical knowledge, but experiential knowledge on how to implement the required changes. This was confirmed by an interview participant who has experience of facilitating on-farm demonstration projects. “*Other farmers who have implemented practices and are doing it, are a much better advocate for soil health and resilient farming that any government agency. Farmers trust other farmers*.”

This was echoed by multiple interviewees, and highlighted the value of peer to peer learning to complement demonstration activity. Combining demonstration and a credible narrative was seen as a vital combination in facilitating behavioural change. Indeed demonstration and peer to peer learning were valued so much by advisors and farmers that especially when dealing with complex issues (like climate change mitigation) it could be seen as being critical to the success of programmes.

The importance of trust and relationships

One of the reasons why demonstration and peer to peer learning is successful in achieving behavioural change is that it requires trust. By being able to see the success of a practice, a farmer can trust that it can be done. However for on-farm advice building relationships between advisors and farmers is identified as a key part of achieving long lasting change.

The concept of trust and the value of trust within agricultural extension is intrinsically bound up in the social capital of the rural communities that it operates in. During interviews, various examples of the importance of trust were cited which built on the

idea of relationships. Being able to form relationships between advisor and farmer was seen as crucial. One advisor explained the value of trust, when advising farmers on steps to mitigate climate change. "*Developing trust and understanding with the farming community is the key first step."*

The issue of trust is also bound up in the speed at which farmers engage and change during projects. Models of delivery that include 'train the trainer' and using existing farm advisory personnel that have that existing relationship with the farmer rather than recruiting new staff that have to build that relationship was seen as valuable. "*Advisors who have existing relationships with farmers, understand the drivers and are able to utilise them to reframe the messages in a way which has lasting impact*."

The advisor survey responses provided consensus around the value of one to one advice on the subject of climate change mitigation and sustainable farming systems. This confirms the importance of trusted advisors as the farmer advisor relationship seems to be key to delivering action at farm level. However it is suggested that the advisor cohort may be biased towards preferring one to one advice as a knowledge exchange mechanism.

The use of framing as a method to encourage adoption of sustainable practices

In order to get farmers to change management and embed more sustainable practices that have environmental and social benefit then the practices and subject needs to be communicated in a way which has meaning and farmers can relate to. T

Results uncovered many views on the importance of framing the topic of climate change mitigation in a way which would enable understanding and relevance to day to day farming. This was identified as a key measure to ensure the success of

knowledge exchange programmes. Climate change is a multifaceted issue and needs to be made relevant and appealing to the farmer audience. This is achieved by communicating the topic in a way which makes sense to the farmers and is framed around current farmer values, beliefs and priorities. The concept can be seen in many of the answers received during the key informant interviews and is highlighted by the responses confirming the need to focus on the issues and benefits rather than the topic itself. Certain phrases were revisited frequently by interview participants. When responses were grouped into key messages for climate change mitigation, these included demonstrating the economic and practical benefits of changing practice; the link to wider management of resources on-farm especially soil health, and the improved resilience of the farm through changing management. When focussing on responses for key messages for climate change adaption (especially seen from respondents from areas where the impacts of climate change were already being felt).

Framing has been used to cover a range of sub themes, including translation into locally relevant practices; understanding prior farmer motivations and communicating the messages in a way which addresses these; the use of proxy or alternative descriptors for communicating climate change; and the translation of environmental benefit into economic impact. Whilst it is acknowledged that these topics cross into the method of communication and the importance of the person undertaking the communication (and whether they are trusted), how the subject is framed was cited as a key factor.

Some key responses which highlighted the importance of framing include the importance of framing on helping farmers adapt to climate change.

"*You have to work out what farmers are proud of and start the discussion there. Reframe the conversation and highlight how climate change will impact on the things they value, find some commonality*." (Climate activist working with farmers).

The importance of framing the issue to make it locally relevant and targeted, specifically talking about the use of carbon footprinting calculators;

"*As good as the data is, there is still an opportunity for disconnect, local knowledge is needed to make it relevant*." (Farm advisor key interview, America).

Building on the importance of framing the topic for the right local conditions, the use of language is also important as it was seen as a tool to either alienate or engage farmers.

"*You've got to talk the right language to get farmers involved, otherwise it's a waste of time*." (Farmer respondent, Australia).

This view was backed up by the frequent references to the importance of developing locally targeted solutions that were communicated in a way which highlighted the benefits.

A key reframing practice which was advocated globally was the use of economic information to highlight the benefits of changing management practice. "*CO2 is often too abstract a concept; whereas a 10% reduction in fertiliser or a 5% improvement in topsoil depth or carbon content leading to a defined improvement in output is perhaps a more tangible benefit*." (Advisor from FAO online discussion, Africa).

Farmers also advocated the approach of linking practice with payments. "*Tell us what is going to make us more money and give us better yields as a key first step*." It

was felt that for mitigation options that did provide these economic benefits it was important to highlight and communicate those during knowledge exchange.

In order to evaluate opportunities for knowledge exchange, an understanding of the value that the research participants, including farmers, advisors and policy makers placed on knowledge exchange was required. Through the key informant interviews various types of knowledge exchange activity were mentioned, including participatory approaches, one to one advice, on-farm demonstration and structured training. Each of these were seen to have different advantages and drawbacks.

Through the key informant interviews and by questioning participatory farmers at the farmer events, the value of the event was understood by both parties, the trainer and the trainees. Many advisors identified the importance of advice provision especially when focussing on the topic of sustainable farm management and the efficient use of resources.

3.2.3 Measuring and monitoring

The results above have been focussed on the delivery method and the ability to use techniques such as framing, demonstration and delivering over a sustained time period to support the transition to sustainable farming practices. However results from key informant interviews showed consent around the need to document the impact of management change. This impact was seen as important in two distinct areas. Firstly highlighting the impact of recommended management practice on-farm from a carbon, economic and resource use efficiency perspective. Secondly there was recommendations for the use of metrics to evaluate the success of knowledge exchange in terms of whether the programme achieved practice change on-farm.

Measuring carbon impact

Results provided a consensus that monitoring tools provided a vital way to document impact and to 'turn complex science into something that a farmer can use and understand.' Interview participants that were involved in working with farmers conducting carbon audits for supermarket supply chains and other government initiatives reiterated some of the points that were explored above around framing the issue to include farmer drivers and motivations, prior relationship with the farmer and ensuring practical relevance to the farmer. As such, interpretation of results was seen to be an important aspect of monitoring tools.

Designing the tools in a way which is user friendly was also highlighted. One participant commented, "*we can design the best tools in the world that are fantastic, however it doesn't make them use it*."

Across the cohort there was consensus that using a consistent approach for tools was important. This was seen to be important for two main reasons, firstly the ability to use the data from these tools to communicate the results and efforts of agriculture across a wide cohort of audiences (including policy makers, other farmers and consumers). The second importance of a consistent approach was that it provided transparency and trust between users.

Once the tools or measurements had been used, advisors and project managers also valued the ability to compare results through benchmarking.

One research participant commented, "*benchmarking is a good way of helping to convince people that it works*." However this response was further honed by a respondent with experience of working with farmers on benchmarking projects who highlighted the importance of communicating the results and facilitating discussions.

"*Benchmarking only works if you can reference it to something that means something to the farmers doing it. If you have a good group of farmers then that's brilliant, but you have to understand what motivates them and frame it in those terms*."

Measuring project impact

Consistency in measuring the impact of projects was seen as important by interview respondents, as well as a need to transition from immediate measuring to longer term monitoring. This is linked to the ability to provide long term support and advice which allows a deeper understanding of the process by which a farmer transitions from knowledge to behaviour and the role of advisors to support the transition.

One project manager commented, "*Currently a lot of success is measured by immediate impact, how many people have we engaged with to complete short term training. This bears no relation to whether they have acted on what we have told them. Longer term monitoring to support these farmers to implement what they have learnt and to continue to adapt and change it to work for their business needs seems much more valuable."*

Longer term monitoring of projects was indicated as important by many respondents which corresponds with the views of published studies (Milstone, 2010). When interview participants were asked about this in more detail, it was felt to be a big shift from current knowledge transfer mechanisms and was identified that it would require 'flexible funding mechanisms' and 'a desire to try something new' from policy makers and organisation that fund training activities.

Farmers interviewed also appreciated the opportunity to be monitored over a longer term, but care was needed to highlight the importance and relevance to the farm, in

some situations. All of the farmers engaged in this research were positive about monitoring, however some researchers interviewed explained the need to value the farmer as a significant knowledge – holder in the system. One extension worker from Africa commented, "*If you are an outsider who acts superior it won't work*."

The initial grouping and analysis of interview responses can be seen in Appendix A

3.3 Farmer training events

3.3.1 Farmer training event survey results

The number of participants at each of the three farmer training events along with their farm type is detailed in Table 3.3.

Farm Walk	Number of farmer respondents	Farm type			
		Arable	Livestock	Mixed	Horticultural
Farm walk 1 (York)	6	5	-	1	-
Farm Walk 2 (Durham)	16	2	4	9	1
Farm Walk 3 (Wolverhampton)	13	4	1	8	-
TOTAL	35	11	5	18	1

Table 3.3 Total number of farmer attendees at three farmer training events characterised by farm type.

Questionnaire part one – completely at start of event

3.3.2. Farmer motivation for attending the event

Responses for motivation for attending the event were written as free text, however the responses were collated into 7 categories to explore key motivations. Where farmers responded with more than one reason, each reason was counted (thus there are more responses than farmers that attended) and 4 categories (for "what did you

want to get out of it?”). The number of responses in each category is documented below in table 3.4.

Response	Number of respondents
An interest in soil health	8
A desire to ‘see it working’	7
Education	7
The use of a local farmer (so conditions would be similar)	6
Meeting other farmers	5
Learning New ideas	2
Seeing good farming	2

Table 3.4 Responses on the motivation for attending the Soil Farmer training events.

3.3.3 Farmer expectation of the event

As well as understanding the motivation of the farmers to attend the event, the questionnaire also evaluated what the attending farmers were expecting to get out of the event before it started. Again, this response was a free text box and the responses were collated and coded, which provided 4 key themes.

Response	Number of respondents
Enhanced technical knowledge	15
Share practical advice and experience with other farmers who are using techniques	15
Meet like-minded farmers	7
Understand latest research	2

Table 3.5. Main motivations of farmers attending the soil farmer events.

It was clear to see that attendees were keen to receive not just technical knowledge (for example crop establishment techniques, residue management and the use of cover crops) but also experiential knowledge and advice from the farmers who were doing these management practices on the farm. Creating a network of ‘like minded’

farmers was also seen as important, allowing for knowledge sharing and a social experience to be had as well as a learning one.

3.3.4: Questionnaire part 2 completed by farmers post event.

Post event, a series of questions was posed that related to the outputs from the events. Along with feedback on whether the event met their expectations (which 100% of respondents said that it did), delegates were asked what the best thing about the event was. Responses could be grouped into three themes.

Firstly, the use of the farmer as the host. Delegates commented on the importance of hearing the information first hand from the farmer. One attendee explained *"Hearing the farmer talk about his soils and fertility management; giving real experiences while being able to see the proof that it works by walking the crops, his enthusiasm was infectious."*

The enthusiasm and knowledge of the host farmer was mentioned at all three events, and was seen as a particularly valuable part of the training event. Another farmer commented "*The farmer's knowledge and enthusiasm meant that I was inspired to see whether I could get this to work on my farm."*

The second key theme was around the opportunity to see practically that the methods that were being advocated were working. At all events, attendees commented on the ability to see that "the system was working, the crops and soil look fantastic." The combination of understanding the technical theory of what should work, with the opportunity to see visually what was happening in the fields, and understand the process by which the fields had got to this condition was valued.

