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An analysis of practice change and the use of behavioural insights in agriculture and horticulture – identifying what works

Rapid Evidence Assessment Report

for AHDB

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Executive Summary

Introduction and aims

This report presents a review of evidence relating to practice change and the use of behavioural insights in agriculture and horticulture – identifying 'what works'. It reviews examples where applying the science of behaviour and behaviour change has been practically used or investigated that would be relevant (directly or indirectly) to AHDB's target audience of farmers and growers across its six sectors.

The aim of the assessment is to review and critically appraise evidence that helps to answer:

What behavioural change methods work in practice?

- What methods are used and work?
- What sorts of outcomes are achieved?
- How can behavioural change interventions (methods) be improved?

Methodology

This Rapid Evidence Assessment (REA) methodology critically appraises the quality of evidence relating to 'what works', specifically what AHDB behavioural change methods work in practice.

Based on a rigorous REA protocol, which defined the criteria for the searching and screening stages, a total of 118 pieces of evidence were selected for the critical appraisal (95 peer review studies and 23 grey literature reports). These represent relevant evidence for the period 2013-present, from UK, Europe, North America, Australia and New Zealand. A framework for the analysis was developed based on the behaviour factors that AHDB use for behaviour analysis and the working methods considered during intervention development.

Scope and strength of evidence

Regarding the scope of the evidence, livestock studies dominate reflecting a growing body of social science work related to behavioural determinants in relation to animal health and welfare and biosecurity. In total for livestock there were 73 peer review studies and 13 grey literature reports, and for crops 21 peer review studies and 1 grey literature report, with 2 peer review papers and 9 grey literature reports covering both.

The strength of evidence is assessed using three components: relevance scoring, robustness scoring and consensus. Relevance and robustness of each piece of evidence was scored. When taken together these (combined scoring and consensus) provide a weight of evidence that allowed us to judge the overall strength of evidence.

Most evidence tends to assess factors and determinants that influence behaviour (more likely with large scale surveys) rather than the methods for achieving behaviour change. Similarly, there is extensive evidence concerning the effectiveness of different types of extension methods although this rarely drills down into the (intentional or unintentional) constituent behavioural methods or behavioural change outcomes of interest to the AHDB. This evidence is more likely to come from programme evaluations and qualitative studies. Not all of AHDB's behavioural methods are supported by evidence in this review. In summary while there is some strong evidence showing the association between a number of determinants and behaviours, particularly in livestock studies, the evidence of behavioural methods being used to bring about change is more limited.

Results

Overall, the combined scores (relevance and robustness) ranged from 2-6 (out of max of 6) with 4 being the most common score. The higher scoring evidence, especially where supported by consensus, provides the weight of evidence for 'what works'.

This report is the outcome of the REA appraisal and is accompanied by the REA classification sheet ('map') which documents the critical appraisal of the evidence, listing all evidence with associated relevance and robustness scores. This is supported by an EndNote library of all the evidence selected for analysis (together with pdfs). A database documenting the search records and screening decisions was also kept.

Results are collated according to groups of behavioural methods that AHDB apply in their behavioural analysis as follows:

Providing information and advice

Knowledge transfer not surprisingly this method has the strongest and largest evidence base, although this is limited to extension design and methods. Evidence reinforces what is already known, but provides robust support for the particular value of one to one advice and combined approaches. Training is seen to work when part of a wider package, although is not effective in some contexts.

Evidence for the **Concrete action perspective** is provided by just two examples that effectively used a structured approach that gave tips and pointers and led to behavioural change.

Evidence confirms that ***Messengers with authority*** are important but it also identified the significance of the style of communication, particularly where veterinarians are the messengers. Evidence of ***Messengers as role models*** is reasonably strong, but extends the understanding to how different sorts of role models (champion farmers, leader, mentors, inspirational) are used and respected by their peers.

Stimulate target group

With respect to ***Interpersonal communications*****,** evidence of the effectiveness of participatory group activities reinforces what is well known in the literature (peer to peer learning etc), although highlights that attributing behaviour change to such activities is not always possible, also that genuine participation does not always take place. This method is particularly effective when combined with a benchmarking tool or concrete action plan. Motivational interviewing is another novel form of interpersonal communication which has shown promise in the veterinary community but requires more evidence.

Evidence for ***Implementation intentions*** is more limited, although providing concrete plans is recognised with respect to action plans, standards and tools has been shown to be effective in a small number of studies.

Gamification is a promising approach, although there is limited evidence of direct behavioural change, the games being used in research projects and shown to more likely lead to enhanced learning and understanding.

Feelings

Evidence that ***Emotions*** are important is quite well developed, with trust (connected to interpersonal communication and one to one advice), sensitivities connected to social approval (injunctive norm),

and negative emotions identified as important in determining some behaviours, although evidence for the effectiveness of applying this as a behavioural method is limited.

There is limited and conflicting evidence of the value of ***Framing***, there are no studies that make a direct association with behaviour change.

Values and Norms

There is a range of evidence from different contexts that agrees that ***Descriptive norms*** can be influential, although this is rarely linked directly to changing behaviour. Benchmarking is one area which is well evidenced in terms of successfully supporting peer comparison.

A number of studies, although not looking specifically at the impact on behaviour of interventions, also identify ***Injunctive norms*** as important. The evidence reviewed here provides further insights to this influence and highlights some conflicting results. The evidence also identifies how injunctive norms overlap with descriptive norms and operate in combination with other behavioural and structural factors.

In the evidence reviewed, there is no explicit mention of using ***Identity*** as a behavioural method however the significance of identity and self-mage in influencing decisions about adopting certain practices is shown, although overall the evidence is limited.

Nudges and prompts

Evidence for using N**udges** (default or stimulus) as an approach is absent, evidence for ***Prompts*** is limited and conflicting, while some studies suggest that ***Friction costs*** can be effective in catalysing change.

Rewards and losses

Although not addressing the specific behaviour change methods of ***Present bias, Reciprocity and Scarcity***, there is evidence of 'rewards and losses ' messages being effectively used in some interventions, however the scope and strength is limited.

Summary

In summary while there is some strong evidence showing the association between a number of factors and determinants and behaviours, particularly in livestock studies, the evidence of behavioural methods being used to bring about change is more limited. Equally while there is strong evidence to support the effectiveness of some extension methods, studies rarely elaborate the constituent behavioural methods or behavioural change outcomes of interest to AHDB.

Of the AHDB behavioural methods, evidence is strongest (with most supporting body) for knowledge transfer, using messengers, interpersonal communication and descriptive and injunctive norms. There is also evidence of combinations of methods being effectively employed. There is a clear knowledge gap with respect to evidence for some of AHDB's behavioural methods, at least within the boundaries of this REA.

Contents

1. Introduction

This report presents a review of evidence relating to practice change and the use of behavioural insights in agriculture and horticulture – identifying what works. It reviews examples where applying the science of behaviour and behaviour change has been practically used or investigated that would be relevant (directly or indirectly) to AHDB's target audience of farmers and growers across its six sectors. Specifically, by using the Rapid Evidence Assessment (REA) methodology, it critically appraises the quality of evidence relating to 'what works'.

The review builds and extends the previous report " Understand how to influence farmers' decision-making behaviour - a social science literature review" (Rose et al., 2018), by assessing the quality of evidence, covering gaps identified in the original report as well as spanning the period 2013-present to ensure all recent relevant studies are included.

The purpose of this work is to start to widen AHDB's understanding of the possible behavioural interventions and methods that have been successfully and non-successfully used in practical situations to address or develop a desired behaviour. The assessment will inform the production of further examples and case studies.

The review is framed by the AHDB programme of behaviour change and the "AHDB guide to behaviour change campaigns" which sets out the behaviour factors AHDB use for behaviour analysis and the working methods considered during intervention development.

The aim of the assessment is to review and critically appraise evidence that helps to answer:

What behavioural change methods are used and work in practice?

- What methods are used and work?
- What sorts of outcomes are achieved?
- How can behavioural change interventions (methods) be improved?

2. Methods

The Rapid Evidence Assessment (REA) methodology was used for this evidence review due to its usefulness in 'the critical appraisal of the relevancy and robustness of the evidence base'. The REA methods used follow the Collaboration for Environmental Evidence Systematic Review Guidelines (Collins et al., 2015) and were carried out systematically and objectively by four project team members familiar with the material available.

The REA process is iterative and the review team worked closely in the development and use of key words, criteria for screening and scoring of relevance and robustness. Pilot tests were performed at each stage to validate and refine the methodology. Due to the range and quality of evidence, it was necessary to adapt the REA methodology at some points as part of this iterative process.

2.1. Protocol

The first stage entailed drafting a protocol, which was shared with AHDB for comment and approval. The protocol specifies the strategies and criteria for each stage of the REA. It also sets out the requirements for the collection of clear records throughout, in order to ensure transparency in reviewer decisions during the development of the search strategy, the screening and appraisal

process. Preliminary key words and assessment criteria were drafted, as well as templates for the database and systematic map. This document was revisited and updated throughout the REA process.

The primary question of the REA is: What behavioural change methods work in practice? Specifically:

- What methods are used and work?
- What sorts of outcomes are achieved?

2.2. Search strategy

Keywords were determined in an iterative process informed by the REA aims and the research team's knowledge. A preliminary list of key words was collected and added to the draft protocol. In the pilot methodology different key words were tested for each intervention type in the search strings. Through an iterative process some key words were retained and others removed on the basis of number, relevance and duplication of search results (judged on title and abstract) and research team's knowledge of the literature. Common synonyms were identified. Different key words were combined for each intervention type in the search strings. These combinations were tested iteratively and refined based on the number and relevance of search records.

2.2.1. Sources and search locations

Peer reviewed papers were identified using searches conducted in Web of Science and Google Scholar. These are complementary and the research results did not overly duplicate each other. Web of Science is a more authoritative source for peer reviewed papers, while Google Scholar proved a good source in terms of results, identifying some grey literature as well as peer-reviewed titles. However, it is important to note that, whilst useful, Google Scholar searches are understood as an 'imperfect tool to perform systematic reviews' (see Piasecki et al., 2018)[1].

Grey and unpublished literature was also identified from searches on websites of relevant specialist organisations as identified by the review team, and expert contacts.

2.3. Screening strategy

Inclusion and exclusion criteria were derived based on the key words and other factors such as geographical source and publication date. Two phases of screening were carried out. All Web of Science papers were screened. Due to large numbers of hits from Google Scholar only the first 5 pages were taken forward to the screening stage. All grey literature was screened. All retrieved articles were assessed for relevance using the inclusion/exclusion criteria. This stage ensures that only the most relevant findings were taken to the evidence analysis stage.

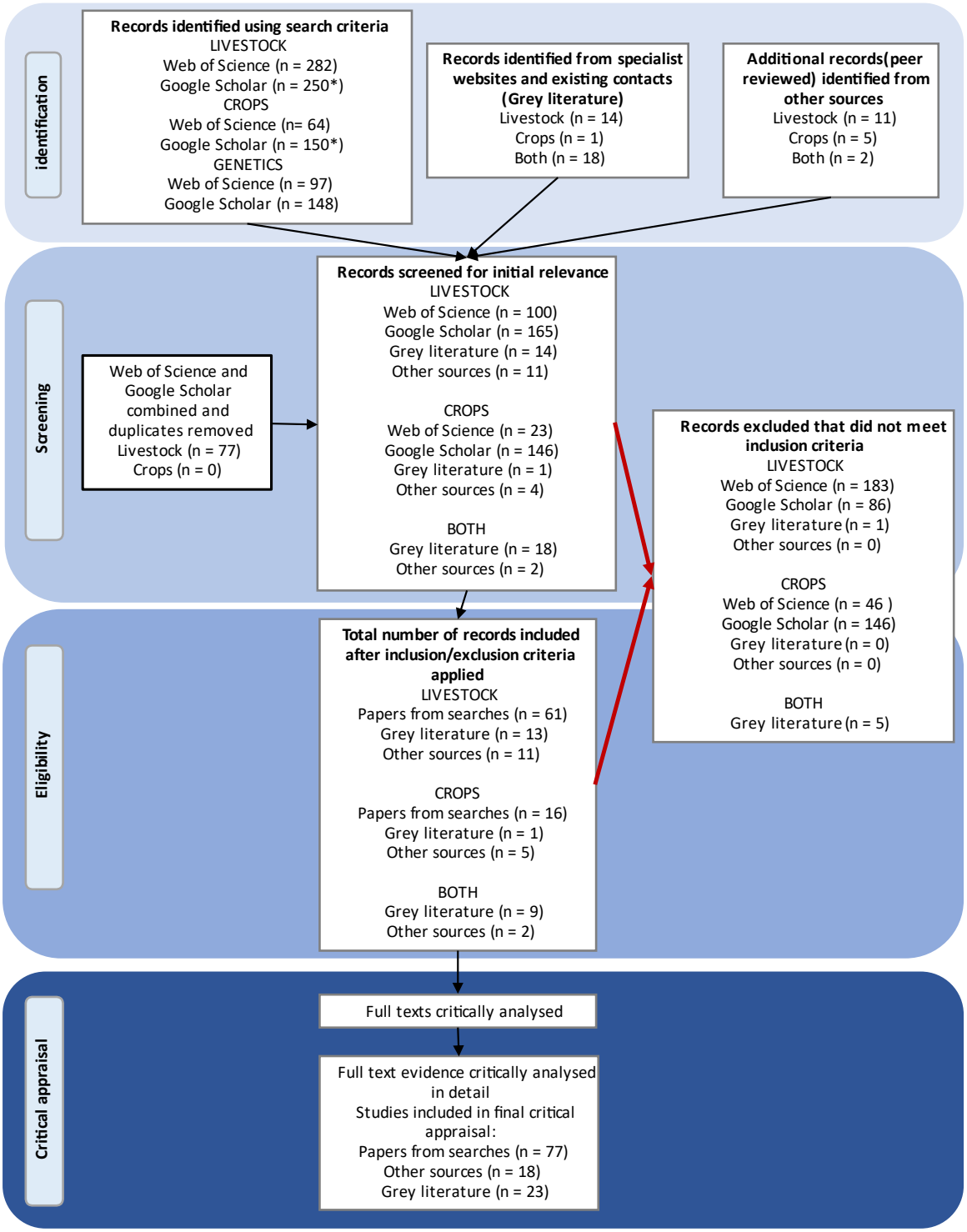
Full details are provided in the Appendix setting out the searching and screening strategies.
Overall a total of 95 peer review articles and 23 grey literature reports were judged to have met the inclusion criteria. A schematic showing the numbers of records that were included and excluded at each stage of the REA is shown in Figure 1.

Following this screening, the Web of Science and Google Scholar results were combined and duplicates removed (by Endnote). Records, abstracts, and where possible pdfs, were downloaded to

[1] Piasecki, J., Waligora, M. and Dranseika, V., 2018. Google search as an additional source in systematic reviews. *Science and engineering ethics*, *24*(2), pp.809-810.

an online EndNote library. Livestock and crops libraries were amalgamated at the end of the process in order to delete duplicates.

Fig 1 PRISMA diagram



2.4. Strategy for extracting evidence

A strategy for extracting evidence that relates to the main REA question was prepared, building on the database of included evidence. This ensured that the extraction was done in a way that was consistent for each piece of evidence. This was refined progressively through team discussions throughout the REA process.

2.4.1 Critical appraisal

Prior to this stage all screened evidence in the Endnote library was uploaded to NVivo 12 software.

In the critical appraisal stage the screened papers and reports were read and subjected to a full text analysis. As part of this analysis, each piece of evidence was evaluated to consider both the relevance of the evidence to the REA question, and the quality and robustness of the methodology utilised. Scores were assigned to each piece of evidence according to relevance and robustness of evidence. The criteria were tested and developed iteratively within the review team to ensure a consistent approach (see Protocol).

A framework for the analysis was developed based on the AHDB's behaviour factors that AHDB use for behaviour analysis and the working methods considered during intervention development. A coding structure was developed in Nvivo 12 software to code and analyse each piece of evidence. Given the focus of the review was on 'What works' the working methods were taken as the main framework for analysis and the behavioural factors (although conceptualised as determinants) have been reconceptualised as outcomes, i.e. the behaviours that change by applying the working method (Table 1). The methods were clustered for ease of analysis and reporting.

As described below, there is seldom explicit references to the behaviour method terms used by AHDB in the evidence, as such inferences were made. A team of four researchers undertaking the task met regularly to ensure a common interpretation was made.

Due to AHDB's interest in practical examples the appraisal style provides details of individual studies under each sub-heading (behavioural method) rather than providing an overall synthesis.

Nvivo 12 also provides a template for information extraction (a map) in the form of classification table which lists key attributes of the evidence such as methods used, and robustness and relevance scores. It was downloaded as an excel file.

This report is the outcome of the REA appraisal and is accompanied by the REA 'map' which documents the critical appraisal of the evidence, listing all evidence with associated relevance and robustness scores and behavioural methods referred to. This is supported by an EndNote library of all the evidence selected for analysis (together with pdfs). A database documenting the search records and screening decisions was also kept.

Table 1 Analytical framework AHDB behavioural methods (clustered)

METHODS	OUTCOMES
WORKING METHODS IN AHDB's PROCESS	**BEHAVIOUR FACTORS CHANGED**
Provide information and advice • Knowledge transfer • Concrete Action Perspective • *Checklists* • Messengers with authority • Messengers as role models • *Personalise message* **Stimulating the target audience** • Interpersonal Communications • Implementation intervention • Gamification • *Entertainment Education* **Feelings** • Emotions • Framing • *Priming* **Values and norms** • Descriptive norm • Injunctive norm • Identity • Commitment and Consistency • *Cognitive Dissonance* **Nudges** • Default nudge • Feedback nudge • Stimulus budge • *Kludge* **Small triggers /prompts** • Prompts • Friction costs • *Foot in the door* • *Substitution* **Rewards and losses** • *Present bias* • *Reciprocity* • *Scarcity*	**Individual** • Ability • Attitudes • Biases • Emotions • Habits • Intentions • Knowledge • Self-image

Italics refer to methods where there was no evidence

3. Results: the evidence

3.1. The Evidence - volume and characteristics

3.1.1. Volume

A total of 118 pieces of evidence were selected for the critical appraisal stage, these comprise 95 peer review studies located through Web of Science and Google Scholar searches, and papers suggested from other sources, and 23grey literature reports located through UK and international organisation website searches and expert suggestions.

For crops there were 21 peer review studies and 5 grey literature report, while for livestock there were 72 peer review studies and 13 grey literature reports, with 2 peer review papers and 9 grey literature reports covering both.

Scope: the bodies of literature

The scope of the evidence reflects the different bodies of research that have developed to understand the behavioural aspects of farming, this falls into the following types.

a) Peer reviewed papers, the majority come from the behavioural science perspective and are characterised by large-scale quantitative studies (surveys, questionnaires) including the following:

- A number of papers that evaluate factors (or barriers) that influence farmers' adoption of best management practices (e.g. Hyland et al., 2018); or factors associated with participation in a programme (e.g. Ritter et al., 2015).
- A number of papers that aim to predict adoption intentions using the Theory of Planned Behaviour (TPB) (e.g. Vande Velde et al.,2015; Hall et al., 2019) largely in livestock studies, which are often quantitative and large-scale.
- A small number of papers from the behavioural economics school looking at determinants of behaviour examining, for example, the determinants of farmers' biosecurity behaviours. (e.g. Toma et al., 2013).
- These are aligned to studies of decision-making (e.g. Roesch-McNally et al., 2017), some extend beyond the farm (e.g. Bartkowski and Barke, 2018), others look at the decision-making process itself (e.g. Doidge et al., 2020).
- These are complemented by published literature reviews of economic, behavioural and sociological literatures in different contexts (e.g. Mankad, 2016; Barnes et al., 2015).

b) Peer review papers that examine the effectiveness of extension methods (knowledge transfer and participatory approaches) comparing approaches and evaluating outcomes (e.g Moravek et al., 2017; Grant et al., 2018) using both quantitative and qualitative methods.

c) Peer review papers assessing novel approaches such as motivational interviewing (e.g. Svensson et al., 2019) and serious games (e.g. Martin, 2015).

d) Grey unpublished literature which falls into the following types:

- A collection of unpublished material drawing on programme experience and setting out principles for extension and behaviour change approaches, for example, BMP adoption (e.g.

InnoTech Alberta, 2017); or the New Zealand Red Meat Profit Partnership (Bewsell and Brenton-Rule, 2019).

- Evaluation reports of UK programmes such as CSF, (Environment Agency); AHDB's DairyCo PLI (Promar International Ltd and University of Reading, 2013); Farmbench (BMG Research, 2018); HerdAdvance (Rose et al., 2020); Innovative Farmers (CCRI, 2015, 2018); Farming Connect (Pates and Hindle, 2020).
- Literature and evidence reviews on: IPM (Adamson et al., 2020),; AHW (Escobar and Buller, 2014); antimicrobial use in livestock (Buller et al., 2015), and Estimated Breeding Values uptake (Brown, no date).

3.1.2. Scope

Sectors and Topics

Livestock studies dominate the evidence reflecting a growing body of social science work related to behavioural determinants in relation to AHW and biosecurity. Arable or cropping system behavioural studies are less well represented; studies cover a range of crops, horticulture is absent bar one paper relevant to smaller USA farms (Stock, 2020).

The extent of evidence across the five AHDB programmes differs: AHW is over represented, whereas evidence for the remaining topics is relatively limited: farm business evidence includes studies of Agrisgôp in Wales and business decision making in general (e.g. Owen et al., 2017; Syster et al., 2013; Hansen, 2015); IPM relevant evidence is limited (Adamson et al., 2020; Hayden et al., 2019); evidence relevant to the environment is covered by reports on water quality initiatives, best management practice, nutrient management planning, and agri-environment management (e.g. Environment Agency 2019; Lobley et al., 2015); for genetics, relevant evidence relates to crop breeding, GM potatoes and animal breeding (e.g. Annicchiarico et al., 2019).

Geographical

Whilst evidence from UK and Ireland is well represented, there is substantial contribution (almost half of studies) from other countries: Australia and New Zealand, North America, and Europe.

3.1.3. Characteristics

With respect to relevance, most evidence tends to assess factors and determinants that influence behaviour rather than the methods for achieving behaviour change. Similarly, although there is extensive evidence concerning the effectiveness of different types of extension methods this rarely drills down into the (intentional or unintentional) constituent behavioural methods or behavioural change outcomes. Evidence is limited for some of the behavioural methods, and absent for some (Table 1).

3.2. The strength of evidence

The strength of evidence is assessed using three components: relevance scoring, robustness scoring and consensus. Scoring (1 to 3, low to high) was assigned to each piece of evidence according to the methodology criteria (see Protocol).

Relevance scores in general are in the range 1-2 (average 1.8) in terms of answering the main REA question. Higher relevance was assigned to studies where practical applications of methods for

encouraging behaviour change were evidenced. Just 21 studies in total received a relevance score of 3. Studies with only marginal relevance to the REA question were scored low (1). Studies that assessed behavioural factors and determinants, rather than specific interventions were scored 1 as they do not directly answer the REA question.

There were no clear differences between the assigned relevance between livestock and crops with and average relevance score of 1.7 for sources specifically relating to crops, 1.8 for those relating to livestock, and 1.7 for those relating to both types of farming.

Robustness scores tended to be between the mid-range (2) and the maximum score (3); the average score for all studies was 2.5. The studies with low robustness scores were generally where qualitative methods used small sample sizes or specific case studies, or included hypothetical or modelling approaches.

There were no clear differences between the assigned relevance between livestock and crops. The average robustness score was 2.4, 2.4, and 2.5 respectively for crop-related, livestock-related, and general sources.

Peer review paper scoring reflects the relevance and range of methods used. Higher robustness scores were assigned to evidence where quantitative methods were used with a large sample size compared to a lower score for small qualitative studies with few participants. Any qualitative studies with >20 participants were assigned as robust as this is a sufficient number where data collected is qualitatively rich.

Grey literature was scored in the range 1-3, with 2 being the most common score for both relevance and robustness. The average scores for grey literature were 1.8 for both relevance and robustness. Just two pieces of grey literature were deemed highly relevant (3), and just 3 were assigned as highly robust (3) due to the lack of peer review. Those with larger scores reflect the scope of study and generally more robust methods while those with lower scores tend to include general recommendations and advice, often organisation- or initiative- specific. The few studies which were deemed highly robust had large sample sizes or what appeared to be a strong model.

Overall, the combined scores ranged from 2-6 with 4 being most common score. When taken together these (combined scoring and consensus) provide a weight of evidence that allowed us to judge the overall strength of evidence, which directed the analysis. Consensus among studies where there was a supporting body of evidence was used to complement the combined score. This allowed a hierarchy of evidence and more attention was paid in the appraisal to higher scored evidence, while low scoring evidence was generally not apprised in this report. However, given the AHDBs interest in practical examples more emphasis is placed on relevance.

4. Results: synthesis of findings

4.1. Provide information and advice

A number of papers assess the effectiveness of extension delivery methods and knowledge transfer and exchange mechanisms rather than behavioural concepts per se. However, these methods implicitly incorporate a number of the behavioural working methods or in some cases explicitly. This evidence builds on a large body of previous work and understanding in this area.

Taking the definition, *Knowledge transfer means to communicate the functional and affective benefits of the desired behaviour*, three sets of evidence are presented: combination of methods, one to one methods and training.

4.1.1. Knowledge Transfer: Combination of methods

There is general consensus in the evidence that a combination of knowledge transfer mechanisms is effective as these often complement each other. Two notable large-scale quantitative studies provide evidence from long term programmes. Interestingly both concur that the methods led to increased awareness, efficacy and confidence.