The last theme was the opportunity to discuss, share ideas and connect with other farmers. A key attribute of these events was the opportunity to participate and

actively learn. During the event, questioning and discussions were facilitated, to allow all farmers to participate. This involved discussing key ideas, questioning the methods that the host farmers had used and evaluating whether these would work on other farms. Questions from farmers during the walks ranged from technical queries on seed application rates and different chemical regimes, to getting an understanding of the transition that the farmer had been through. This also included discussion about how these host farmers (who were all pioneering new methods) had been viewed by other farmers in their communities.

A key part of the questionnaire was to understand whether, having attended the event, the respondent would go home to their farm and change management. Attendants were asked whether they would change management following what they had learnt and all delegates stated that, having been to the events, they would change some aspect of their farm management practice. This ranged from trialling different tillage options, experimenting with cover crops or integrating livestock into arable rotations, to an increase in confidence with experimentation. Even attendee farmers who were running similar systems to the host, had found something to adapt or change from the event. An example included one farmer who had already changed to a zero tillage system, but was now going to look at increasing his seed rate to improve crop establishment. At the last event, the host farmer was applying various different biological products that were being produced in a low cost system on the farm, which inspired three other farmers to build similar systems post event.

3.3.5: Current thoughts and actions around climate change.

The final section of questions that delegates completed post event was intended to get an understanding of farmers' views and any on-farm action being taken because of climate change.

Response	Number of responses
I am slightly concerned about the impacts of climate change on my business	18
I am very concerned about the impacts of climate change on my business	13
I am not concerned about the impact	2
I don't believe in climate change	2

Table 3.6 Responses from farmers attending the soil farmer events detailing their concerns on climate change impacts on-farm

Results showed that the majority of farmers were either slightly concerned or very concerned about how climate change will impact on their business in the future. Impacts that were of concern included changing weather patterns and potential price rises for input costs.

Farmers were then asked whether they were already adapting their management due to the impact of climate change. 75% of farmers responded that they were already adapting their management (22% were not currently changing their management, and 3% didn't respond). For those respondents that confirmed that they had changed their management, they were then able to list some of the practices that had been changed either by ticking a pre selected practice or by adding their own. Practices that were added included reducing cultivation, sowing crops earlier in the spring, managing watercourses better and remediating field drainage.

3.3.6: Barriers to adoption of practices

Farmers were asked what was stopping them implementing a change of practice on the farm. Responses can be seen in the table below. Although there were set responses that could be ticked some farmers added their own responses which weren't covered by the current options. These were then summarised into the two additional categories that can be seen in table 3.7. Management in business was used to classify those responses that were submitted by farm managers or farm workers where they were not currently able to implement management changes (as they were not the key decision makers in the business). The 'age / succession' category referred to the responses from farmers at or near the end of their career with no future successor. There were some categories that received no responses.

Response category	Number of responses
I don't know what action to take	37
I don't manage the business	6
Age / succession	6
Its too costly	5
There is a lack of support from industry	-
I don't have enough time	-
There is a lack of scientific evidence	-
I don't know	-

Table 3.7 Responses from farmers attending the soil farmer events detaining their current barriers to taking action on climate change

3.4. Farm advisor survey results

As mentioned in the methodology, there were a small number of respondents to the Farm Advisor survey, and as such the results may not be representative of all advisors. The advisor location and the farm type receiving advice from the farm advisors that completed the survey can be seen in Table 3.8.

Advisor region Main farm enterprise	South West	South East	North West	East of England	West Midlands	Yorks and the Humber	East Midlands	North East
Cereals		1		1	1			
General Cropping		2		1				
Horticulture				1				
Specialist Pigs						1		
Specialist Poultry				1				
Dairy	3		1					
LFA grazing livestock						2		2
Lowland mixed Grazing	2		1		1		1	
Mixed	1	1		1	1		1	1
Other							1	

Table 3.8 Respondents to the farm advisor survey classified by location and farm type receiving advice.

There was a dominance of farm advisors from the South West region. There was also a dominance of advisors working with livestock farms, predominantly ruminants. Specialist pig and poultry farms, and horticulture were not represented well within this survey.

3.4.1: Main advice specialism

There was a range of advice being given to farmers, but a dominance in agronomy, crop nutrition, soil and water management as can be seen in table 3.9 below

Main advice specialism	Number of responses
Soil and / or Water management	8
Agronomy / crop nutrition	7
Animal health	3
Farm Business management	3
Environment / Biodiversity	3
Livestock reproduction	1
TOTAL	25

Table 3.9 Responses from farm advisor survey showing main advice specialism

3.4.2: Current knowledge level of advisors

The results from the questions looking at the current knowledge level of advisors on greenhouse gas emissions showed that 15 out of 25 survey respondents were happy with their current knowledge and were capable of advising clients without having to search for more information. A further 4 respondents had some knowledge around greenhouse gas emissions and were confident that they knew where to go for further information should they require it. The remaining 7 were either not interested (n=5) or were waiting to upskill themselves for when either legislation is changed or their clients request it (n=2). The advisors that were not interested were advising general cropping, specialist pig and poultry, horticulture and mixed farming systems, so not allied to one particular farming enterprise.

3.4.3: Communication with clients about greenhouse gas emissions

Only 3 survey respondents communicated regularly with their clients about greenhouse gas emissions. These respondents were advising farms with general cropping and grazing livestock enterprises. The majority of respondents were conversing with certain clients about GHGs (n=12). 5 respondents did not ever talk

to their clients about greenhouse gas emissions, either directly or indirectly (by talking about business efficiencies).

Of those advisors who do talk to their clients about GHGs, 15 cited that discussions were directly about emissions rather than indirectly by talking about efficient productions.

3.4.4: Farm Practices and farmer knowledge

Current farmer knowledge was evaluated by asking the survey respondents to rate their client's current knowledge level against three categories. The categories were: their farmer client's current knowledge level of greenhouse gas emissions and agriculture, the link between economic efficiency and emissions reduction on-farm, and where to obtain more information on agricultural emissions and what to do about them (sources of information). The results are shown in figure 3.2 below.

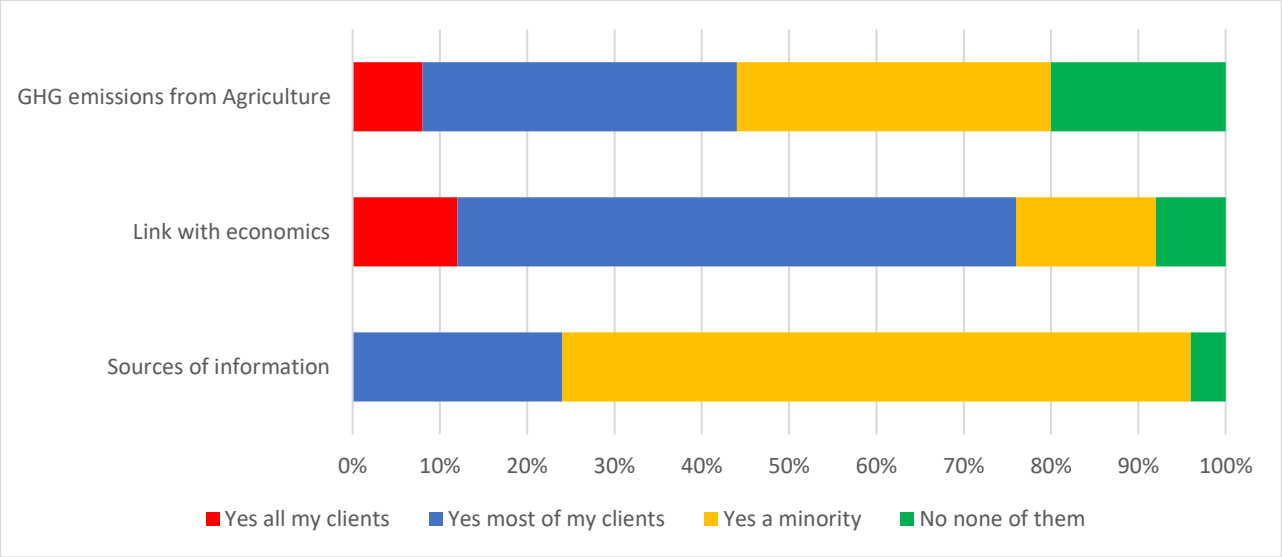


Figure 3.2: The current knowledge level of farm advisor's farmer clients on a range of topics evaluated by advisors completing an online survey related to the provision of advice on greenhouse gas emissions.

From the surveyed advisors, 20 reported that clients had some level of understanding about greenhouse gas emissions from agriculture. 5 respondents

indicated that none of their clients had any knowledge, these responses came from advisors working with Grazing livestock and general cropping.

Considering where farmers can find sources of information on GHG emissions, then the knowledge level was lower, with 18 advisors reporting that only a minority of their clients knew where to find more information. 5 advisors reported that none of their clients would know where to find more information.

Within the Greenhouse Gas Action Plan, potential management practices are divided into five key categories. Within the survey, advisors were asked about their client's current knowledge around these key practices, the advisors views on whether these practices are currently being undertaken on-farm, whether there are any issues for wide take up of these practices and whether they will achieve the key GHG reductions that are needed. The key categories evaluated were:

- Soil management – including soil structure, cultivation, and nutrient status
- Crop nutrition – including nitrogen use efficiency, integrating manures and fertilisers, optimal timings and rate of application
- Energy efficiency and renewable energy generation
- Integrated farm management – managing land in a way that balances environmental value, resource protection and productive farming)
- Performance monitoring and / or benchmarking to ensure efficient production and maximise marketable produce

Figure 3.3 below shows how these categories are being managed on-farm with advisors stating how many of their clients are focussing on managing these resources already.