Moravek et al. (2017) provides a robust quantitative analysis of extension methods linked to practice change. The Grazing Best Management Practice Extension Support project aimed to support beef producers with extension activities to adopt grazing systems that are productive and profitable with improved water quality outcomes for the Great Barrier Reef in Australia. A range of extension approaches were used, workshops, one-on-one extension, producer demonstration sites, field days, e-extension. In the evaluation of the effectiveness of extension delivery mechanisms, 93 surveys of randomly selected producers who had engaged with the project from 2011 to 2015 were conducted. These quantified practice change, improved confidence (knowledge, attitude, skills and aspirations =KASA)[2] and intention to change. Results showed that targets for engagements, KASA and practice change were exceeded, demonstrating the success of the project. Also, the producers who interacted with the extension officers on grazing land management topics were significantly more likely to make a grazing land management practice change than those who did not engage in these extension activities. Interestingly, the type of interaction or delivery mechanism used between producers and the extension department did not influence resulting practice change. Either one-on-one extension and workshops, or a combination of these, were just as likely to result in practice change. The majority of producers reported confidence levels above four, out of a top score of 7, in their ability to make decisions due to interaction with the project but there was no significant difference in the percentage of producers undertaking practice change based on their level of confidence. It was recognised that invariably there is a lag between interaction and practice change. Four years after the inception of the project, all producers who had engaged with the department reported making a practice change.

The Catchment Sensitive Farming (CSF) approach used in England to improve management practices

[2] Feedback sheets were used at the end of key events, workshops and field days to assess participants change in KASA. Improved confidence was assessed on a scale of 1 (low) to 7 (high). This reflected the change in confidence to make a decision after an extension interaction. In 2015, improved confidence was changed from asking producers to rate change in overall confidence to asking producers about confidence in the specific management practice categories Confidence data were categorised into low confidence (1, 2, 3, and 4) and high confidence (5, 6, and 7).

for water quality, used a combination of group events followed-up with more specific one-to-one advice (Environment Agency, 2019). A mix of one-to-one and group events, as practised within CSF, can therefore be seen as optimal for effective delivery. The CSF evaluation report attributed a number of benefits to the combination of approaches. Over 40 per cent of farmers in both the High and Medium Priority Areas reported having made changes to their farm or the way that they farmed in the previous two years, that helped reduce water pollution. Significantly more CSF-engaged farmers (55 per cent) have made such changes. CSF-engaged farmers had greater awareness of, or concern about, water pollution. Among farmers who had made changes to their farm over two years, around seven in ten believed these changes had improved water quality at least a little. Effectiveness of implementation was linked to farmer understanding of how a measure reduced water pollution. This suggests that the advice delivered through CSF successfully raised awareness of water pollution and how it can be mitigated. Planned action to address water pollution also correlates with the belief that a farmer's own farm contributes to water pollution. Unravelling cause and effect is difficult. It is likely that farmers will be persuaded to implement a measure once they understand its potential benefits, but it is also possible that understanding how a measure improves water quality is enhanced from first-hand experience implementing a measure.

4.1.2. Knowledge Transfer: One to one advice

The value of one-to-one advice is well evidenced in the literature in a number of contexts (e.g. Garforth et al., 2013). The evidence reviewed here adds support to these previous findings and identifies some nuances.

In CSF, for example, the evaluation found that holding-specific, one-to-one, advice is most effective for building trust and confidence (Environment Agency, 2019). The CSF officers (CSFO) play an important role in supporting farmers to tackle water pollution. In the evaluation of CSF farmers surveyed agreed universally that CSFO have a good understanding of the issues relating to water pollution from farming activities; understood the needs of their farm; provided practical suggestions; was a person whose advice they could trust; was helpful and encouraging rather than telling them what to do; listened to them; provided them with new information; understood the range of grant mechanisms available for their farm. 80 per cent of CSF-engaged farmers indicated that working with their CSFO increased the priority they give to water pollution. The 128,691 measures advised through one-to-one farmer engagements have an overall implementation rate of 59.6 per cent. The impacts reported above can in a large part therefore be attributed one-to-one advice.

This concurs with a large-scale study by Grant et al. (2018) who evaluated the effectiveness of three knowledge-transfer intervention trial types (postal, group, one-to-one) to promote best practice to treat sheep with footrot in England. The intervention was a message developed from evidence and expert opinion, 'Six steps to sound sheep', which was summarised in six key words: catch, inspect, diagnose, treat, mark and cull. A questionnaire[3] was sent in 2013 with a follow up in 2014. The results

[3] In 2013, 4000 randomly-selected English sheep farmers were sent a questionnaire, those who responded were recruited to the postal (1081 farmers) or one-to-one intervention (32 farmers) trials. A random sample of 400 farmers were invited to join the group trial; 78 farmers participated. A follow-up questionnaire was sent to all participants in summer 2014. There were 72%, 65% and 91% useable responses for the postal, group and one-to-one trials respectively. In the 2103 questionnaire farmers reported on management of footrot, the prevalence of lameness in their flock and their opinions, knowledge and attitudes towards footrot. There were three classes of farmer management of lameness identified by latent class (LC) analysis: 11% 63 (LC1) used best practice, 57% (LC2) followed best practice but treated sheep within a week rather than 3 days and 32% (LC3) of farmers were more likely to use traditional managements (see O'Kane et al., 2016).

showed during this period that proportional between flock reduction in lameness and within flock reduction in lameness was greatest in the one-to-one, followed by the group and then the postal trial. The greatest behavioural change was a reduction in therapeutic and routine foot trimming and interestingly the greatest attitude change was an increase in negative attitudes towards foot trimming. All three intervention trial types led to a significant reduction in prevalence of lameness. The increased reduction in prevalence of lameness followed a "dose-response" effect, with farmers who received greatest exposure to the intervention message in the one-to-one trial having the greatest change in prevalence of lameness, followed by the group, and then the postal trial. One to one visits discussed farmer current management of footrot. Following this, the researcher(s) and farmer examined some lame sheep that the farmer had gathered. Throughout, the researcher and the farmer discussed best practice and whether a strategy could be identified so that the farmer could adopt the Six steps. The biggest behavioural change was in relation to foot trimming but this was gradual with an initial reluctance to stop foot trimming and a demand for more evidence and then later in the project (i.e. 2014) a rapid reduction in the percentage of farmers practising routine and therapeutic foot trimming.

The issue of the time lag to achieving outcomes was reflected in the study by Duval et al. (2018) of a Herd Health and Production Management programme involving 20 organic dairy farmers and their advisors in France and Sweden. The programme involved initially setting individual farm objectives and then through meetings with the farmers and advisors, monitoring herd health, identifying and implementing disease preventive practices, if deemed necessary, and finally evaluating them. Results from a questionnaire showed that the programme functioned as intended (e.g. by allowing early identification of herd health problems), stimulated change in farmers' herd health management practices and farmer–advisor dialogue. Even though the majority of the users perceived that the programme contributed to herd health improvements, no significant differences in health outcomes were found when compared with control farms 12 months after the start of the intervention.

One the benefits of one to one advice is understanding the individual needs of farms. Tailored services that meet the different needs of different types of producers based on farm and farmer characteristics such as type of commodity, experience, age, size of operation, education and culture can be effective according to a programme review (Alberta, 2017). This has been demonstrated with tailored on farm biosecurity advice (Cardwell et al., 2016) and the advice offered under Farming Connect whose success is attributed to personal, tailored and bespoke advice (Pates and Hindle, 2020). Also, Bard et al. (2019) when looking at how veterinarian-farmer interactions influence the enactment of change on farms, suggest that cattle veterinarians may benefit from tailoring advisory services to the farmer's specific world view, facilitated by a shared understanding of the farmer's immediate and long-term motivational drivers. To positively engage farmers in advisory interactions they could consider a farmer-centred approach that focuses on farmer priorities, motivations, and goals, as explored in section 4.2.2.

Some authors identify contextual factors around advice in the livestock sector. Borthwick et al. (2014) reports a scarcity of independent advisors with genetics expertise which is a barrier to uptake of Estimated Breeding Values (EBVs). They also suggest that there is a lack of use of the consultancy services that are available, and that the privatisation/commercialisation of advisory services can have a negative impact. They argue that farmers generally do not want to pay for consulting, but are sceptical of free advice, as they question its legitimacy. Furthermore, they suggest that if scientific information and concepts cannot be effectively translated by advisors for livestock farmers, then this results in a lack of understanding. The relevance of these findings to interpersonal communications and messengers is also clear.

4.1.3. Knowledge transfer: Training

As education and information access are known to be among the factors influencing multiple technology adoption, attention has been paid to the provision of education and training in a number of studies. The evidence available concurs that training has positive outcome although the means of assessment vary from self-reporting to a direct link to behavioural change.

Researchers tested the perceived impact of providing specific training to help farmers to understand the rationale and consider best management approach, for two Entry Level Stewardship scheme options sowing a Wild Bird Mixture (WBM) and establishing a Pollen and Nectar Mix (PNM) in field margins, to support pollinator species. Both options required a moderate level of skill to implement and have been demonstrated to be effective in encouraging wildlife. Twelve farmers from intensively managed arable/cereal farms of eastern-central lowland England and 12 from arable and mixed farms in South West England were recruited. Following baseline interviews with all farmers, group training events were convened in each study area. The training was provided by an experienced trainer and tailored towards the requirements of WBM and PNM. The training day was composed of two parts; the 'theoretical' and the 'practical'. 18 of the 24 farmers reported that the training had been significant or very significant to them, in improving the management of their ELS options. The impact of training can be identified in the short term on farmers' intentions and the longer term on their attitudes and actions towards agri-environmental management. The authors suggest that the intervention boosted farmers' confidence, encouraging them to view environmental land on a par with productive land (Lobley et al., 2013).

Farmer uptake of formal agricultural training and liaison with agricultural extension services are shown to have significantly improved mastitis herd health in a study in Ireland. Collectively, education, extension and milk recording resulted in an overall somatic cell count (an indicator of mastitis herd health) reduction of 25% for the average herd. The results from a regression model strongly suggested that both education and extension were positively related to the uptake of milk recording by farmers. The model presents the estimated odds-ratios and the results suggest that those farmers who undertook agricultural training were ten times more likely to monitor milk quality in this way compared to those who had not (Dillon et al., 2016).

In a study assessing training in biosecurity, workshop participants (22 from 12 institutions) in Northern Ireland farmers were asked to discuss and give their opinions about a series of questions across four key areas in a semi-structured approach with an external facilitator. The key areas were 1- disease risk perception at the farm level; 2-perceived barriers to implementing on farm biosecurity measures; 3-avenues to successful behaviour change and 4-key industry responsibilities and roles. The discussion showed that training in biosecurity for farmers is important and necessary. Training was recommended to be provided by veterinary surgeons, preferably via a face-to-face format. FBD groups and organised farm visits were identified as key training delivery mechanisms participants felt that exemplar farmers could play a key role in helping to inform, train and educate other farmers about biosecurity, aligned to the messenger role model method. There was a strong consensus amongst the participants that the focus of training should be on biosecurity relating to non-statutory endemic diseases (Lahuerta-Marin et al., 2018).

Some training is seen to be insufficient in some contexts. A study of Farm Safety-Awareness Workshop (FSAW) (630 workshops over 2 years) in New Zealand found only a small improvement in attitude and behaviours towards safety (Morgaine et al., 2014). The 5-hour interactive education sessions were implemented to "capture the hearts and minds" of farmers and farm workers, and bring about a change in attitudes and behaviours but the findings show that those who participated had a high level

of safety knowledge, but only a small improvement in their attitudes toward farm safety. Interestingly those which sent someone else to the workshop had a significantly higher safety and environment score than those who did not. It may be that having two people interested in safety - with one attending training - is enough to signal change. This poor outcome was not attributed to the training approach however it is noted that the Farm- Safe agencies have implemented further educational programs which focus on making an action plan for the farm, and farm skills development courses, which may have a longer-term cumulative impact.

4.1.4. Knowledge transfer: Providing information

According to a recent review of IPM evidence (Adamson et al., 2020) in order for education programmes (the term is conflated with knowledge exchange) to be successful, there must first be thorough research to avoid contradictory evidence and give clear messages to farmers. They describe a number of successful IPM education initiatives such as benchmarking and decision support tools largely for the research community (DEXiPM as part of the ENDURE project, EuroWheat, AMBER (Warwick Crop Centre)). The OSCAR project produced a toolbox and wiki but the impact was limited. They also note that there is a lot of IPM information available online but farmer to farmer was viewed as the most effective for achieving IPM uptake. Platforms that allowed growers to trial practices, discuss with peers and better understand the benefits and risks involved in the uptake of IPM built confidence and trust.

Clarity of the message is important particularly in new complex fields. Farmers can receive unclear messages and information from too many organisations making it difficult for them to identify and assimilate the appropriate knowledge. With regard to unclear messages from research, they refer to a 2019 Voluntary Initiative survey, 22% of farmers said that they receive too much information from too many organizations regarding IPM (Johnswire, 2019) (not reviewed here). They conclude that without accurate knowledge, IPM measures are not being used to their full potential and the results can discourage farmers from continuing to follow this approach. This is alluded to by Martin-Collado et al. (2018) who argue that complexity may be overwhelming farmers and compromise potential genetic gain in livestock industries animal breeding. Analysis of the literature suggest that the complexity of animal breeding choices is likely to lead to farmers using conscious or unconscious simplifying strategies (heuristics) to handle such complexity. When these heuristics are ineffective, poor selection decisions and a potential loss of genetic progress can be expected. Attempts are made to assist farmers in their choice making but their effectiveness is not well quantified and understood. There is also scepticism and mistrust of data used to generate EBVs, the data are farmer-recorded and, some suspect, manipulated (Islam et al., 2013).