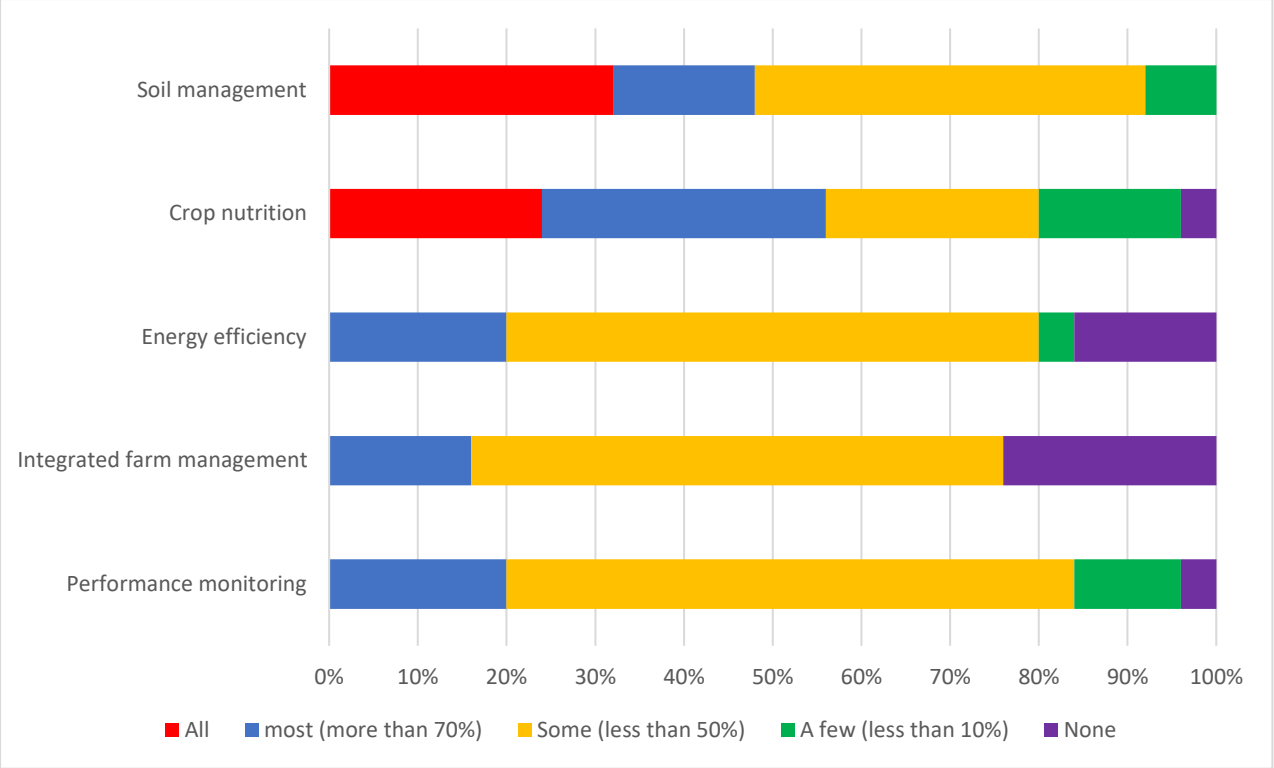


Figure 3.3: The current uptake of key farm management practices on-farm evaluated by advisors completing an online survey related to the provision of advice on greenhouse gas emissions.

It is possible to see that managing soils and crop nutrition have the highest uptake, with the more general categories (for example, energy efficiency and integrated farm management) not been taken up so readily. These were the only two sets of management practice that had responses in the ‘all clients’ category. 6 respondents stated all their clients were addressing crop nutrition with a further 8 confirming more than 70% of their clients were managing inputs. It is worth noting that these categories are fairly broad and span a wide range of practices. For all categories - apart from crop nutrition - the most common response was that some (less than 50%) of their clients were adapting their management. Integrated farm management had the highest proportion of ‘none’ responses (n=6).

3.4.5: Ease of implementation on-farm

Advisors were asked to rank each of the categories in terms of their ease of implementation, with a score of 1 being the most difficult and 5 the easiest.

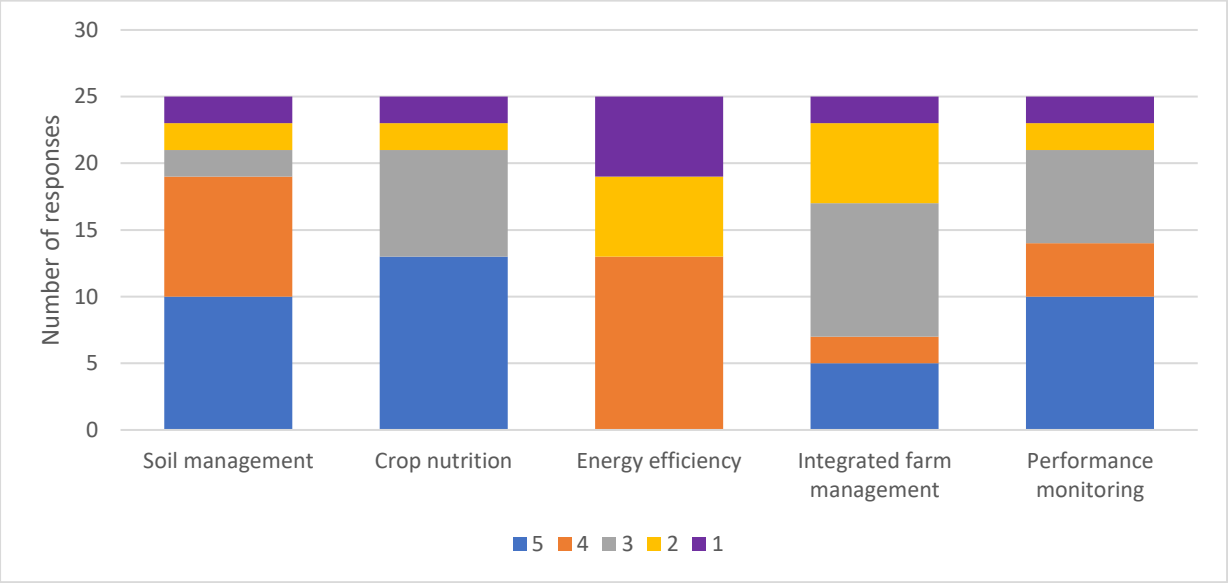


Figure 3.4: The ease of implementation of key management practices by farmers evaluated by advisors completing an online survey related to the provision of advice on greenhouse gas emissions. A score of 1 represents the most difficult and 5 easy.

Figure 3.4 shows the rankings across the categories. It is possible to see that soil and crop management are seen to be the easiest to implement on the farm with energy efficiency and renewable energy generation being seen to be the hardest (potentially due to the perceived initial investment associated with renewable energy). It is interesting to note that for soil management, integrated farm management and performance monitoring there are responses for each of the scoring criteria, however for energy efficiency there were no responses for score 5 (easy) or 3. For crop nutrition no advisor scored a 4.

Advisors were then asked to rank the categories from 1 to 5 (with 1 being low and 5 being high) according to their potential to deliver a reduction in greenhouse gas emissions.

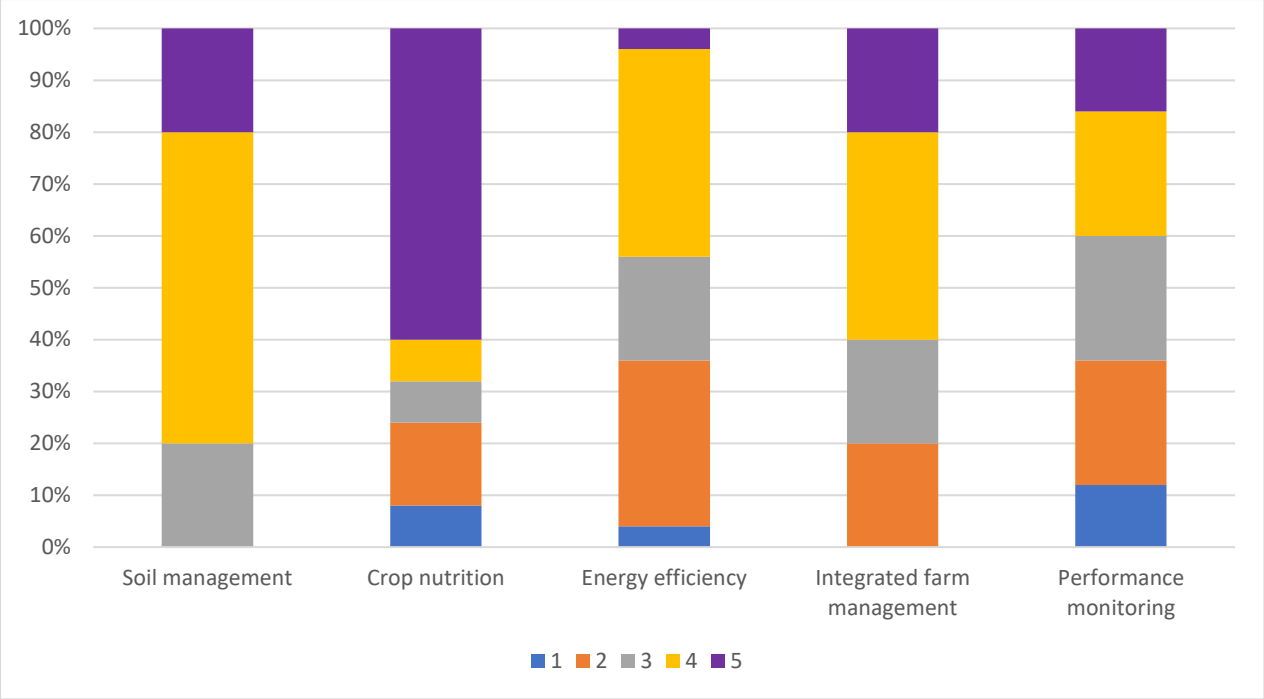


Figure 3.5: The potential of key management practices to deliver GHG reductions evaluated by advisors completing an online survey related to the provision of advice on greenhouse gas emissions.

In figure 3.5 advisors thought that crop nutrition had the largest potential to deliver a reduction in greenhouse gas emissions with soil management and integrated farm management also scoring well in the rankings. When comparing these results with figure 3.12, looking at how easy these practices are to implement on the farm, the results would seem to suggest that advisors think that soil and crop nutrition offer the most potential for reducing GHG emissions and are the easiest to implement on-farm.

3.4.6: Delivery mechanism

The final question in this section was looking at the best way to deliver these practices at the farm level, looking at a range of delivery options from one to one advice, group events, payments or legislation. Survey respondents were able to indicate all that they felt were appropriate from the range of options.

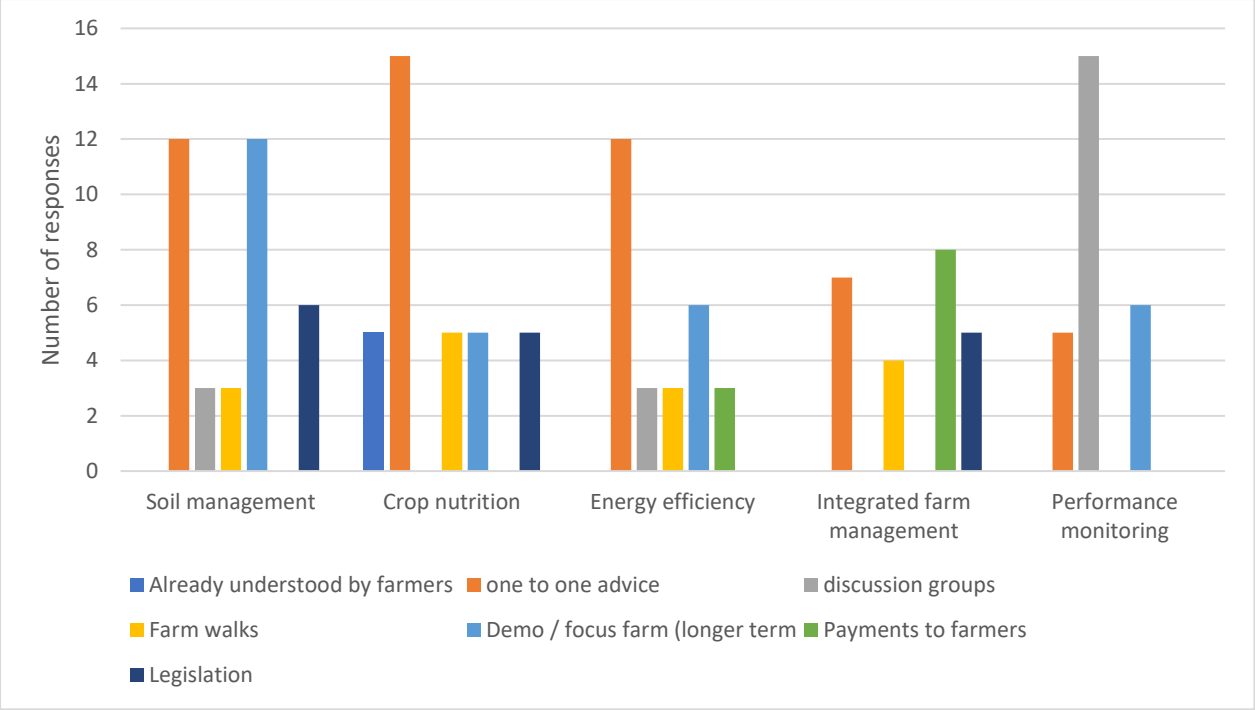


Figure 3.6: The best way to deliver advice on the key management practices to deliver GHG reductions evaluated by advisors completing an online survey related to the provision of advice on greenhouse gas emissions.

The results indicate that there is a preference towards the provision of one to one advice across most of the key action areas. Payments to farmers are only suggested as a suitable delivery mechanism for energy efficiency and integrated farm management, and legislation is advocated for soil and crop management and integrated farm management. Discussion groups are seen as a suitable option for delivering performance management advice, and the use of demonstration or focus farms which provide options for longer term monitoring are also seen as suitable for energy efficiency and performance monitoring which may be related to the need to refine and evaluate output from these categories.

3.4.7: Livestock related questions

Following the general questions about the options for GHG mitigation at farm level, particular focus was paid to livestock enterprises and there were four questions identifying key mitigation measures and options for delivery with livestock farmers.

The questions took the same format as those above, looking at current knowledge levels, the potential of these options for GHG mitigation and the best way of delivering them. Of the 25 respondents to the survey, 18 responded to the livestock specific questions. The results from the livestock responses are available in Appendix C.

3.4.8: Practices being undertaken by livestock farmer clients.

As with the more generic practices that are advocated for all farmers by the GHGAP, there are a set of livestock specific practices that are focussed on management of forage, stock and manure. These practices were evaluated by the advisors that completed the survey, in terms of their relevance and farmer uptake.

These categories are:

- Grassland and forage management
- Genetics and breeding planning
- Livestock health planning
- Livestock nutrition planning
- Manure management, treatment, storage and spreading

Results from the advisor survey showed that grassland and forage management was taking place on farms advised by farm advisors undertaking the survey. There was a good level of uptake across most of the recommended management practices, with no practices showing a zero percent uptake. As with the general practices, livestock advisors were asked about the ease of implementation of these management practices on-farm. Manure management seemed to have some inconsistencies associated with it, as it was the only category which has responses within each score, potentially reflecting the different issues with manure depending on livestock

species and geographical location as well as current farm infrastructure and tenure status.

When focussed on the best way to deliver messages to livestock farmers, one to one advice was highlighted as a good approach across all categories. For grassland and manure management, longer term monitoring and demonstration was suggested as a potential delivery mechanism. The use of demonstration and long term monitoring were also discussed as themes for successful knowledge exchange in section 3.2.2 above.

Chapter 4: Discussion

This research aimed to assess the opportunities for knowledge exchange to support farmers in adopting more sustainable farming practices which are important for climate change mitigation. To achieve this aim, a mixed method approach was used, which included a thematic analysis to understand how farmers learn new ideas and identify current barriers and drivers for farmers to change management practices. As well as the thematic analysis, two distinctive groups of actors were targeted to explore in more detail; farmers attending a knowledge exchange event and farm advisors who were delivering one to one advice to farmers on climate change mitigation.

This research has considered different approaches to knowledge exchange and their efficacy in delivering key messages, engaging farmers in the topic, and achieving the elusive behavioural change. The results have highlighted some key areas for consideration, especially in terms of the importance of knowledge exchange activities, their value for farmers, and the opportunities that are available to make the most of interactions with farmers to achieve a sustained legacy.

The thematic analysis revealed several key attributes that were seen to be important for knowledge exchange programmes for climate change mitigation. Although the issue is multifaceted, the study showed that important factors included the use of demonstration and narrative; the importance of a trusted relationship and the importance of framing the issue.

4.1: Advice provision for farmers

The importance of providing advice and guidance to farmers on a range of technical subjects to improve productivity, environmental credentials and skills development is

well known and reported in the literature. This was confirmed within the interview cohort of the research. Through the development of new technologies, emerging research, climatic phenomena, animal health issues and environmental issues, there is a need to bring farmers together to learn new skills and knowledge and work out how the knowledge applies to their farm.

Throughout the key informant interviews and by questioning farmers taking part in knowledge exchange events, the value of these events was understood by both parties, the trainer and the trainees. Many advisors identified the importance of advice provision, especially when focussing on the topic of sustainable farm management and the efficient use of resources. However, there is a possible bias here from advisors, which could be challenged by deeper understanding of whether farmers value one to one advice as much as advisors.

The value of advisors as ‘change agents’ has been recognised both in agricultural research (Solano et al, 2003; Ingram and Mills, 2018 ;), and in public health research (Nahchahal et al 2012). Therefore we can acknowledge that the provision of advice is important; however, it is important to evaluate the aspects of knowledge exchange which are most favoured by this research cohort, and to understand the value of training and knowledge exchange, specifically in the subject of sustainable agriculture and mitigating and adapting to climate change.

Farmers valued the ability to discuss their individual business requirements but during the farm events, the value for the farmer was on demonstration and speaking to other farmers; engaging in peer to peer learning. In an increasingly connected world where farmers can connect with farmers in their location, or even globally though technology there may be conflicting objectives in the future. However, the role of sustained advice over the long term was valued by farmers and advisors.

How the advice is delivered and the mechanisms thorough which farmers could be supported to change practice were key narratives of the thematic analysis.

4.2 Timescale

Length of project and support were valued, as it provided the ability to support the farmer over a longer timescale. This desire for longer term activities has been echoed by other research completed by Andersson and Orgill (2019). This research evaluated the impact of a three year soil training programme for farmers. The farmers were revisited 10 years later to assess whether the practices that had been advocated were still being undertaken. The results showed that the changes had broadly not been sustained, leading to the recommendation from this paper that continued engagement along a learning pathway is not just beneficial for farmers, but also maximises the value of financial investment in knowledge activities. However, this result could have been as a result of the relevance and quality of the training as much as the length of time that the training is given. However, research by Barupa (2019) focussing on sustainable soil management concluded that there was a need to reinforce key messages with continual learning. This is seen to be especially important when dealing with the area of sustainable farming which has been characterised by various studies as containing "complex, wicked problems" (van Latesteisn and Rabbinge, 2012, Murahahni, Hendrickson, and Siegel, 2016, and Grove and Steward, 2019). Indeed, Grove and Steward highlight that there is a need not just for long term knowledge exchange, but also long term research that allows these issues to be assessed holistically over a longer time period than traditional studies. Murakami *et al* (2016) suggests that when dealing with these complex issues, there are various aspects that are crucial in achieving understanding, including the facilitation of practice-based and community based

learning and ensuring that the issues are situated in the regional context. This research however was completed with agricultural students at a Land Grant University in the American Mid-West, rather than with farmers, so it may not be applicable to the UK farming context.

4.3 Demonstration and narrative

Demonstrating concepts in the field has been shown as an effective knowledge exchange mechanism in other studies. Indeed Tulla *et al* (2017) showed that the main added value for the end users (in this case farmers) was seeing the knowledge being implemented by a farming business. Indeed, Azumah (2018) showed that for rice farmers in Northern Ghana, demonstration was the most effective agricultural extension method. The value shown by farmers to demonstration activities has also been seen through other research projects, especially when focussing on the Farmer Field School approach, which has been widely studied in terms of its effectiveness at improving technical skill development and changing practice (Goatland *et al*, 2004, Kenmore, 2002, Daroini *et al*, 2015, Duveskog, 2013, and Waddington 2014). Indeed, the use of demonstration has been seen to be a crucial part of effective learning, both within the higher education sector (Van Doorn and Van Doorn, 2014) and as the key strategy for teaching learning to robots! (Fitzgerald and Thomas, 2015).

The importance of demonstration and narrative was seen as effective by project staff, advisors and farmers during this research. For farmers, the value seemed to be in the ability to see the concept in action (demonstration) and to discuss practical implementation with other farmers (the inclusion of peer to peer discussion). This would concur with the concepts cited above focussing specifically on the use of demonstration as a crucial part of effective learning and development of technical

skill. The farm events were included in the research specifically to understand the value of demonstration events as an effective knowledge exchange strategy.

The concept of experiential learning was pioneered by David Kolb in 1984. The concept has four distinct stages, including observation of the activity, thinking of how the activity would work in the practitioner's individual scenario, plan how to complete the activity and then finally do the activity. Within the context of the farmer events, the demonstration of the practices and concepts of sustainable soil management and different tillage options was the first step which allowed the farmer to then think about how their system could be transformed. The added practical knowledge that comes from the peer to peer discussions at the event allow the planning (step 3) process to be started before assessing the opportunities to change management on-farm. The value of experiential learning has been a subject of research, especially in the world of business and finance and is seen as a useful tool to improve knowledge, understanding and business performance (Bhatti, 2016, Okasavara, 2010, and Bruneel 2010). It has also been seen as a valued tool within the education sector with students valuing experiential learning, especially in the field of agriculture (Mahoney and Retallick, 2015).

The concept of experiential learning and the use of demonstration farms has been researched within the agricultural context. Although the farm walks evaluated as part of this research weren't set up on specific demonstration farms, the farmers were being highlighted as soil farmer ambassadors and as examples of good practice. Results highlighted that farmers valued the ability to see practices in action, thus there are synergies to be drawn with research into demonstration farm networks. The research could have been further enhanced by evaluating a range of training events to be able to draw more robust comparisons between the three farm events

(that all followed a similar format) and other farmer training formats. The value of demonstration farms has been researched and shown to provide a range of outputs that were not the focus of this study but are beneficial to the uptake of sustainable management practices. These include increased economic output (Garforth et al, 2005) and the creation of new knowledge (Kamia and Kielbasa 2015). The use of demonstration farms was shown by Taylor and Bhasme (2018) to bring not just production of knowledge but also 'materials and legitimacy.' This concept of legitimacy is particularly important for farmers as evidenced by the responses within the farmer survey, being able to not just hear what to do, but see it as well. The Horizon 2020 project Agri Demo evaluated the impact and potential of demonstration farms as effective knowledge exchange mechanisms that stimulate behavioural change and found some key factors that influence its success, including the selection of the demonstration farm, both in terms of physical location and its similarity to the farms of the visiting farmers (Bailey et al 2006), and the selection of the individual farmer as the host both around their characteristics and their reputation within the farming community (Koutsouris *et al*, 2018). Indeed Kiptot *et al* (2006) confirmed when working with farmers in Kenya that farmers with leadership skills were seen as influencers by other farmers and as such made good demonstration hosts. This is confirmed by the survey responses from the soil farmer walks where the knowledge, experience and enthusiasm of the farmer host were all seen as positive attributes and of value to the learning event.