4.1.5. Concrete action perspective

The concrete action perspective gives the farmer concrete tips and pointers in order to give them the confidence that they will be able to perform the desired behaviour. Evidence for this method is limited but the review identified the following two studies that used a structured approach that achieved this. Both identify benefits when combined with participatory approaches.

The 5 Farmer Action Groups (FAG) established in the South West of England aimed at reducing antimicrobial usage and improving herd health and welfare used Action Plans (Morgans et al., 2019; Morgans et al., 2021). The farmers met approximately every six weeks to discuss medicine usage. The

outcome of each meeting was for the farmers to co-create an Action Plan for the host farm of concrete practical measures to achieve antimicrobial reduction without adverse impacts on herd health/welfare. The Action Plans and host farm were re-visited several months later to discuss how well the Action Plans had been implemented. The farmers involved had implemented changes such as re-designing sheds to reduce the incidence of disease and increasing discussions with their veterinarians. On average more than half of the actions had been attempted by the second FAG meeting.

Although the preferred and most influential source of advice for many farmers is their own vet it has also been acknowledged that veterinary advice is not always followed even when perceived to be useful by farmers. A study was designed to assess the effectiveness of biosecurity advice packages specifically tailored to individual beef suckler farms, provided by veterinary practitioners via a participatory approach, in changing farmer behaviour and in reducing the risk of introduction or spread of infectious diseases (Cardwell et al., 2016). Veterinarians developed a set of recommendations tailored to specific risk characteristics of the individual farm and farmer, informed by results of the risk assessment as well as qualitative observations including the veterinarian's perception of the farmer's behavioural characteristics and decision-making priorities. Control farmers saw the results of their risk assessment but received only general feedback and advice, within the usual scope of the veterinarian-farmer relationship, and did not examine aspirational scores or agree on a specific strategy for improvement. Evidence of behaviour change in all participating farmers, indicated by reducing risk scores on both intervention and control farms, indicated that a structured annual risk assessment process, conducted as a collaboration between veterinarian and farmer, is valuable in encouraging improved biosecurity practices.

Along with other supporting activities (e.g. training, networking) farmers who comply with the LEAF Marque Standard have to complete of the LEAF Sustainable Farming Review. This online management tool provides guidance to support their implementation of IFM (including IPM) and their preparation for LEAF Marque certification as well as generates action plans, policies and review dates. An evaluation of the impact of LEAF Marque found that it allowed managers of the business to engage in a critical reflection on the strategic direction of their activities, resulted in savings for members and change in practice (e.g. general decrease in the use of plant protection products and increased testing of soil) (CCRI, 2017).

4.1.6. Messengers with authority

The use of a messenger who is regarded by farmers as an authority, can be effective in changing behaviour, by sending the signal that the behaviour is desirable.

Much of the evidence relates to studies of veterinarians who are considered important messengers with authority. There is consensus, however, that this authority can accompanied by an inappropriate style of communication. The relevance of these findings to interpersonal communications is clear.

Cardwell et al. (2016) argued that farm veterinarians are well placed to effectively advise on individually-tailored biosecurity strategies because they have the knowledge and are the preferred and most influential sources of advice for farmers. However, their impact is questioned and communication style criticised.

Veterinarians play an important role in influencing Swiss dairy farmers in decision-making concerning animal health and treatment according to Gerber et al. (2020). However, veterinarians were not viewed by farmers as important motivators for reducing antimicrobial use. Therefore, Swiss

veterinarians were encouraged to be aware of their influence on farmers' decisions and to use that influence to more clearly promote antimicrobial reduction on dairy farms.

Aligned to this, Escobar and Buller (2014) in their review of the active use of a Farm Health Plan (FHP), found that the relationship that farmers have with their vet is both a driver and a barrier to uptake of a FHP. Their research indicated that although a close farmer-vet relationship increased the likelihood of farmers having and using a FHP, farmers seemed reluctant to see vets getting actively involved in farm management decisions.

In line with this, Baird et al. (2017) suggest that the typical veterinarian adopted a paternalistic communication style that is largely directive in style; for example veterinarians use predominantly closed questions, rarely employ empathetic statements in relationship building and rarely encourage client participation in appointments. This is supported by the study by Svensson et al. (2019) reported in section 4.2.2. According to Baird et al. (2019) cattle veterinarians recognise their influence and the need to be proactive advisors but struggle with acting upon this awareness in daily practice, reporting a need to enhance their advisory approach to inspire farmer behaviour change.

Although authorities are often reliable sources of credibility, "experts", may not be the best way of encouraging farmers to use the AHDB benchmarking tool Farmbench, according to the evaluation (Research, 2108). Based on farmers responses to promotional videos, they suggest that the best messengers should have authority, expertise, but also should be relatable or "one of us" suggesting a role for both authority and role model messengers.

The involvement of an interdisciplinary team of scientists as participants was important for ensuring the science-based credibility of the Healthy Grown Potato Program in USA according to Duff et al. (2017). This also ensures practice change message, certainty, accuracy, and science-based credibility are important.

4.1.7. Messengers who are role models

The use of a messenger who has similarities with farmers can change behaviour by demonstrating to the farmers that they too can make the behaviour change.

Our review identified a number of studies that used role models as messengers. The evidence seems to concur that using farmers as messengers that are relatable can be effective, however, the value of experienced, influential and inspirational farmers was also highlighted suggesting that the term role model might need to be understood in different ways.

A study of the BETTER Farm Beef programme in Ireland undertook an in-depth examination of case study beef farmers to identify factors affecting farmer behaviour. One of the main results identified farmer role models as having high credibility among farmer peers in demonstrating the use of adaptation technologies (Áine Macken-Walsh et al., 2013). Also, in an evaluation of Farmbench, it was suggested that having the product presented by a relatable peer-like figure, rather than a professional farmer manager, may increase the credibility of the message (Research, 2108).

The premise of demonstration farms is that they should be relatable to farmers. In Farming Connect, after attending knowledge transfer events at a Demonstration Site, three beneficiaries, with help from their local development officer and guidance from experts, implemented changes on their farms. This has led to a reduction in antibiotic use, improved flock performance and improved profitability in the longer-term (Pates and Hindle, 2020). The AbacusBio review on genetic improvement of beef and

sheep in the UK highlights that knowledge exchange must be underpinned by demonstration farms to be successful with farmers (Amer et al., 2015). The lack of on-farm demonstration of the benefits of EBVs in beef and sheep was also identified by Borthwick et al. (2018) as limiting their use.

Experienced farmers have a positive influence on the adoption process as found with oilseed farmers in a study in USA. Embaye et al. (2018) recommended that oilseed experienced farmers should share their experience with other farmers, to provide mentoring and encouragement to less experienced farmers. Mentoring is identified as important in other initiatives, for example, the Red Meat Profit Partnership project in New Zealand farmers found that a skilled and successful mentor was very valuable for making changes on the farm (Denise Bewsell and Tony Brenton-Rule, 2019).

Mentoring is also a key part of Farming Connect, the national farming support service in Wales, which provides a mentoring programme to enable farmers to receive guidance and advice from their peers on a wide range of topics. They can access 22.5 hours of fully funded mentoring services with their chosen farming, over an 18-month period. Pates and Hindle (2020) in their evaluation identified a number of examples where the mentors have provided practical advice and guidance that enabled new practices to be implemented immediately and avoided uninformed and inappropriate decisions – for example one beneficiary consulted had accessed soil sampling on the advice of his mentor, which outlined phosphorous deficiencies that were having adverse effects on his herd's fertility and calving. Without the support of the mentor he would not have considered this as a potential issue and, it is likely that he would still be experiencing calving problems and losing money. However, Pates and Hindle also reported that the mentoring programme was under-utilised, with a lack of understanding of its potential value and a "taboo"/image issue around having a mentor.

Influential farmers who demonstrate leadership are also identified as important. The involvement of engaged and knowledgeable producers who are influential within the state potato and vegetable industry benefited the Wisconsin Healthy Potato Grown Program (Duff et al., 2017). The authors identified the following conditions in key agricultural producers to contribute to the success of the network of: (1) described as "early adopters" (i.e., producers who are particularly receptive to trying new practices); (2) hold leadership positions within their community or industry; (3) own or manage lands that are strategically important to meeting regional conservation goals; (4) own or manage significantly large or profitable operations, and are thus instrumental in affecting regional stewardship outcomes.

Inspirational farmers are important, particularly where the practice is novel. A study of farmers transitioning to agroecology identified the importance of inspiration (Padel et al., 2018). The farmers' interviewed (n=14) highlighted the crucial importance of seeing practical examples and of social networks to meet them. Several agroforestry farmers mentioned the same person as the main source of inspiration, support or advice. At present, such peer-to-peer contact opportunities with experienced practitioners of agriculture are valued but scarce. Although not connected to any particular intervention or evidenced with behaviour change, it supports the premise that other farmers are important messengers.

4.2. Stimulate target group

4.2.1. Interpersonal communications: Participatory group meetings

Stimulate the target group to talk to each other about the subject

There is an established body of literature providing evidence about the effectiveness of interpersonal communications in groups referring to facilitation of participatory group activities, discussion groups, social networks and peer to peer learning. The evidence here contributes and builds on this. Although not explicitly referring to the behavioural methods, these studies clearly incorporate a number of those that aim to stimulate change. Also, as group activities are a vehicle for introducing other approaches such as plans, tools etc, the evidence here relates to more than interpersonal communication.

A range of different forms of evidence point to similar conclusions with regard to the positive impacts of participatory group meetings on behaviours. The group activity takes a number of forms and the behaviour change assessed ranges from self-reported changes in practice on the farm to enhanced confidence.

Participatory group meetings are used to facilitate interpersonal communication by stimulating the participants to talk to each other about the practice change. A number of studies highlighted the effectiveness of participatory meetings in stimulating practice change. For example, a study investigating Swiss dairy farmers' motivation to reduce antimicrobial asked farmers about the value of organized meetings and discussion between colleagues and its influence on their decision-making. Thirty-seven of 55 farmers liked the idea for organized group meetings with their work colleagues for professional exchange and rated it as important or very important. Most (41/55, 74.5%) of the farmers ranked the statement "I can benefit from the meetings" as important or very important . Furthermore, the majority of respondents (37/55, 67.3%) indicated that they had implemented tips received from other farmers during group meetings (Gerber et al., 2020).

Ontario Focus Farms (FF), is an agricultural extension approach that aims to influence producer behaviour by addressing their knowledge and attitudes (Roche et al., 2015). Conceptually, FF uses the principles of adult education and experiential and participatory learning theory and follows 4 key principles: (1) participatory, self-directed, and collaborative, based on group-identified priorities; (2) honest communication and trust; (3) planning, action, and implementation; and (4) reflection. Practically, FF is implemented as a series of meetings, with group sizes between 7 and 12, which are facilitated by professionally trained veterinary practitioners. The proportion of FF participants who reported making at least one on-farm change (81%) was significantly higher than that of control respondents (38%). The FF respondents significantly increased their score at the post-intervention assessment, with a median of 82.8% (24/29); control-respondent scores did not significantly change.

The Farmer Action Groups helped play a role in creating an attitude shift in farmer participants away from using antibiotics, as qualitative data shows (Morgans et al., 2019). Farmers involved have implemented changes such as re-designing sheds to reduce the incidence of disease and increasing discussions with their veterinarians. They became confident in trialling new treatment protocols and initiating conversations with their vets about antimicrobial products used on their farm. The sharing of successes and challenges within a cohesive group of farmers and hearing from other like-minded farmers has given participating farmers the confidence to reduce reliance on antimicrobials. Feedback from the participants has been overwhelmingly positive. Farmer participants felt empowered and encouraged by the peer-to-peer learning environment.

Similar observations come from two evaluations of Farmer Field Labs (latterly Innovative Farmers) (CCRI, 2015, 2018). Analysis using a range of methods (Interviews, surveys, cases studies and a facilitator workshop) showed for phase one that the majority of survey respondents (86%) agreed that their understanding of the topic had been enhanced by attending the Field Lab. Evidence of farmers changing practices was less clear. Whilst participants were inspired to do something new or differently on their farm (just over half of survey respondents), actual change or plans to change were less evident (37% of respondents). At the second phase overall 95% respondents reported learning something new from their participation, 66% have made or are planning changes to their farming system, with 28% reporting it was too early to decide.

Discussion groups are a forum for interpersonal communication that have been extensively studied. In Farming Connect many of the beneficiaries consulted had made cost savings as a result of support they had received through Discussion Groups (Pates and Hindle, 2020). These Discussion Groups typically involve 8-10 members who raise the same animals/grow the same crops in the same locality and thus face similar challenges and opportunities. Each Group is facilitated by a FC member of staff and each meeting covers one topic and lasts around two hours, including a presentation from an expert speaker. An incentive budget of £250/300 per farm per year is provided to allow farms to try something different on their farm. 30% of the group members had undertaken benchmarking and there was evidence that beneficiaries had learned from their peers how to improve silage storage, reduce antibiotic usage, better control mastitis, and change foot bathing policy to reduce dermatitis.

Discussion Clubs are part of Tine Efficiency Analysis (TEA) in Norway, which is an advisory service where dairy farmers' financial results are compared with other farms of similar size and region. According to Hansen (2015) through membership TEA farmers learn to improve their problem solving, and this improves their financial performance. The findings also showed that frequent interaction with dairy consultants through regular farm visits helped farmers become more proactive, given that they have enough relevant knowledge.