When evaluating the responses from the farm walks, one of the stark results was the response to the question around why farmers weren't currently taking action to mitigate climate change on-farm. The majority of farmers from all three events cited that inaction was due to the fact that they didn't know what actions to take. This

highlights the importance of knowledge exchange; however, it also can be linked to the multifaceted nature of climate change mitigation on-farm which can sometimes mean that it is overwhelming and difficult to know where to start. Farmers valued the ability to see and engage with farmers who had changed their practice and could provide confidence that it was achievable and manageable. The farm walks contained both demonstration activity (host farmers were showing the impact of changing practice) and also peer to peer knowledge exchange. The concepts that were demonstrated could be discussed with farmers who had experience of implementing them.

The concept of peer to peer learning was characterised by Boud in 1988 and represents a transition from independent to interdependent or mutual learning. While this concept is fairly new within conventional educational research; within the agricultural sector, farmer to farmer learning has been recognised as a value training tool for a long time. It has been used to pursue the uptake of agro ecological farming methods particularly using the 'campesino a campesino' model which prioritises farmer to farmer knowledge (Rosset *et al.,* 2011). It has been seen as complementary to conventional training activities within agriculture (Kiptot and Franzel 2015), providing context and practical relevance to concepts being explained by researchers or advisors. When focussing on the context of sustainable farm management, social learning networks (farmer to farmer) have been seen as an effective tool to adopt new technologies and productivity (Nakano *et al* 2018), improve economic and agronomic performance (Taweekul *et al* 2009), and co-create new knowledge (Kiptot *et al* 2006). The peer to peer learning was valued by the farmers attending the soil events, as the top reason for attending the event - along

with obtaining technical knowledge was the ability to share practical information and experience with other farmers who are using the techniques being advocated.

As this is so valued, both by advisors and farmers, including peer to peer learning within knowledge exchange events, being able to provide on-farm demonstration opportunities - especially when dealing with complex topics - is critical to the success of these programmes and to ensure that effective learning and practice change occurs.

4.4. Trust and relationships

The importance of trust and building relationships between advisors and farmers were identified as key themes. The importance of trusted advisors was cited by interview respondents across categories including farmers. Trust seems to be valued by farmers. Trusted advisors were characterised as having a good technical knowledge, but also the ability to deliver results that are targeted to an individual farm situation. This is confirmed by other research which has shown that relationship building is the foundation for successful extension (Fleming *et al* 2014). Indeed, the nature of trust between farmers and extension agents has been a key attribute to the generation not just of increases in agricultural productivity (Reid and Salmon 2000), but also of the uptake of new ideas and management practices (Turhahikato and Kamangara, 2016). Research has also shown that, during a training event, farmers who trust the educator providing the training learn more than those that do not (Buck and Alwans 2010).

To test this approach further, the research design could have focussed on evaluating the use of knowledge exchange events that had advisors leading them, rather than the three farm walks which were led by the host farmers.

This is confirmed by other research, including work into the take up of animal health advice by farmers, which found that those advisors who have established relationships with farmers are better received than those who are not known (Croyle *et al*, 2019). This is especially valuable when talking about the broad subjects of climate smart agriculture and implementing sustainable practices.

As climate change and the impact of farming on greenhouse gas emissions have been politicised issues in the past, and policy development has been fragmented and piecemeal, focussing on the importance of trust of the advisor on affecting behavioural change of farmers is incredibly important. Farm advisors have been cited as a significant knowledge source (Thomas *et al*, 2020) and as such can be useful dissemination mechanisms for achieving management change at the farm level. As such, providing materials and knowledge which allow the extension providers to frame that knowledge in a way which will have meaning to the farmer is critical. When focussing on the post event responses from the farmers attending the soil events, it is evident that, although a majority of farmers were either very or slightly concerned about the impact of climate change on their business, the main barrier to changing management was that they didn't know what action to take. This highlights the immense potential for advisors to fill this role and provide relevant and practical information that inspires engagement. This is confirmed when examining the results of the advisor survey, which shows that advisors see a part of their role as to translate current science into a format that makes sense to their client. However, this will only transform into on-farm practical action if the advisor is trusted. The area of trust can be related to the previous provision of advice that has been successful. There is a lack of research that examines the relationship between previous advice and current trust levels within agricultural advice, however research

has been undertaken in the area of law which confirms this theory (Sniezek and Van Swoll, 2001 and Van Swoll and Sniezek, 2011). The issue of trust over time can be shown in the context of the value of long term knowledge exchange activities, where the creation of long term projects allows a sustained relationship between advisors and farmers, which can also trial new approaches and evaluate the results. This is seen to be a method which will help achieve behavioural change and inspire farmer engagement.

When evaluating the effectiveness of knowledge exchange programmes, it is important to differentiate between those farmers who are 'trained' and those who change behaviour or management as a result of the training. This latter method is much harder to evaluate in the timescale of a project, but is integral to developing projects that actually achieve this target. The use of trusted advisors as knowledge extension agents can help to achieve the desired method and behavioural change.

4.5 Framing the issue

Often, the issue of climate change adaptation and mitigation is not a key motivation for changing on-farm management, so the topic needs to be reframed so that relevance to day to day farming can be appreciated.

Within the sphere of public health research, the use of framing has shown good results. By translating the reasons for changing behaviour (through increased amounts of exercise, altering diet or other lifestyle changes) into something that has worth and value to the individual, there is a higher rate of behavioural change (Keyworth *et al*, 2017, Grady *et al* 2011). This is confirmed in a meta-analysis of research looking into changing behaviour, which found that awareness-raising strategies provided little or no advantage in achieving change. They found strong evidence that, where they used an inter-sectoral approach and highlighted the

benefits of changing practice (the ‘win-wins’), then behavioural change was undertaken and sustained (Molnar et al 2016).

The concept of using win-win scenarios for agricultural extension has been used for some time. However, when discussing the opportunities for increased engagement by farmers into climate smart practices, a common answer was that there needed to be more of an emphasis on the economic benefits of adopting these practices. There was consensus that, while the environmental benefits of practices had been well communicated, the economic benefit (or impact) was often overlooked.

There is a good synergy between cost savings and emissions reductions for numerous climate smart agricultural practices and this should be a priority in communication methods in order to inspire farmers to engage. In order to communicate these benefits effectively, there is a need for tools and metrics that allow in-depth monitoring of these practices and allow the impact of adopting practices to be seen. The provision of decision support and monitoring tools that are fit for purpose and show real impact was another key theme of interviews. However, care was also needed to provide frames for those farmers for whom economic gain was not the main motivator.

Although some farmer respondents at the farm walks and during the key informant interviews cited economic gain as a key frame, it is important to not focus solely on economic benefits. Although there are economic benefits to be had from more efficient use of resources, if we rely solely on economic benefits, when these are not apparent or when practices may incur financial cost – the framing will not be effective. There is also potentially an emerging conflict, if climate messages are all framed to reflect their relevance to an individual farmer, there may be potential to

avoid improving understanding of the global issues concerning climate change and the necessity for everyone to contribute to climate change mitigation.

This is confirmed by research into the reasons behind decision making and the use of evolutionary evidence on why some behaviours are taken up. Indeed, Prager and Posthumus (2010) who were focussing on the uptake of soil conservation practices, confirm that there are four socio-economic factors that will influence farmer adoption which are: environmental and technical, personal, economic and institutional. So, although providing economic motivations is important, it is not the only aspect affecting the decision. Climate smart agricultural practices are based on technical factors; as such, in order to achieve behavioural change, a wider approach may be needed to address the other factors cited above. This is where communication of the issues is important. Although the technical information is important, how the technical information is framed and communicated will impact whether the information is adopted.

In order to get farmers to change management and embed more sustainable practices that have environmental and societal benefits, then the techniques need to be communicated in a way which farmers can relate to and have meaning. This concept is confirmed by research undertaken by Ritter (2017) which evaluated the factors determining farmer adoption of management specifically focused on animal health in dairy cows. This research concluded that farmers make decisions using a range of factors including their farm context and beliefs and citing universal benefits may not be sufficient to change on-farm practice.

The concept of framing and communicating these issues in a way which enables behavioural change rather than inhibiting action has been highlighted as a value

aspect to achieve a true transition to climate smart agriculture and a resilient industry.

4.6 Measuring and monitoring

In order to achieve the transition, it is necessary to document change and develop metrics that demonstrate impact. Measuring carbon impact of different practices was seen as important, however carbon accounting tools were mainly seen as a resource to be used together with an advisor, rather than solely by the farmer. It is important to say that this could be a reflection on the current tool design and provision rather than a universally accepted view. Advisors, project managers and researchers seem to be the main target for most carbon accounting tools and then there is an interpretation interaction with the farmer where results are discussed and evaluated. This is confirmed by the literature which cites a limited uptake of decision support tools by farmers more generally (Rose, 2016) and around carbon tools (Lewis *et al*, 2013). Interview participants who were involved in working with farmers conducting carbon audits for supermarket supply chains and other government initiatives reiterated some of the points that were made above around framing the issue to include farmer drivers and motivations, prior relationship with the farmer and ensuring practical relevance to the business, as well as linking to economic benefits. There was limited use of carbon footprint tools by farmers within this research, however evaluating current usage was not a key focus of this study.

Designing the tools in a way which encouraged user input was valuable and a key attribute to tools which farmers could value and use. This is where training can be very important to ensure that end users have the required skills to use the tools, but also highlights the importance of considering the end user at the design phase. Involving the end user in co-design of the tools was a key conclusion of Cert *et al*

(2012) when focussing on the use of decision support tools in agriculture. Indeed, in developing countries, where the amount of data available may be more limited, a key recommendation from Paustian (2013) was to include farmers in the design and data gathering phases of the footprinting. Research from Rose (2016) highlighted five key factors when designing decision support tools for agriculture (not specifically around carbon) which were considering its usability, its cost effectiveness, its reliable performance, its relevance to the end user and its compatibility with compliance demands. Although this research was conducted in the UK, results from global respondents confirm these factors as pivotal in developing effective tools that are focussed on carbon.

Across the cohort, there was consensus that consistent methodology for tools was important. This was also seen to be important for using the data for communication with policy makers, funding bodies, other farmers and outside of agriculture. There was also a focus on the transparency of methodology to elicit trust among users. Tools which allowed benchmarking of results were valued by interview participants and tool users. This could provide a way of ensuring that results from carbon assessment tools are then a starting point to change management. Benchmarking has been seen as a useful tool with animal health projects (Van Meensel *et al*, 2012), innovation (Spielman, 2008), Biodiversity (de Snoo *et al*, 2010) and Sustainability (Halberg *et al*, 2005).

Longer term monitoring of knowledge exchange and climate mitigation projects was indicated as important by many respondents, which corresponds with the view of some published studies (Milstone, 2010). It does pose an issue, though, which relates to how to fund and implement long term monitoring. There can be a contradiction between the desire for future collaboration between farmers and

researchers engaged in co-creation activities and the way that extension, knowledge exchange and research is currently funded. Co-creation processes are more creative in nature, however when applying for funded projects – concrete deliverables and milestones are required. Change is required, but there is a need to develop flexibility from funders to accommodate this change and quantify the results in a meaningful way. One of the recommendations from the recently concluded Agri Demo project (https://agridemo-h2020.eu/) which evaluated the extent of learning during demonstration farm activities, was a need to change traditional monitoring to adequately capture impact, rather than just engagement.

This changing role of monitoring and evaluation, especially around farmer-centred innovation, is an emerging research topic with lots of interest around it. Studies are experimenting with the use of emerging technologies to acquire meaningful evaluation and monitoring of projects (Eitzinger *et al,* 2019), and also looking to implement participatory monitoring and evaluation (Thapa *et al,* 2017) which collects and analyses data to track progress of activity within the project and allows the group to find ways to improve outcomes. This is an area where more development is needed to be able to fully assess the impact of both publicly and privately funded extension work with farmers. Currently, a barrier to this is the relative simplicity of providing evidence-based results to justify public investment, as with this simplicity, there is an issue with attributing the attending of an event with a change in practice, when in reality the change will have been prompted by multiple drivers and interactions. The evolvement of iterative monitoring and evaluation frameworks that are more able to take into account the complex decision making, the extrinsic and intrinsic values (Meijer *et al,* 2014) and management practices are research priorities

for the future. This is something that would be aided by monitoring over a longer time period than currently practised.

The combination of interviews, farmer questionnaires and advisor surveys has allowed for a detailed look at the aspects of advice provision and extension that contribute to a successful and valued interaction with farmers. By talking to farmers about what they value and the opportunities that they see as open to them to develop resilient farming systems that are fit to the future, it is possible to see that what is of value to them is demonstration, practical relevance, metrics that provide analysis of the economic and environmental benefits of changing practice, and support through the change, both from the wider community of farmers but also from advisors and mentors.

Advisors have a critical part to play in enabling this transition to sustainable farming systems, through the evolving of trusted relationships with their farmer clients. The importance of these relationships and the opportunities that this knowledge pathway brings for achieving effective action cannot be underestimated. Advisors are able to frame the knowledge in a way which has meaning to the farmer and can often understand the previous history which has got the farmer to his current situation. Advisors can also have a key role in facilitating peer to peer knowledge exchange and providing the technical base that farmers can scrutinise and mould to fit their current farming scenario. However, it is important to remember that not all farmers have a traditional farm business advisor or consultant who is attached to the farm; as such, when looking at upskilling current advice providers, it may be necessary to widen the scope of who the information is disseminated to on sustainable resource management, to enable other individuals who are engaging with farmers to have the base knowledge (for example, vets).

The current environmental situation regarding climate change, the impact on agriculture and the development of more sustainable farming systems provided a unique opportunity for farmers to change behaviour and practice to achieve the multifaceted goal of environmental protection, food production and sustaining of rural communities. This is no mean feat and will require everyone to work together and a degree of innovation: around methods of knowledge exchange, monitoring and evaluation metrics, both for projects and for the impact of management, flexible funding options; and an enabling policy which promotes ownership of these issues by farmers and inspires action.

4.7 Limitations to this study

There are several limitations to the legitimacy of the results found within this study. The method chosen for analysis, although flexible in its approach, may have led to some key responses being missed or miscoded. During the key informant interviews, the responses were written down during the interview. This could have led to errors in accurately capturing responses and ensuring that researcher bias was minimised. Future research would ensure that all interviews were recorded and transcribed verbatim to allow for a more comprehensive coding process to be completed.

The researcher was also responsible for the whole process from data collection, write up, coding and analysis. As such, in future, more collaborative working may lead to a reduction in bias towards key outcomes and a more robust analytical process.

Although the farm advisor survey was promoted through a multitude of dissemination networks, as respondents were voluntary, the sample cohort will be biased. The bias could well be that respondents had strong views on the topic and so were motivated to respond, and don’t reflect the wider views of the advisor sector. Efforts were

made by the researcher to gain a representative sample; however if the research was repeated this method would be refined.

Farmer attendees to the on-farm events would also have been biased, as by attending the event they were confirming their interest in the topic of soil health. Although the current level of experience was collected within the questionnaire along with their main motivations for attending the event, these farmers will represent a certain sector of the agricultural industry. Future research should include a wider scope of events to question farmers; this would enable a wider representation of farmer views. Also, as these events were being run by the researcher, there is the potential that farmers gave false positive feedback as it was the researcher's event. Respondents were voluntary and anonymous to try and allow for honest feedback to be collected.

A key issue with the dataset used for the Key informant interviews was the refocussing of the Nuffield questions to be able to use the data to compare with the FAO online information. The use of thematic analysis in a narrative context allows a more flexible approach and doesn't require the use of a theoretical framework, however the combination of the data sets during the research, was less than ideal. The research would have been more accurate if the exact same questions were posed to all interview participants. Also, the mixed method through which the interview data was collected may have led to bias. The FAO data was collected online, the key informant interviews were predominantly face to face so this may have compromised the results.

The timing of the data collection may also be less representative of the situation currently as policy changes and farmer interest has changed over the last four years. Indeed, the Greenhouse Gas Action plan is no longer active and policy has now

changed to new Net Zero legislation which is leading to an increased attention on agriculture's environmental impact.

4.8 Future research recommendations

The data for this research was collected in 2016 and 2017. Since then, so much has changed within the UK. This has included the transition to Net Zero legislation which now includes agriculture in emissions reduction legislation; the rising media and consumer interest in the carbon footprint of agriculture; the increasing interest in the ability of soil carbon to provide a climate solution and the creation of net zero strategies by the NFU, Local authorities and supply chains. This research has highlighted some aspects of knowledge exchange which were considered valuable by participants within the study, these could be further refined and scoped to see if the views of farmers and advisors remain the same or have changed. There are now existing projects that are focussed on climate change mitigation within the UK and these would be a good resource to examine whether farmer participation is enabling behavioural change. Further research needs to be completed to understand the future monitoring requirements and the ability to use decision support tools (including carbon footprinting tools) as a method to document project impact.

4.9: In Conclusion

Through this research it is clear that knowledge exchange in all its many guises is an important tool to help achieve the transformative shift that is required to meet the challenges of climate change and resource depletion. Climate change is a multifaceted issue and involves both mitigation of current farm practices and adaptation of business management, both of which require technical knowledge and support. Technical knowledge to deal with these emerging challenges is often developed during knowledge exchange events. While it is accepted that knowledge

exchange is important, how the knowledge exchange is managed and implemented was also identified of key importance.

Aspects that were important to include in successful knowledge exchange programmes were the timeframe of advice, the use of demonstration and narrative, the importance of trusted advisors and relationship building, and the use of framing techniques to communicate key practices and messages in a way which inspires engagement.

Farmers attending demonstration events found these an effective way to learn more about soil management and particularly valued demonstration of key concepts and the peer to peer learning opportunities. A key conclusion from the farmer events was that there is a significant knowledge gap for farmers about which practices to implement on farm to improve resource use efficiency and mitigate climate change. Farmers are seeing the direct impacts of climate change on-farm but don't seem to have a clear understanding of the most suitable management practices to adopt.

Advisors were seen as a key part of helping farmers transition, however those who completed the advisor survey reported that currently they were not providing large amounts of advice on this topic. The wider cohort of advisors who participated in the key informant interviews were more directly involved in advising farmers on climate change mitigation and confirmed that advice needed to be targeted, locally relevant and sustained.

Recognising the importance of existing farmer knowledge, using practical demonstrations, and framing these topics in a way which has meaning for the farmers involved was seen to being crucial to long term success. This, coupled with a change in the way of monitoring projects that allows for the understanding of

genuine impact of training and events which takes place over a longer time period and requires continual mentoring and support, could help to develop truly sustainable farming systems that have merit environmentally, economically and sustain our rural communities for years to come.

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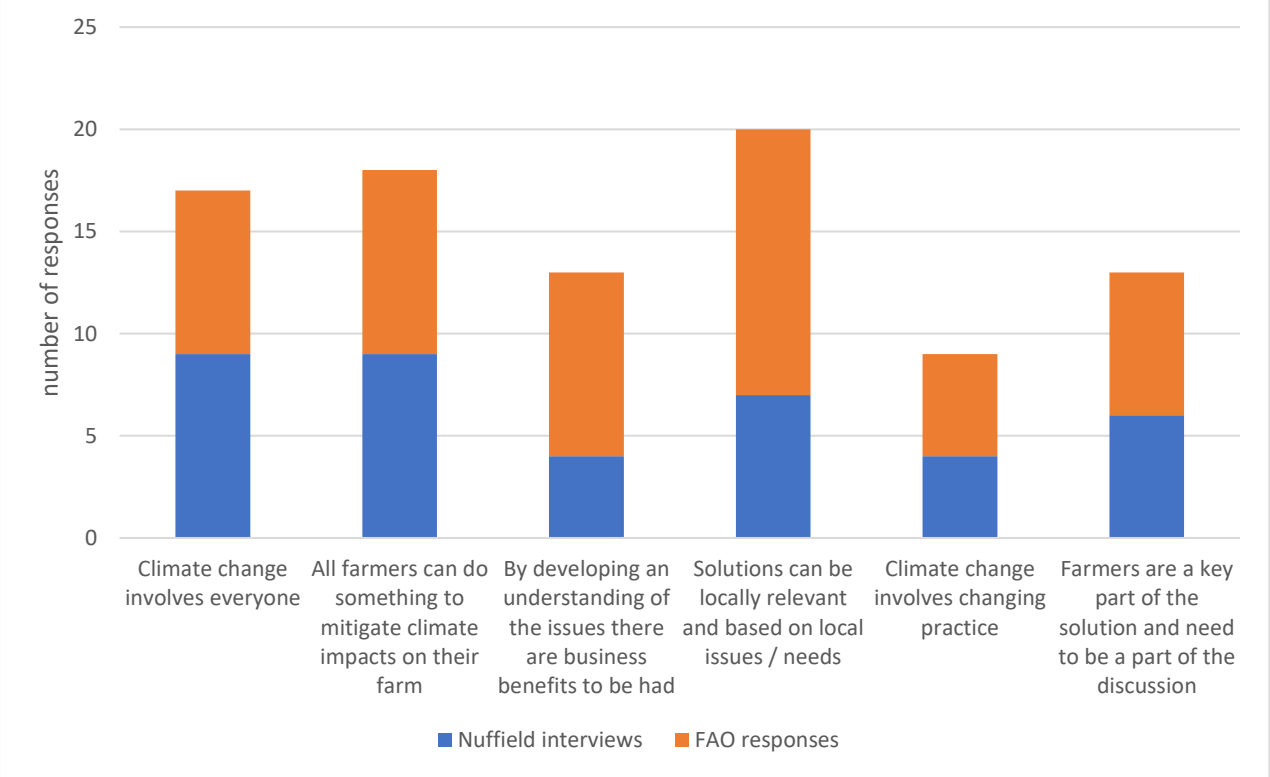
Appendix A: Initial groupings and analysis of key informant interview data

Key messages when communicating about climate change with land managers

Table showing the key messages that research participants felt were important when communicating to farmers about climate change and the number of respondents that fell into each key message.

Key message	Number of responses
Climate change involves everyone	17
All farmers can do something to mitigate climate impacts on their farm	18
By developing an understanding of the issues there are business benefits to be had	13
Solutions can be locally relevant and based on local issues / needs	20
Climate change means changing practice	9
Farmers are a key part of the solution and need to be a part of the discussion	13
TOTAL	90



A graph depicting the key messages to communicate to farmers, split into those responses from key informant interviews and those participating in the FAO online forum.