In an evaluation of discussion groups in Ireland Lapple et al. (2013) assessed whether discussion group participants have improved farm profits. Generally, the discussion groups consist of 12–15 dairy farmers who meet several times a year usually at demonstration farms, but also at farms of discussion group members. During a discussion group meeting, farmers share ideas and information among themselves while examining different parts of the farm where the meeting is hosted. To encourage membership in discussion groups, the Dairy Efficiency Programme not only funds the facilitation of these groups but also provides farmers with a payment of approximately €1,000 per year for participation. Analysis showed that farmers with larger, more intensely farmed holdings were more likely to participate in discussion groups. They find that even after controlling for this self-selection bias, the economic returns to discussion group members are positive, on average €310 gross margin per hectare (or an approximate 12% increase), thus supporting government targets to enrol more farmers in discussion groups. This is similar to findings from Lapple & Hennessey (2015) who used data from a dairy farm extension programme operated in Ireland, to assess whether farmers who joined before a financial incentive was introduced received larger benefits from the extension programme than farmers who joined after the financial incentive. They found that farmers who joined discussion groups before the financial incentive was introduced received a return from discussion group membership of €150.7 gross margin per cow and were also able to achieve higher milk yields of 355 litres per cow.

One study compared the learning and adoption outcomes for discussion groups within the Beef Technology Adoption Programme (BTAP) in Ireland and monitor farms in Scotland (Prager and Creaney, 2017). They assessed these outcomes as generally higher for discussion groups than for the

wider monitor farm participants, although the most substantial practice changes can be expected for the monitor farmer. They argue that the more structured the group extension approach and the more detailed the programme targets, the more likely it is to achieve the expected (technology adoption) outcomes. However, they question whether discussion group members who have adopted practices for the duration of the BTAP group, may abandon the innovation afterwards. The timing of an evaluation therefore has a critical influence on its results.

Duff (2017) describes a participatory approach used to connect enrolled producers in the Healthy Grown Potato Program with support from extension professionals from the University of Wisconsin-Extension and agricultural industry representatives, and non-profit conservation scientists. Participants from the program attend meetings and events where they can communicate the accomplishments and lessons of the network in practice, however, they found that it is often the unplanned conversations and interactions that circulate the expertise and shared experience of the network actors. This contrasts to this recommendation for a structured approach made by Prager and Creaney (2017).

A further participatory group programme, is Agrisgop, funded by Farming Connect in Wales. The programme involves an Action Learning process designed to develop management capabilities, instigate change and empower and encourage group members to create viable and sustainable businesses across all sectors. It involves a group of farmers who regularly meet with an experienced facilitator, with each group member being given the opportunity to develop an idea or resolve an issue with the support of the group. Other group members are encouraged by the facilitator to ask clear, open, neutral questions with a view to supporting the group member to develop their own solutions. Over 1,000 Agrisgôp group members completed questionnaires as part of a longitudinal study designed to evaluate the impact of the programme. The respondents reported increased confidence, improved communication skills, were better able to apply new information to their business, had a more positive attitude to change, and were more likely to have a long term business strategy as a consequence of the Agrisgôp group intervention (Owen, 2017).

Although not linked to any particular behavioural change method, peer to peer learning is identified as a powerful influence in groups. It can be facilitated through group extension methods or occur informally amongst peer interaction. More complex or new practices in particular benefit from farmer-to-farmer initiatives. Given this it was suggested that more should be set up to provide support groups to encourage successful IPM adoption (Adamson et al., 2020). In a study of farmers transitioning to agroecology the support of social networks and peer to peer learning is important in helping farmers make the necessary changes in their personal and professional beliefs and mind-set, in relation to management of the farm and the environment, but also about the relationship with buyers. Other farmers also support emotional shifts in enjoying new skills and knowledge (finding your own agronomic solutions, involvement in marketing, discussions with community) and gaining confidence (Padel et al., 2018).

The role of social networks was explored in an agent-based model of farmer adoption of Bacillus thuringiensis (Bt) maize as part of a population genetics model of resistance to Bt toxins by the insect Ostrinia nubilalis (Saikai et al., 2021). Neighbouring farmers have been shown to create local environments that affect individual farmer adoption decisions, both broadly and specifically for hybrid maize seed and Bt maize. To capture this social network effect, the model assumes that farmers are connected to farmers in neighbouring fields. The model showed that the most effective mitigation policies for maintaining a low resistance allele frequency were 50% refuge and localized bans. Social networks further enhanced the benefits of refuges relative to other mitigation policies but accelerated the emergence of resistance.

Without genuine participation group approaches are not always effective, however. In one study of the influence of a disease control scheme (the Norfolk-Suffolk Bovine Viral Diarrhoea Disease (BVD) Eradication scheme) on farmers' bio-security attitudes and behaviours (Azbel-Jackson et al., 2018). In 2010, a survey of 100 cattle farmers (53 scheme members vs. 47 out of scheme farmers) was undertaken among cattle farmers in Norfolk and Suffolk. The study found that while participation in the BVD scheme improved farmers' perception of the scheme benefits and participation in training courses, there was no impact on farmers livestock disease priorities or motivation for scheme participation, knowledge or bio-security measures employed. It appears that the explicit goal of the scheme did not relate to the formation of farmers groups or group participation per se but that local veterinarians led the scheme and encouraged farmers to participate. They concluded that to enhance farmer bio-security behaviours significant effort must be made to address underlying attitudes to the specific disease threat involved (see section on Emotions).

It should be noted that although participatory crop breeding has not been evaluated, no evidence is available about the effect of interpersonal communication or participation in groups on farmers behaviours in this context (Annicchiarico et al., 2019; Goldringer et al., 2019).

4.2.2. Interpersonal communications: Communication styles

Motivational interviewing (MI) is a collaborative, conversational, communication approach, that is designed to empower people to change by drawing out their motivations and capacity for change. It evokes a person's own desires, reasons and willingness to change as a means of clarifying and strengthening their positive intent. Critical to this process is the relational context of empathy, acceptance and partnership, which facilitates the spontaneous emergence of the language of change, combined with technical communication skills that shape and enhance. A study at the University of Bristol evaluated a 6-month MI-training programme for veterinarians with participants' MI skills being evaluated before and after training using audio recordings of roleplay conversations with professional actors. Their analysis showed that veterinarians in the role-play and on-farm conversations relied predominantly on giving information, questions, and persuasion in their consultation approaches. Veterinarians gave advice without exploring the client's need for the advice or how the information was perceived. They found a significant reduction in so-called relational scores (Empathy plus Partnership) and an increase in MI-nonadherent behaviours (Persuasion plus Confront) as years of veterinary experience increased. Results showed that there was room for improvement in the communication style of veterinarians involved in VHHM. However, all participants improved their MI skills after training in at least one parameter (Svensson et al., 2019).

Motivational interviewing is also seen to be able to empower farmers to utilise their own knowledge and motivations in herd health discussions, this is important as farmer behaviour surrounding mastitis is underpinned not only by practical considerations, but also by established beliefs, many of which may conflict when considering how to address issues on farm (Scrase and Reyher, 2015).

4.2.3. Implementation intentions

Implementation intentions refer to activities that stimulate the target group to formulate concrete plans to implement the desired behaviour in specific situations. This method is closely related to the Concrete Action Perspective.

The value of providing concrete plans is recognised with respect to action plans, standards and tools. Although not extensive, there is some evidence of implementation intentions being effective although only one demonstrating direct behavioural change.

The Agrisgôp initiative and the Farmer Action Groups described earlier (Owen, 2017; Morgans et al., 2019), demonstrate implementation intentions as the groups prepare plans which identify concrete actions to be implemented. The HerdAdvance interim study also found that farmers appreciated simple data collection charts especially if they have not collected data previously (Rose, 2020).

For genetic improvement and selecting sires, DairyCo recommend that GB dairy farmers use PLI (Profitable Lifetime Index) as a screening tool to filter down to a 'short list' of high PLI bulls and then make the final selection based on particular traits or other requirements of the farm. A study with focus groups and a survey (n=141) identified factors contributing to the perceived sub-optimal uptake of such recommended breeding strategies (Promar International Ltd and Reading University, 2013). The main finding was that outcome attitude, the measure of the persons attitude towards PLI is the main driver, with knowledge of PLI being important for forming positive attitudes towards them. Subjective norms were not correlated significantly with intention, however 'other farmers' were likely to be the most influential referent in modifying farmers use of PLI. This contrasts to a study in the same year examining why AHDB members were not referring to EBV (Estimated Breeding Values), the equivalent genetic index for beef farmers in EBLEX's 'Better Returns Programmes'. The single biggest predictor that a respondent did not intend to refer to EBV was a belief that it is "Better to rely on visual assessment and experience rather than EBVs". This concurs with Martin-Collado et al's (2018) study of EBVs reported above. These studies all agree that farmers had a range of motivations which determine whether they use these tools or not.

An example of enacting implementation intentions is highlighted in the Wisconsin Health Grown Potato Program. This agricultural network translated its early shared goals into the Healthy Grown Potato Standard, an open, modular, science-based set of best practices that are implemented by the enrolled agricultural producers. The open format allowed for regular revision and expansion of the standard as the conditions of system change, in response to issues raised by program participants, or with scientific advances related to agroecosystem management (Duff et al., 2017).

Motivational interview (MI) as described above can lead to implementation intentions. One study looked at the effectiveness of Motivational interview (MI) on the uptake of strategies for reducing injurious pecking (IP) in 29 flocks of free range (FR), aviary and enriched cages (EC) (Baker et al., 2020). MI was used to facilitate farmer ownership over maintaining feather cover by co-developing bespoke Feather Cover Action Plans (FCAP). The approach resulted in 80% of farmers making changes to their management and resource provision, with 90% of farmers of (FR) and half of those using (EC) making changes. Up to 9 actions were planned in their FCAP (average 3 on FR farms) and 67% of all planned changes had been achieved on average 9 months later.

In Grant et al.'s (2018) study the intervention was a message developed from evidence and expert opinion, 'Six steps to sound sheep', which was summarised in six key words: catch, inspect, diagnose, treat, mark and cull. There was a marginally greater reduction in lameness in farmers using most of Six steps than those not using Six steps at all. When farmers followed the 'Six steps' and stopped routine foot trimming, reduction in lameness from 2013 to 2014 was 22% across all flocks and 30% in flocks with 5 – 5% lameness in 2013.

Although no evidence is presented, Jansen et al. (no date) in the HIPRA Mastipedia document notes the value of tools in implementation intentions (as well as in prompting). There are many tools available to optimize udder health (technical provisions, analytical software). Convenience seekers, can be stimulated to take little steps towards change, for instance by doing an analysis of year-round

mastitis data, rather than aiming at a monthly approach. A modification to a stepped approach was suggested in a study on the use of biosecurity measures in UK. Richens et al. (2019) carried out a cross-sectional study with postal questionnaires sent to 2505 dairy cattle farmers in USA. They identified an opportunity to develop stage-matched interventions that might help to transition individuals from the pre-action to action stages (rather than using the five stages on a continuum proposed in TTM theory). This aligns to removing steps and frictions costs.

4.2.4. Gamification

Gamification is making use of gaming techniques in an environment where that is not usually done, in order to motivate the target group by means of gaming elements.

A number of studies were identified that used gamification to stimulate and motivate farmer learning and behaviour change. The evidence in the most part is from farmer participants, with one study using simulations in a lab setting. Although there is no evidence of direct behavioural change, the games lead to enhanced learning an understanding.

Martin (2015) describes the Forage Rummy board game, in which French farmers' groups use their empirical knowledge to select and combine sticks and cards representing forage crop and grassland production and animal feeding, production and reproduction from a range of possibilities to design a livestock system. The system designed is instantaneously evaluated using a spreadsheet from a computer model among other things about the matching of forage production and animal feeding requirements. Throughout the iterations, it aims at developing farmers' adaptive capacity by stimulating their reflections and discussions. Two thirds of farmers replied that they had liked to get a better understanding of the adaptation challenge at the farm scale and to share knowledge about most promising adaptation practices with their colleagues.

Ambrosius et al. (2019) analysed the effect of social interaction on the diffusion of investment strategies in capital-intensive livestock production systems with groups of Dutch pig farmers, using a simulation game. The game was constructed to stimulate interaction and to trigger the imagination of the participants. A total of seven sessions were played, with 4–8 pig farmers and/or participants who were affiliated to the sector as an advisor or successor. The results showed that (1) only investment strategies with a financial benefit, under influence of social interaction, resulted in high adoption; (2) for high adoption to occur, communication between participants was necessary; (3) opinion leaders played an essential role in high adoption of investment strategies; and (4) there was a common understanding among participants that favoured scale enlargement. The gaming methodology triggered participants to communicate their tacit knowledge, i.e. assessment criteria that are important in real-life investment decisions, and to experiment with investment strategies.

The risk of genetically modified presence at field level was assessed using a role-playing game and simulations in Sausse et al.'s (2013) study, The results of the first round in Beauce, France, show how the game improved players' assessment of risks as a function of the distances between fields and made them more aware of the importance of information. The participants agreed that the method adopted encouraged their active participation, probably more than other more common participatory methods might have done, like focus groups or workshops where stakeholders do not assume a role and do not manipulate realistic objects, though simulated.