3.1.2: The best way to exchange on climate change with farmers through rural advisory services.

The best engagement method to get farmers to understand the issues surrounding climate change

Engagement method	Number of responses
The use of creative techniques	1
Long term / consistent support (rather than project driven)	4
Focus narrative on management resources	3
Focus narrative on business benefits of adaptation and mitigation	8
Set up on-farm demonstration activity	13
Bring scientists and farmers together for discussions	7
Enable farmer to farmer learning and discussion	9
Set up on-farm research activity	3
Keep the messages simple	2
Develop activity over the landscape scale (rather than individual farms) to enable collective action	5
Focus on local issues – target knowledge to local need	5
Value the knowledge held by the farmer	4
Use a multimedia approach for communication	7
TOTAL	71

3.1.3: Lessons learnt when using these tools and approaches with farmers.

The figures in the table below indicate responses from participants around lessons that had been learnt through delivering knowledge exchange programmes to rural communities on climate smart agriculture.

The key lessons learnt by advisors working with farmers on climate change projects

Key lessons learnt (initial groupings)	**Number of responses**
Ensure relevance of the material to the farmer	13
Focus on measures that will deliver multiple benefits	8
Make recommendations business focussed	8
Use tools that are outcome focussed and provide clear next steps to the farmer	4
There is a need for skills development in the areas of climate mitigation and adaptation	5
Interactions with farmers need to take place over a sustained time period	2
Ensure that farmers can take ownership of potential solutions	5
TOTAL	45

Additional resources needed to ensure that tools and approaches used are effective.

Additional requirements for effective delivery	Number of responses
Tools that assess ecological impact	5
Knowledge on carbon cycling	3
Development of consistent metrics	3
Development of community resilience models	4
Access to knowledge	5
TOTAL	20

3.1.4: Delivery mechanisms for enhanced engagement

Opportunities to improve engagement through adaptation of delivery mechanism.

Delivery mechanism	Number of responses
Policy	14
Financial assistance direct to farmers	8
Financial assistance to projects	10
Legislation	9
The use of market mechanisms	15
TOTAL	56

The responses were then categorised by responder type. The categories were: consultants and advisors, policy and government, farmers, and researchers. The breakdown of responses per category are displayed below.

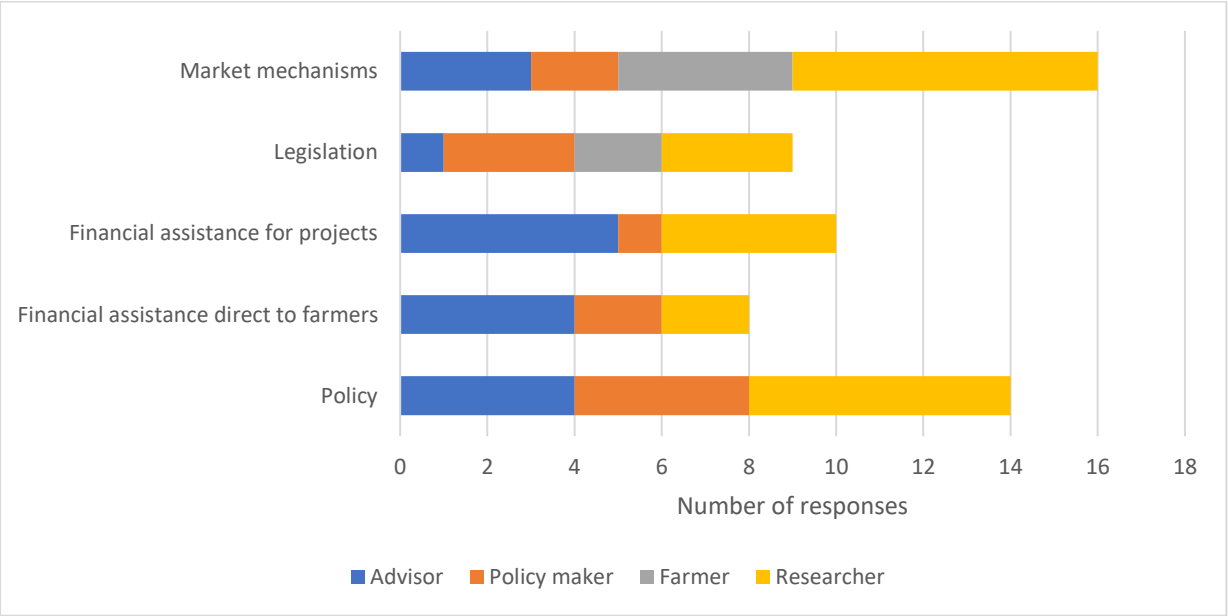


Figure 3.3: A graph showing the breakdown of responses from participants in the online discussions and key informant interviews around key delivery mechanisms to achieve enhanced farmer engagement in climate smart agriculture.

3.1.5: Future engagement opportunities to engage more farmers in climate smart agriculture practices

Future engagement opportunities	**No. of responses**
The use of technology	7
Integration of climate targets with other environmental issues (for example water quality, nutrient management)	4
More use of demonstration farms	8
Working more across the landscape scale	8
More research into practice	4
Creating a positive narrative for farmers and consumers around climate smart agriculture	4
Use of the market to drive economic mechanisms	7
Legislation	4
Enhanced farmer knowledge and skills development	5
Use of data to demonstrate impact	2
TOTAL	**53**

Responses were also classified as to whether they were from advisors, policy and government representatives, farmers or researchers.

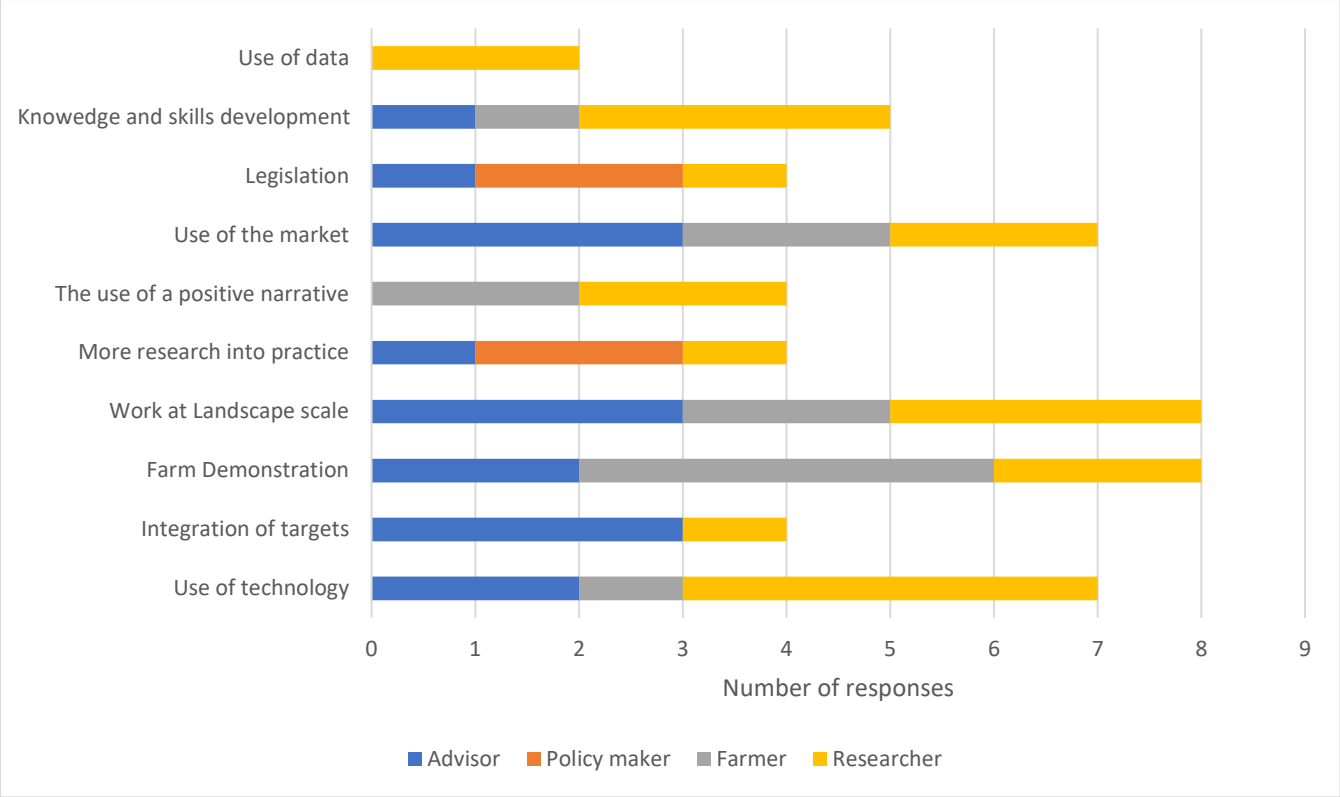


Figure 3.4 The future opportunities to engage more farmers in climate smart agricultural practices broken down into respondent type.

Appendix B: Farmer training event questionnaire

Farm Walk Feedback Form

Name…….

Email address…….

Farm Type (please tick the relevant box)

Arable ☐

Livestock ☐

Mixed ☐

Horticulture ☐

Where did you hear about the event?

…….

What do you want to get out of the event?

What made you want to come to this event?

Yes it completely met them Just about No I didn't get what I came for

What was the best thing about the event?

What was the worst thing about the event?

Yes ☐

No ☐

Don't know ☐

If you answered yes, how will you change your management?

I am slightly concerned about the impact of climate change on my business ☐

I am not concerned about the impact of climate change on my business ☐

I don't believe in climate change ☐

What are the impacts that most concern you? (please tick all that apply)

More unreliable rainfall ☐

Increased flooding ☐

Increased drought ☐

Price rises for input costs ☐

Higher temperatures ☐

Other (please specify) …….

What is the biggest barrier stopping you from taking action? (please tick all that apply)

Its too costly ☐

Lack of support from industry ☐

I don't know what actions to take ☐

I don't have enough time ☐

There is a lack of scientific evidence ☐

Don't know ☐

Are you already adopting to the impacts of climate change? (Please tick the relevant box)

Yes ☐

No ☐

If yes, what practices are you doing on-farm? (please tick all that apply)

Water management (storage / more efficient use) ☐

Changing crop varieties / livestock breeds ☐

Installed Renewable Energy Generation ☐

Planting trees ☐

Altered grazing patterns ☐

Crop rotation ☐

Increasing soil health ☐

Is there anything you would like more information on?

Thank you!