Utilizing a "serious gaming" approach Merrill et al. (2019) examined how information about infection risk impacts compliance with biosecurity practices in USA. Participants (non-farming) acted as workers

in a simulated swine production facility and were confronted with experimental treatments that differed by the risk of infection if they broke protocol. This showed that compliance is influenced by message delivery methodology, with numeric, linguistic, and graphical messages showing increasing efficacy, respectively. Moreover, increased situational uncertainty and increased risk were correlated with increases in compliance behaviour. With increased diagnosis and contagion uncertainty, participants increased the frequency of their safe choices (compliance with biosecurity). Graphical information in the form of a threat gauge increased compliance more than information delivered linguistically. They also found evidence of psychological distancing—the more time that passed since participants experienced the consequences of their animals getting a disease, the less compliant they became.

4.3. Feelings

Our feelings can influence behaviour change by generating the personal response, connection and agency within us to change behaviour.

4.3.1. Emotions

Triggering emotional responses can influence behaviour change by *linking positive feelings to the desired behaviour, or negative feelings to the undesired behaviour.* There is a clear connection to framing and to rewards and losses.

Although recognised as important, evidence for the effectiveness of applying this behavioural method is limited.

There is evidence that farmers demonstrate different emotions in connection with farm management. For example O'Kane (2017) in a study of the management of footrot in England looked at the influence of farmers' emotional reaction (compassion and empathy) to footrot in their sheep on the uptake of best practices. From analysis of a questionnaire sent to 4000 farmers (32% response rate) they concluded that emotions and personality traits are associated with differences in farmer management of footrot and prevalence of lameness. Also, that further understanding about how personality and emotions influence change in behaviour is key to increasing uptake of new information. They suggest that modern personality theory and evidence shows that personality traits can change in response to specific training. Similarly Doidge et al. (2020) analysed data from 431 posts by 133 different users of an online discussion forum were analysed and identified negative emotions as one of the five categories that influenced farmers risk perceptions around prophylactic antibiotic use in lamb.

Emotions can be used to connect to farmers' different needs. Although not presenting any evidence, in their evaluation of Farmbench, BMG Research (2108) recommended that as well as appealing to a narrower concept of self-interest by talking about Farmbench's ability to save farmer's money, AHDB could develop more emotional appeals. This they argue can be focused on the varying motivations of the farm audience. For example, messages could appeal to the farmer's needs for security, protection, safety and stability, whist at the same time also appealing to their need for self-actualisation and the ability to realise their farming potential. There are clear links here to farmers' perceptions of risk.

Trust is a powerful emotion and critical to the success of a number of approaches and behaviours. This

is well evidenced in the literature (e.g. Rust et al., 2020 (not reviewed here)[4] and reinforced by the evidence reviewed here with respect to one to one advice and interpersonal relationships. Trust in the advice and the source of the advice is an important factor in achieving behavioural change. Bard et al. (2019) identified the importance of a critical bond of trust between farmers and veterinarians in influencing behaviour change. The sense of trust between farmer and veterinarian was reported to build up over time and become embedded through a variety of attributes of the working relationship (longevity, intensity, frequency of communication, sociality, community integration), facilitating the decision to trust and enact behavioural change.

This long-term relationship is typical of many one to one advisory associations. A clear link is also apparent between one-to-one engagement and trust and confidence in CSF's effectiveness in tackling water pollution. 70 per cent of one-to-one engaged farmers state they have trust and confidence in CSF, compared to 50 per cent of those attending only group events (Ipsos MORI, 2014 cited by Environment Agency (2019). Trust in/perceived usefulness of the different information sources is also known to influence technological uptake (Toma et al., 2020).

Animal health information sharing had a large emotional component. Shame is another emotion closely linked to social approval (disjunctive norm). In the study of the influence of a disease control scheme (the Norfolk-Suffolk Bovine Viral Diarrhoea Disease (BVD) Eradication scheme) on farmers' bio-security attitudes and behaviours farmers reported that sharing information about animal health to be a very sensitive subject (with 36% of in scheme farmers and 34% of out of scheme farmers reported to share the information about animal health with members of their social network). Wider animal health issues were also not disclosed, 75% of the in-scheme farmers and 72% of out of scheme farmers noted that they were too embarrassed or/and ashamed to discuss livestock disease. participants in both groups explained their choice to not share animal health information in order to avoid feeling embarrassed or ashamed. The links to social approval (disjunctive norm are clear) (Azbel-Jackson et al., 2018).

4.3.2. Framing

Framing means referring to something in such a way that positive or negative associations become attached to it.

There is limited and conflicting evidence of the value of framing, there are no studies that made a direct association with behaviour change.

Frames are different arguments about or conceptions of an issue. Framing effects are increasingly recognized as an important influence over decision-making. The role of framing in the context of farmer decision making about conservation tillage practices potentially eligible for carbon (C)-offset credits was investigated by Andrews et al. (2013). The results confirmed the importance of prior beliefs and experiences in moderating framing effects. The same frame can have very different effects on groups with different prior beliefs.

Framing was also successful in Le Coent et al.'s (2017) study of farmers' willingness to participate in two agri-environmental scheme contracts. One scheme adopted a negative goal framing (it prevents

[4] Rust, N.A., Ptak, E.N., Graversgaard, M., Iversen, S., Reed, M.S., de Vries, J.R., Ingram, J., Mills, J., Neumann, R.K., Kjeldsen, C. and Muro, M., 2020. Social capital factors affecting uptake of sustainable soil management practices: a literature review. *Emerald Open Research*, *2*(8), p.8.

or avoids a loss) being framed as part of a biodiversity offset program, the other a positive goal framing, as part of a biodiversity conservation program (it provides a benefit or gain). The biodiversity-offsets programs were viewed less favourably than the biodiversity conservation programs. Grant et al. (2018) evaluated whether the benefits of best practice to treat sheep with footrot framed positively (highlighting the gains from best practice adoption)) or negatively (focusing negatively on losses incurred by not adopting best practice) influenced change in behaviour in large-scale study (described above). Unlike Le Coent et al. (2017) they found no message framing effect, there was no difference in prevalence of lameness by framing, although they hypothesised that farmers open to new ideas or already using some or all of best practice to treat sheep lame with footrot (i.e. LC2) might consider the risk and uncertainty about the outcome of adopting best practice as low and thus respond to gain framed messages whilst farmers resistant to change, using traditional techniques to manage lameness (i.e. LC3) might consider the risk and uncertainty high and thus respond better to loss framed messages). This lack of consensus is most likely due to the different study settings, as the first concerns environmental behaviours in a development planning context, and the second, specific farm management practices. More evidence is therefore needed to draw any conclusions.

4.4. Values and Norms

The influence of social norms on decision-making and behaviour has long been recognised in the context of farming (see for example the review by Mankad 2016). Norms are an inherent part of social systems and structures, such as farming groups or communities and are typically developed through a process of socialisation within a given social context so are linked closely to group activity and social networks.

Social norms are defined as having two perceptual references: perception of what is commonly done in a given situation (descriptive norm) and the perception of what is commonly approved of (injunctive norm).

4.4.1. Descriptive norm

Descriptive norms demonstrate that the desired behaviour is displayed by the majority of other people (who are important to the target group).

There is a range of evidence from different contexts that agrees that descriptive norms can be influential although this is rarely linked directly to changing behaviour. More often qualitative outcomes such as increased confidence or farmer beliefs were assessed. Whilst it is agreed that normalising certain behaviours should be encouraged, currently there is limited evidence of initiatives directly applying this approach.

Descriptive norms are illustrated in benchmarking where farmers are encouraged to compare themselves to their peers. A qualitative study involving 18 dairy farmers in Canada assessed the effect of benchmarking reports, providing data on calf performance and peer comparison, on how farmers think about calves and their management (Sumner et al., 2018). Benchmarking encouraged farmers to make changes in their calf management by identifying areas needing attention and promoting discussion about best practices. Collectively, the responses suggest that benchmarking motivated farmers to improve calf management because of the intrinsic and instrumental value of having access to data and peer stock comparisons. This instilled a sense of confidence and having control over the outcomes. Benchmarking allowed farmers to changed ingrained habits, to thinking 'outside the box' and to prompt new thinking regarding calf nutrition. Peer comparison also motivated farmers based on a sense of pride in doing well, although this was valued less if participants believed that the

performance differences were related to different strategies at work on the different farms. The data also supported farmer efforts to enact change and strengthened their role as a decision-maker as the reports were used to help convince a family member that increased milk allowance would be beneficial. However, making changes based on access to data in the first report led to the expectation that there would be improvements, and this led to a sense of ambivalence if these were unrealized.

In another example, a study of biosecurity reporting in Australia found that producers rated moderately highly the fact that most producers think that other producers in their district would report emergency animal diseases when found. This indicates that producers perceive a social norm to exist for monitoring and reporting suspicious clinical signs of disease (Wright et al., 2016). They believe that these behaviours are expected of them (the normal thing to do) by other members of their community and that the expectations placed upon them are not unreasonable. The study concluded that , if social norms are related to behavioural intentions, intervention strategies that capitalise on social rewards of approval and social sanctions of peer disapproval are likely to be effective. For example, using social networks to communicate information and provide support. The use of field days (where producers come together on farm) to communicate "role model stories" describing behaviour change successes is another suggested option.

A review of the effect of animal health compensation on 'positive' behaviours towards exotic disease reporting and implementing biosecurity (Barnes et al., 2015) also noted that the behaviour, or perceived behaviour, of neighbours is referred to in a number of papers as an influencing factor in biosecurity behaviour on farm.

This is supported with a study by Marier et al. (2016) which presents British farmers' perception of, and barriers to, implementing Salmonella control on pig farms, where three intrinsic factors known to influence motivation –attitudes, social norms and self-efficacy – were evaluated using interviews. Both before and after the intervention trials, all farmers had a positive attitude towards Salmonella control and felt that their peers and authorities were supportive of controlling Salmonella on farms. This study confirmed that farmers recognised their responsibility for controlling Salmonella in pork –even though their confidence in their ability to control Salmonella (self-efficacy) decreased over time

In other examples, the Wisconsin Healthy Grown Potato Program, an agricultural network, translated its shared goals into the Healthy Grown Potato Standard which acted to influence social norms and expectations of farmers concerning resource use and management of the agroecological system (Duff et al., 2017). The CSF evaluation also found that peer group learning at group events is important for developing farmers' confidence and skills and establishing CSF as a good farming 'norm'. Also, Carlisle (2016) in a review of factors influencing farmer adoption of soil health practices in USA recommends highlighting the growing use of soil health practices by mainstream producers and researchers to 'normalize' soil health practices. However, normalising a situation is not always positive as Reyher (2016) notes with mastitis as it occurs in all herds, making its presence often normalised, both in farmer attitudes and in subjective norms.

4.4.2. Injunctive (subjective) norm

An Injunctive norm is seen when a link is made to social approval of the desired behaviour. It is very similar to subjective norms often referred to in the theory of planned behaviour as it incorporates the potential of normative social influences.

A number of studies, although not looking specifically at the impact on behaviour of interventions, confirm the importance of subjective norms. This is in line with other research showing that 'subjective norm' is a particularly important determinant of farmer behavioural intention, for example in the context of farmer decision making and soil health (Bartkowski and Bartke, 2018) and other contexts (Schaak, Mushoff, 2018; Senger et al., 2017 (not reviewed)[5].

The evidence reviewed here provides further insights to this relationship, highlighting some conflicting results. These studies assess perceptions or intention of farmers rather than actual behaviour change as a result of using this as method. The evidence also identifies how injunctive norms overlap with descriptive norms and operate in combination with other behavioural and structural factors. This adds to the body of work cited by (Rose et al., 2018) (e.g. Kauppinen et al., 2013; van Dijk et al., 2015; Kuhfuss et al., 2016; Mills et al., 2017).

A number of large-scale studies largely in the livestock sector endorse the importance of social norms. In the context of biosecurity, Richens et al. (2018) carried out a cross-sectional study with postal questionnaires sent to 2505 dairy cattle farmers in GB. Questions were asked about the extent to which a host of biosecurity measures were used, the influence of various stakeholders (e.g. veterinarians, industry bodies) in informing biosecurity choices, and the perceived control farmers felt they had over biosecurity on their farms. Farmer attitudes towards biosecurity were also explored. Farmers appeared to be more likely to be carrying out direct biosecurity measures if they were influenced by the opinion of, or believed that their subjective norms (normative beliefs, e.g. vets) thought it was important that they implemented biosecurity measures on their farm, and they knew the current disease status of their herd (control belief). As suggested above in Wright et al.'s biosecurity study, peer disapproval can be influential in the way farmers behave. This was also seen in another Australian study where farmers do not seek government assistance in drought situations, because they do not want to be seen as having failed and do not want to be identified as needing government hand-outs (Perlesz et al., 2019).