Appendix C: Farm Advisor survey – Livestock responses

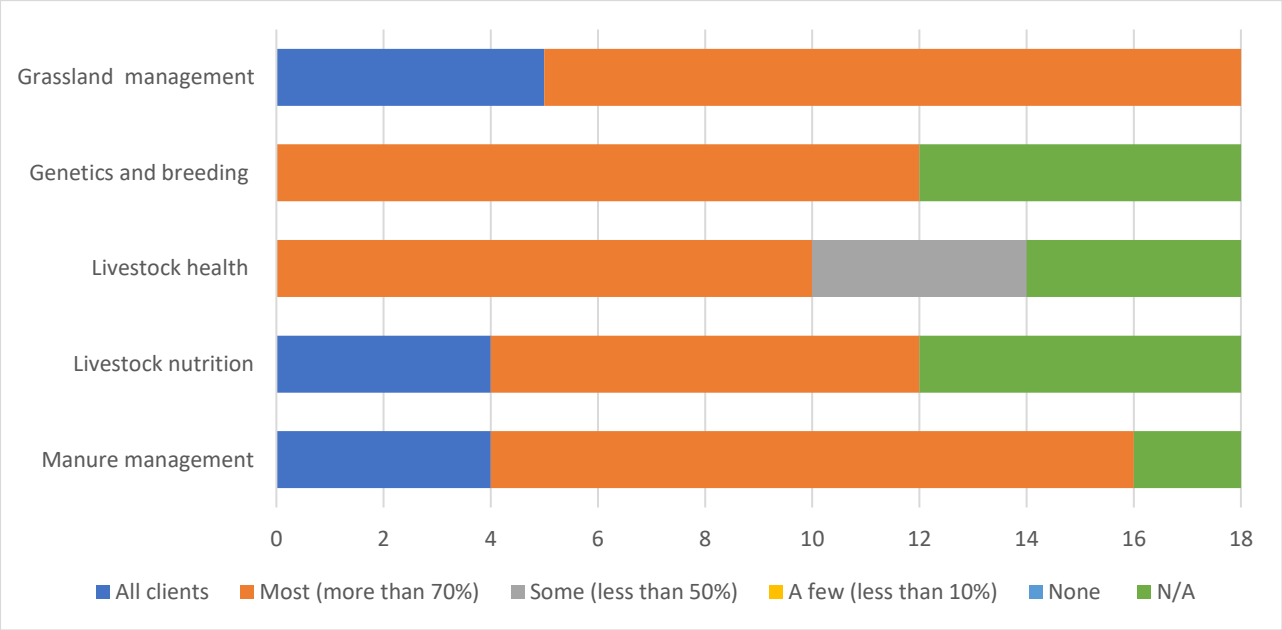


Figure 3.15: The proportion of farmer clients that are engaging in key livestock management practices evaluated by advisors completing an online survey related to the provision of advice on greenhouse gas emissions.

3.3.11: Ease of implementation for livestock practices

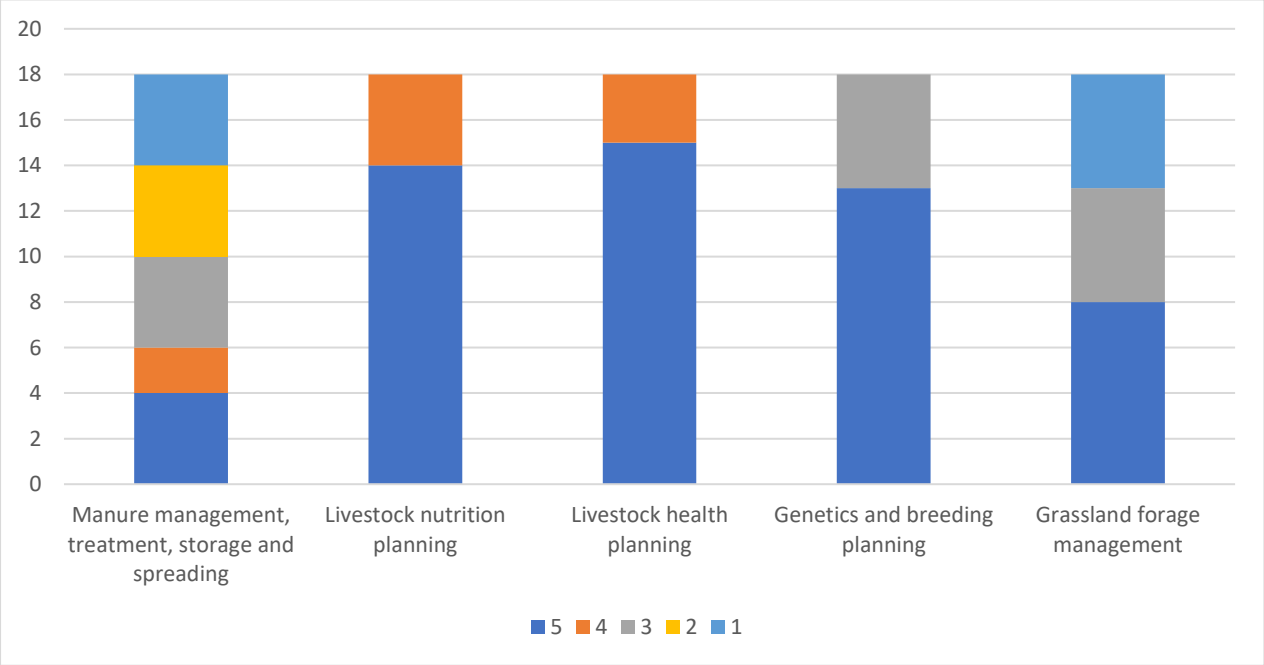


Figure 3.16: The ease of implementation of key management practices by livestock farmers evaluated by advisors completing an online survey related to the provision of advice on greenhouse gas emissions.

3.3.12: Potential for delivery of GHG emissions reductions

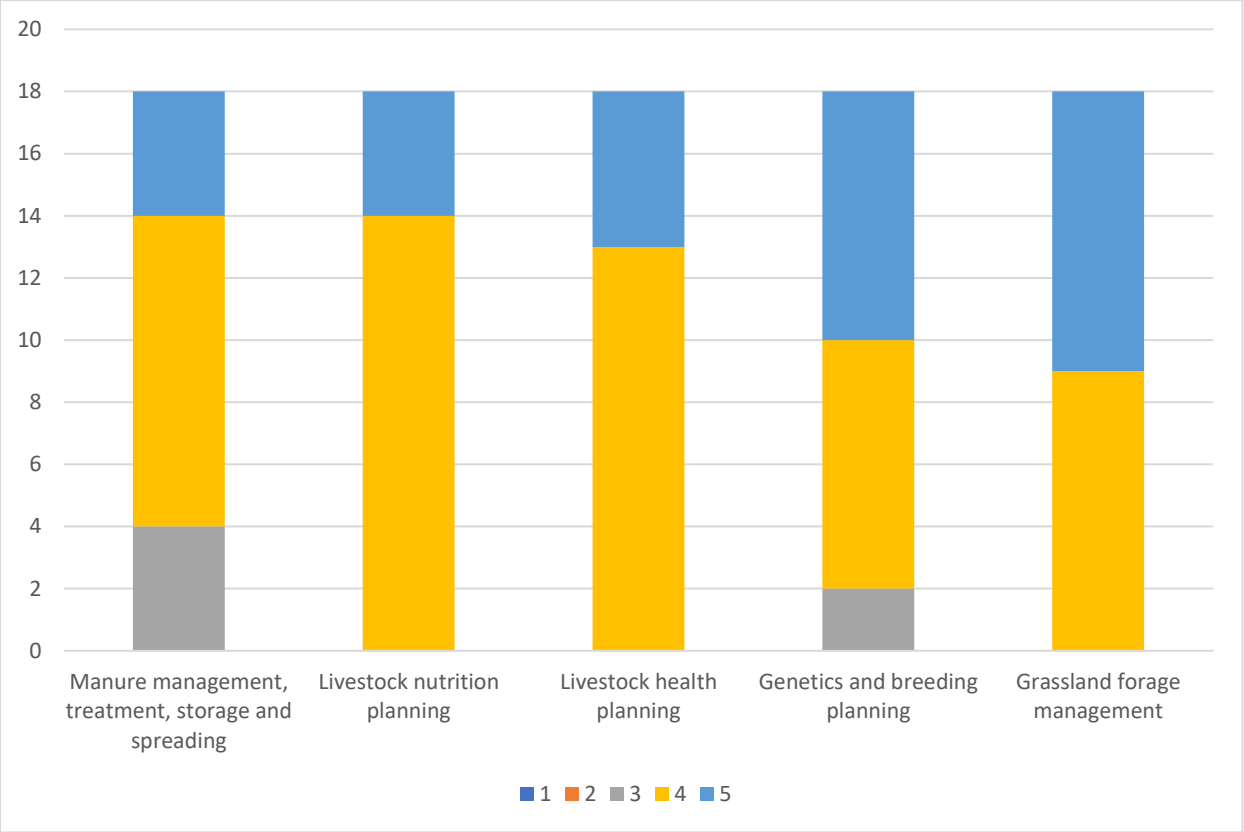


Figure 3.17: The potential of key livestock management practices to achieve emissions reduction as evaluated by advisors completing an online survey related to the provision of advice on greenhouse gas emissions.

3.3.13: Delivery mechanisms

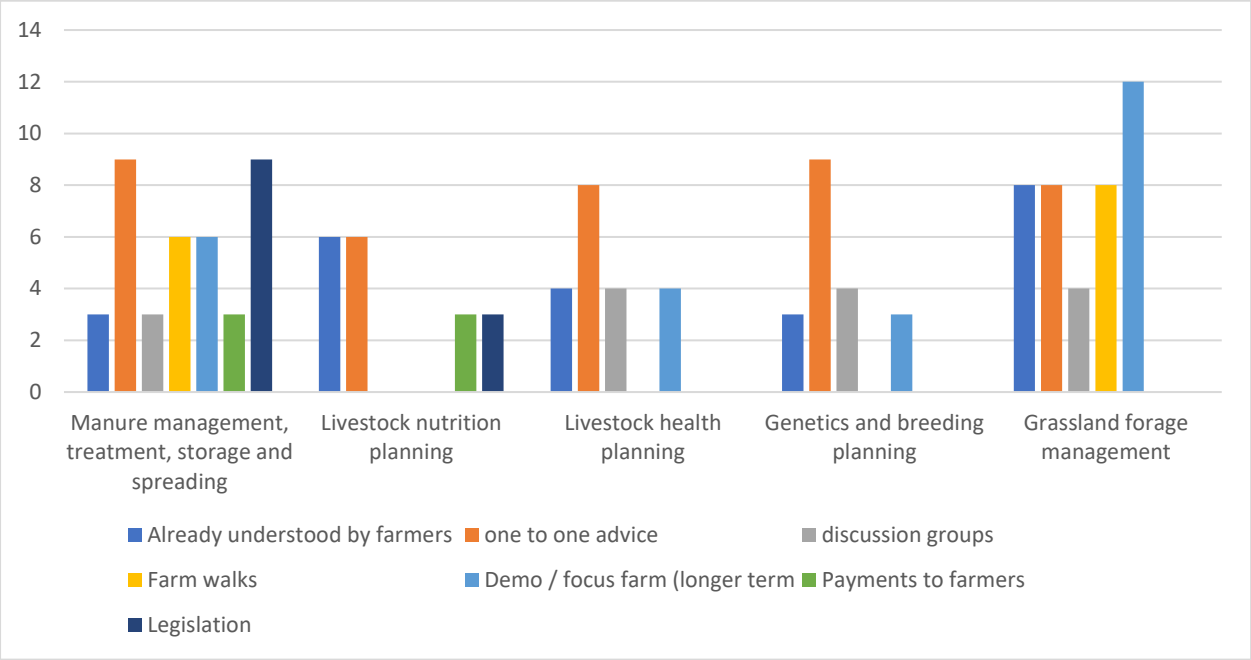


Figure 3.17: The best way to deliver advice on the key livestock management practices to deliver GHG reductions evaluated by advisors completing an online survey related to the provision of advice on greenhouse gas emissions.