A study to understand farmers' naturalistic decision-making around prophylactic antibiotic use in lambs by Doidge et al. (2020) examined social judgement. Data from 431 posts by 133 different users of an online discussion forum were analysed. Qualitative analysis identified perception of social judgement as one of the five categories that influenced farmers risk perceptions around prophylactic antibiotic use in lamb (others included anticipated regret, negative emotions and experiential avoidance; economic considerations; farmer identity; perception of capability). Farmers were worried about the impact on their image if consumers or animal rights activists were aware of others using antibiotics as a prophylactic. However, farmers who use antibiotics as routine in their lambs appear resistant to the social pressures around antibiotic stewardship and were unwilling to adhere to their vets' advice. The authors suggest that for successful behaviour change, it is particularly important to de-normalise the use of prophylactic antibiotics around lambing time.

A large-scale survey study among 574 farmers in Belgium found that subjective norm was a strong factor influencing intention to adopt diagnostics before treatment in gastrointestinal nematode control. The authors conclude that this factor has great potential for persuading farmers into changing

[5] Schaak, H., Mushoff, O., 2018. Understanding the adoption of grazing practices in German dairy farming. Agric. Syst. 165, 230–239.
Senger, I., Borges, J.A.R., Machado, J.A.D., 2017. Using the theory of planned behavior to understand the intention of small farmers in diversifying their agricultural production. J. Rural Stud. 49, 32–40.

control practices, that significant others like family or the veterinarian feel positive about diagnostic methods could increase the farmer's adoption (Vande Velde et al., 2018).

This is supported by a study which looked at the duration of antibiotic treatment of clinical mastitis, in which 38 dairy farmers in the Netherlands (n = 17) and Germany (n = 21) were interviewed (Swinkels et al., 2015). Farmers were sensitive toward social norms of other farmers and recognition for good stockmanship. Extended treatment is perceived as part of the social norm of "being a good farmer." The more "cow-oriented" farmers, expressed insecurity on how to treat mastitis effectively which made them more sensitive to comply with other farmers' injunctive ("what ought to be") and descriptive ("what is done") norms and the perceived veterinarians' informational norm that extended treatment is better, resulting in an approved social norm. According to the authors social approval reduces the insecurity of being perceived as a poor farmer; thus, extended treatment is emotionally rewarded.

Daxini et al. (2019) used structural equation modelling to analyse survey data for Irish farmers (n=1009) interviewed face to face. Results show that intention to follow a Nutrient Management Plan (NMP) is primarily driven by perceived behavioural control (ease/difficulty) over following a NMP, followed by subjective norm (social pressure) and finally attitude (negative/positive evaluation). The subjective norm is an important predictor of both attitude and perceived behavioural control. The highly influential role of subjective norm in the study may be related to an increase in focus on improving nutrient management on farms in recent years, which may have stimulated an increase in social pressure on farmers to voluntarily use best management practices, such as NMPs. This may explain findings from the CSF evaluation as well.

Studies of farmers changing to new practices or systems typically highlight the importance of social norms and approval. In one study (qualitative) of farmers (n=14) transitioning to agroecology, steered largely by informal peer to peer learning, farmers reported big challenges to getting started which were related to self (symbolic capital – self-belief, prestige, reputation) and to other people's negative attitudes since agroecology was seen as different from the mainstream (Padel et al., 2018). Similarly, a study (using focus groups) of barriers to using cover crops found that commonly held beliefs, or regional norms that emphasize maximizing output of key commodity crops, negatively impacted acceptance and adoption of conservation practices such as cover crops (although structural influences were also strong). Farmers noted that this influences landlords as well (Roesch-McNally et al., 2018).

In the same way Hayden et al.'s (2018) study investigated the challenges and opportunities experienced by farmers interested in integrating crops and livestock (ICLS) on organically managed farms in Iowa, Pennsylvania, and Minnesota. Using focus groups and interviews they identified farming norms as one of four categories of challenges, others included: complexity of management, biophysical conditions, and financial costs, and four categories of opportunities: increasing support for ICLS, financial and labour advantages, biophysical improvements, and animal welfare). However, the analysis demonstrates how this challenge is mitigated by increasing support for ICLS, growing communities of practice in which farmer-to-farmer knowledge exchange and peer support overcome obstacles to success in these systems. Farmer participants spoke of formal groups, such as Practical Farmers of Iowa, and informal groups mediated through internet forums or national conference attendance, as being "life-savers" when navigating the transition to integrated crop–livestock systems.

However, another set of evidence (not such large-scale but robust) shows that the injunctive norm influence is not universally experienced and that other factors are more influential. For example, in a study of Swiss dairy farmers' motivations to reduce antimicrobial Gerber et al.'s (2020) survey (n=58),

found that the subjective (injunctive) norm had only a minor influence on their intentions. Farmer responses in the questionnaire were mostly neutral or negative with regard to the role of social pressure from family, colleagues or other consultants in decision-making. They argue that this finding is in line with the results of a survey of grain farmers and their decision regarding organic or non-organic production Hall et al., 2010) [6] (not reviewed here) where study farmers were interested in the opinion of individuals within their social environment but did not allow themselves to be pressured by the social environment to make a decision.

Hyland et al. (2018) used psychological constructs to analyse factors that affect the adoption of the Spring Rotational Planer tools by commercial dairy farmers in Ireland (n=256). Cluster analysis found two farmer clusters: low and high adopters of the SRP. Low-Adopters of the SRP were characterised by their high sense of resource constraint. Beliefs which represented social norms were least influential in farmer's intention to adopt the SRP, this was attributed to people generally denying the influence by important others when asked about it , also SRP is not necessarily observable, in that it is hard to distinguish it from normal rotational grazing, which may also explain the low influence of social norms.

Similarly, social norms had no observable effect on intent to take action to control Salmonella in a study of British farmers' perception of, and barriers to, implementing Salmonella control on pig farms (Marier et al., 2016). Whilst farmers may value support from their peers, the key intrinsic factors that had an effect on their behaviour were their belief in self-efficacy and, in a related way, their attitude.

In a study aimed to identify and understand factors influencing pasture management decision-making and behaviour for different farmer subgroups. The Theory of Planned Behaviour was used to identify and explore key factors influencing pasture management behaviour with semi-structured interviews with 30 Tasmanian dairy farmers. They identified a lack of social influence consistent with the strong perception that experienced farmers do not necessarily need to measure pasture or extension activities (it is seen as an activity only for young). This negative social norm led the authors to recommend an extension strategy based on encouraging farmers in the Triallers subgroup to return to measuring pasture through demonstration of what others are doing (Hall et al., 2019).

4.4.3. Identity

Identity refers to convincing the target group that the desired behaviour fits with their self-image.

In the evidence reviewed, there is no explicit mention of using identity as a method. Overall, the evidence is limited, one study directly refers how identity influences decisions about adopting certain practices, the others are more tenuous although they reveal the significance of identity and self-mage.

Doidge et al. (2020) in their study reported above identified one of the five categories that influenced farmers risk perceptions around prophylactic antibiotic use in lambs as centring on the perception of a conflict between two good farming identities, i.e. "A good farmer doesn't need to rely on antibiotics" and "Animal welfare is the priority". It highlights the importance of animal welfare in being a good

[6] Hall K, Rhoades E. Influence of subjective norms and communication preferences on grain farmers' attitudes toward organic and non-organic farming. J Appl Commun. (2010) 94:51–64. doi: 10.4148/1051-0834.1192

farmer for both identities, but also the relative importance of low antibiotic use. There are implications here for managing cognitive dissonance[7] in messaging.

A multi-method study was undertaken looking at farmers' decision- making with regard to afforestation under a scheme in Ireland (Duesberg et al., 2014). They identified policy tools that best match farmers' behaviour with regard to afforestation. The results indicated that the majority of those surveyed do not make their decision to afforest based on profit maximisation goals, they suggest that symbolic tools such as information and PR- or image-building campaigns should be deployed to further encourage afforestation by farmers since forestry does not align with their self-image as food producers.

Social identity can be used to understand environmental beliefs and behaviours and how identities can prompt individuals to behave in more (or less) environmentally friendly ways (Fielding and Hornsey 2016)[8] (not reviewed here). This builds on a body of knowledge in the social sciences literature about the notion of a 'good farmer' where symbols of tidy farms and fields, and cultural practices have been shown to be significant for behaviour. This is updated recently by studies looking at farmers managing the agri-environment and riparian features (Riley, 2016; Thomas et al., 2019), implementing no-till farming (Skaalsveen et al., 2020) and dealing with livestock disease (Naylor et al., 2018).

Pickering et al. (2017) gives the hypothetical example of how an Australian cane grower might identify as a member of the overarching cane industry and a particular region or district within the industry. As such they suggest that targeting group membership and identity could prove a powerful method of promoting behavioural change. For example, self-enhancement may provide an important target for bolstering growers' desire to adopt change in order to preserve their group identity. Constructing a mechanism for promoting positive competition among socially identifiable groups to become better than one another may reduce uncertainty and promote positive behavioural change.

There are also examples where farmers reflect on their identity and self-image following engagement with an intervention or new practice, as indicated above in the Padel study. Equally in the Farming Connect evaluation, subtle changes were associated with a change in how farmers involved view themselves and their business: their engagement had made them look at certain aspects of their business in a different way. Whilst this is important, some external stakeholders were concerned that – if this was the only impact of Farming Connect for some - it was "not enough" to deliver the degree of change needed in the sector (Pates and Hindle, 2020).

It is also important to build in the identity of a programme and user community as Stock (2020) describes for a U.S. Intermountain West, Instagram account which was the top-rated platform for sharing information by predominantly new and female farmers. They found that developing an extension account around one niche or target market creates identity and conveys expertise in a focused area.

Some researchers recognise cultures rather than identifies but question how epidemiologists and others frame farming behaviours. Hidano et al. (2019) conducted qualitative research with 15 New

[7] This is separate behavioural method (make use of this tendency to align their values/attitudes and behaviour, by emphasising the dissonance between these two) but no evidence was found for it in this review.

[8] Fielding, KS & Hornsey, MJ 2016, 'A social identity analysis of climate change and environmental attitudes and behaviours: Insights and opportunities', *Frontline Psychology,* vol. 7, pp. 121.

Zealand dairy producers with varying bovine tuberculosis bTB experiences. Using the Trigger Change Model, they show how farmers' livestock purchasing behaviour evolve with culture under a given farm environment, or culture. Farmers' behaviour is not a result of specific intentions, but emerges from deeply embedded, path-dependent and location specific farming "cowshed cultures" which creates a path-dependency. However, established cultures may be disrupted by various triggers such as disease outbreaks, introductions of animals with undesired characteristics, and farm relocation. They conclude that voluntary disease control schemes such as farmers revealing the disease status of their farm may fail to induce their intended changes in farmers' behaviours without a greater understanding of such trigger events. This is supported by a review conducted by Barnes et al. (2015) which argues that behaviours without considering context can be misleading since behaviours and policy structures evolve jointly and neither are geographically uniform. These triggers can also provide an opportunity to lever change. In the transition to agroecology Padel et al. (2018) found that key triggers for getting started were taking over the farm or business.

4.4.4. Commitment and consistency

Stimulate the target group to form an (emotional) bond with the desired behaviour.

Although not entirely commensurate with this concept, there is evidence from the CSF evaluation that the 'quality' of farmer engagement with CSF and the outcomes of that engagement are important to the delivery of long-term, pro-environmental, behaviour change. As such farmer motivation to remain engaged and continue positive management practices was identified as important. Furthermore, there is no suggestion from the survey that, farmers having made changes will not continue, and farmers who have made changes in the last two years are more likely to be considering further changes. This implicit commitment could be linked to the effectiveness of the one to one advice, backed up with interpersonal communications in groups, (as well as underlying regulation) (Environment Agency, 2019). Normalising best management practices and meeting the expectations of neighbouring farmers may also explain this commitment.

Pickering et al. (2017) cites The Queensland Water Commission Target 140 campaign, implemented in South East Queensland in 2007 as a high quality example of a behaviour change campaign that included a focus on social norms. The project was successful in securing the region's water supply in response to the worst drought on record using techniques to personalise the problem ('this is not someone else's problem'), and individualising the solution ('everyone can play a part'). These findings from Project 140, are corroborated by other studies according to Pickering that have shown that framing messages as a foregone-gain (i.e. something that is relinquished) is likely to be better received than framing something as a loss.

4.5. Nudges and prompts

Evidence for nudges[9] (default or stimulus) [10]. is very limited. One study refers to the term but as an

[9] Pickering et al. 2017, p6" Nudges are designed to be brief, low-cost, and simple prompts and reinforcers that seek to modify the behaviour of individuals and groups. Nudges can be embedded in social marketing approaches and other techniques of behavioural change"

[10] Default Nudge: *Introducing conscious changes to the architecture of choices in order to push the target group in a particular direction*

observation within a wider study. In Grant et al.'s (2018) study of farmers responses to promoting best practice to treat sheep with footrot (one to one section). They clustered three groups of farmers, LC2 had a marginally lower prevalence of lameness than LC3 (LC1 had lowest). According to Grant et al., LC2 farmers, who may be needed 'nudging' to treat sheep more promptly, changed their behaviour more than LC3 farmers who would be difficult to influence because of negative attitudes and may need specially designed intervention. Although not nudge in the true sense it suggests that farmers who were already carrying out the practice to some extent were more amenable to change through persuasion. A set of choice related interventions for 'nudging' individuals towards socially desirable behaviours and regulation ('budging') implied a reduction in the choice-set for these individuals in the context of voluntary adoption of water quality in and out of Nitrate Vulnerable Zone (NVZ) across Scotland (Barnes et al., 2013). The authors argue that it is important to identify the right combination of nudging and budging, which are seen as more legitimate by the actors being regulated.

4.5.1. Feedback Nudge

Give the target group direct feedback on the behaviour in the situation where the behaviour occurs

Feedback and reflection are important processes in all group approaches built on iteration and learning with participants, however, only one piece of evidence specifically mentions feedback using a structured tool as part of the approach. In the Farmer Action Groups (FAGs) described by Morgans et al. (2019) meetings were arranged in two phases- phase one where the group met on each other's farm for the first time and worked together to co-create an Action Plan to reduce antimicrobial use, and then phase two, where each farmer participant and their Action Plan was re-visited (6-12 months later) to discuss and reflect on any changes made on farm. FAGS use medicine reviews as an auditing tool to not only quantifiably evaluate the success of the FAGs in reducing AMU, but also as a facilitated discussion tool. The researcher and facilitator used the data from the medicine review to frame questions to the group and host farmer to stimulate discussion around AMU. This insight into the host farm allowed a more constructive and informed discussion, which can lead to a more relevant and useful Action Plan. The researcher and facilitator also developed a repertoire of workshop activities to help structure discussion and facilitate reflection on each host farm.

4.5.2. Prompt

A prompt involves giving people reminders at the right time can help them take action. Encourage individuals to take action through a well-timed message or intervention.

There is no evidence about the effectiveness of prompts. In one example the U.S. Intermountain West, Instagram platform (Stock, 2020) use weekly ''Fact Sheet Fridays'' which promote well timed fact sheets with a fresh photo and action-oriented caption (e.g., vegetable growing guides during local planting times), although no measure is given of uptake or acting on the prompt. As a measure of the audience for such factsheets, a similar Instagram account that is focused on production horticulture in Utah had 1400 followers after 60 weeks, suggesting large engagement overall).

Stimulus Nudge; *Nudge the target group by introducing specific features into the physical environment direction, whilst retaining freedom of choice.*

Although not necessarily a true prompt, in the evaluation of AHDB farm bench it was suggested that unexpected messages are more likely to stick because the surprise breaks a pattern and makes us pay attention and think. AHDB could introduce Farmbench by posing an intriguing fact, question or problem; our curiosity is often fuelled by our gaps in our knowledge (Research, 2108).

One large-scale study of farmers response to lameness suggests that some barriers are deeper and need more than friction costs removed or prompts given at certain times. O'Kane et al. (2017) concluded that barriers that led some farmers to avoid treating lame sheep at specific times of the production cycle (pregnancy and tup-ping for adults and finishing (fattening) period for lambs were also less likely to use best practice and so less likely to treat sheep promptly at other times of the year. This suggests that these farmers are not prioritising lameness at any time of year and so the barriers to change might be greater than initially anticipated.

4.5.3. Friction costs

Friction Costs are the small barriers (i.e. 'frictions') which require effort to overcome can prevent people from doing something. Reduce friction in a system, for example by removing steps from a process.

Evidence for friction costs is limited. In the CSF evaluation it was found that, of those farmers considering further changes, 31 per cent of the CSF-engaged farmers surveyed were prompted to consider change(s) by CSF. One way of doing this is that the CSFOs help them overcome practical barriers to making changes.

Removing early barriers was also identified as important in the transition to agroecology, where Padel et al. (2018) found in farmer interviews that "The biggest step is getting started". This was also observed in the Heradvance interim survey where not knowing where to start was identified as a barrier to improving herd health (Rose, 2020).

Enabling change through financial incentive extends this idea. In AHDB's HerdAdvance Animal Health Five Knowledge Exchange Managers (AHKEMs) worked alongside vets in Wales to assist 500 dairy farmers, making regular visits/phone calls through a 'measure, manage, monitor' approach, collecting data yearly to measure progress. Interventions are based largely on education, economics, and tools from the RESET model. However, an interim study (survey (n=110) and a focus group of AHKEMs) found that two interventions – a financial incentive (e.g. tests being paid for) (85% of farmers found it enabling) and free advice from the vet (78%) – were by far the most useful in enabling the implementation of a new management action (Rose, 2020).

Whilst not presenting evidence, Jansen et al., (no date) suggests that tools can be used to make a certain desired behaviour easier to perform in dealing with mastitis. Tools may take away barriers for people to change behaviour, that would otherwise not do so (friction costs). Technical provisions can also be a big help in changing behaviour. Sometimes simple adaptations, like the amount of light in the milking parlour, can hugely influence behaviour, like the early diagnosis of clinical mastitis cases.

Regarding online systems, the use of online trading tools in the UK (Tamar trial and by Wessex Water) for reverse auctions has attracted land managers who had previously not engaged in agri-environment activity (half of participants in the Tamar trial), as these systems save time and are less bureaucratic than agri-environment schemes (Hackett, 2019).

4.6. Rewards and losses

4.6.1. Scarcity

Emphasise limited availability of something so that people will value scarce products/services more highly

Although not addressing the specific behaviour change methods of present bias and reciprocity[11], there is some evidence of 'rewards and losses ' messages being effectively used in interventions.

Scarcity can be explored through studies of reverse auctions, where farmers are asked to bid competitively for a limited amount of funds. These have been piloted in selected UK water catchments for pollution abatement, where farmers bid for the costs of carrying out certain practices or installing capital works. In analysis of bidding motivations for the Fowey catchment auction, 39% of farmers were motivated to make a competitive bid so as to improve their chances in the auction, however not all were motivated by being competitive against other farmers, some wanted to ensure some fair distribution of funds (Day and Couldrick, 2013). In past studies multi-rounds of auctions have offered greater potential for bidder learning and collusion, however, studies in UK examples have not observed this (Wheeler et al., 2021).

5. Summary of findings

The REA set out to review the strength of evidence relating to practice change and the use of behavioural insights in agriculture and horticulture – identifying 'what works'. It focuses specifically on AHDB's behaviour working methods considered during intervention development.

The scope of the evidence reflects the different bodies of research that have developed to understand the behavioural aspects of farming. The main types of evidence available are: peer reviewed papers, from the behavioural science literature, characterised by large-scale quantitative studies; those that examine the effectiveness of extension methods using both quantitative and qualitative methods; and those assessing novel approaches. Grey literature draws on programme experiences and evaluations and literature reviews and REAs. Livestock studies dominate the evidence reflecting a growing body of social science work related to behavioural determinants in relation to AHW and biosecurity. Arable or cropping system behavioural studies are less well represented.

[11] Present bias: Present bias is as we value costs and benefits more in the present than in the future, try to shift the costs of good behaviour into the future and bring rewards into the present.
Reciprocity: Give the target group the impression that he/she is being given a 'gift', to encourage the tendency to do something 'in return'.

Regarding the strength of evidence, combined relevance and robustness scores range from 2-6, with 4 being most common. More weight was given in the analysis to higher scores and where there was a supporting body of evidence.

In summary, while there is some strong evidence showing the association between a number of determinants and behaviours, particularly in livestock studies, the evidence of behavioural methods being used to bring about change is more limited. Equally while there is strong evidence to support the effectiveness of some extension methods, studies rarely elaborate the constituent behavioural methods or behavioural change outcomes of interest to the AHDB.

Of the behavioural methods, evidence is strongest (with the largest supporting body of literature) for knowledge transfer, using messengers, interpersonal communication and descriptive and injunctive norms being practically used or investigated. There is also evidence of combinations of methods being effectively employed. There is a clear knowledge gap with respect to evidence for some of AHDB's behavioural methods, at least within the boundaries of this REA.

6. References

Adamson, H., Turner, C., Cook, E., Creissen, H.E., Evans, A., Cook, S., Ramsden, M., Gage, E., Froud, L., Ritchie, F., Clarke, J., 2020. Review of evidence on Integrated Pest Management. DEFRA.

Alberta, I., 2017. Understanding Farmer Motivation and Attitudes Regarding the Adoption of Specific Soil Best Management Practices.

Ambrosius, F.H.W., Hofstede, G.J., Bokkers, E.A.M., Bock, B.B., Beulens, A.J.M., 2019. The social influence of investment decisions: A game about the Dutch pork sector. Livestock Science 220, 111-122.

Amer, P., Byrne, T., Fennessy, P., Jenkins, G., Martin-Collado, D., Berry, D., 2015. Review of the genetic improvement of beef cattle and sheep in the UK with special reference to the potential for genomics AbacusBio Limited.

Andrews, A.C., Clawson, R.A., Gramig, B.M., Raymond, L., 2013. Why do farmers adopt conservation tillage? An experimental investigation of framing effects. Journal of soil and water conservation 68, 501-511.

Annicchiarico, P., Russi, L., Romani, M., Pecetti, L., Nazzicari, N., 2019. Farmer-participatory vs. conventional market-oriented breeding of inbred crops using phenotypic and genome-enabled approaches: A pea case study. Field Crops Research 232, 30-39.

Azbel-Jackson, L., Heffernan, C., Gunn, G., Brownlie, J., 2018. Exploring the role of voluntary disease schemes on UK farmer bio-security behaviours: Findings from the Norfolk-Suffolk Bovine Viral Diarrhoea control scheme. PloS one 13, e0179877.

Baker, P., Stokes, J., Weeks, C., 2020. Enabling behaviour change in laying hen farmers using Motivational Interviewing, Presented at the 1st International Electronic Conference on Animals, p. 20.

Bard, A., Main, D., Roe, E., Whay, H., Reyher, K., 2019. To change or not to change? Veterinarian and farmer perceptions of factors influencing the enactment of veterinary advice on UK dairy farms. Journal of Dairy Science.

Bard, A.M., Main, D.C.J., Haase, A.M., Whay, H.R., Roe, E.J., Reyher, K.K., 2017. The future of veterinary communication: Partnership or persuasion? A qualitative investigation of veterinary communication in the pursuit of client behaviour change. PLoS One 12, e0171380.

Barnes, A., Toma, L., Willock, J., Hall, C., 2013. Comparing a 'budge'to a 'nudge': Farmer responses to voluntary and compulsory compliance in a water quality management regime. Journal of Rural Studies 32, 448-459.

Barnes, A.P., Moxey, A.P., Ahmadi, B.V., Borthwick, F.A., 2015. The effect of animal health compensation on 'positive' behaviours towards exotic disease reporting and implementing biosecurity: A review, a synthesis and a research agenda. Preventive Veterinary Medicine 122, 42-52.

Bartkowski, B., Bartke, S., 2018. Leverage points for governing agricultural soils: A review of empirical studies of European farmers' decision-making. Sustainability 10, 3179.

Borthwick, F., Barnes, A.P., Lamprinopoulou-Kranis, C., 2014. A comparison of innovation in the Scottish livestock sector: the case of genetic selection techniques.

Brown, no date. Factors that influence the engagement of farmers with genetic information such as estimated breeding values (EBVs) and performance recording in the beef and sheep sector. AHDB.

Buller, H., Hinchliffe, S., Hockenhull, J., Barrett, D., Reyher, K., Butterworth, A., Heath, C., 2015. Systematic review and social research to further understanding of current practice in the context of using antimicrobials in livestock farming and to inform appropriate interventions to reduce antimicrobial resistance within the livestock sector. DEFRA Report.

Cardwell, J.M., Van Winden, S., Beauvais, W., Mastin, A., De Glanville, W.A., Hardstaff, J., Booth, R.E., Fishwick, J., Pfeiffer, D.U., 2016. Assessing the impact of tailored biosecurity advice on farmer behaviour and pathogen presence in beef herds in England and Wales. Preventive veterinary medicine 135, 9-16.

Carlisle, L., 2016. Factors influencing farmer adoption of soil health practices in the United States: A narrative review. Agroecology and Sustainable Food Systems 40, 583-613.

Daxini, A., Ryan, M., O'Donoghue, C., Barnes, A.P., 2019. Understanding farmers' intentions to follow a nutrient management plan using the theory of planned behaviour. Land Use Policy 85, 428-437.
Day, B., Couldrick, L., 2013. Payment for ecosystem services pilot project: the Fowey river improvement auction. Defra, London.
Denise Bewsell, Tony Brenton-Rule, 2019. Extension Design Project Final Report. Red Meat Profit Partnership.
Dillon, E.J., Hennessy, T., Cullinan, J., 2016. The role of agricultural education and extension in influencing best practice for managing mastitis in dairy cattle. The Journal of Agricultural Education and Extension 22, 255-270.
Doidge, C., Ferguson, E., Lovatt, F., Kaler, J., 2020. Understanding farmers' naturalistic decision making around prophylactic antibiotic use in lambs using a grounded theory and natural language processing approach. Preventive Veterinary Medicine 186, 105226.
Duff, A.J., Zedler, P.H., Barzen, J.A., Knuteson, D.L., 2017. The Capacity-Building Stewardship Modelassessment of an agricultural network as a mechanism for improving regional agroecosystem sustainability. Ecology and Society 22.
Duval, J.E., Bareille, N., Madouasse, A., De Joybert, M., Sjöström, K., Emanuelson, U., Bonnet-Beaugrand, F., Fourichon, C., 2018. Evaluation of the impact of a Herd Health and Production Management programme in organic dairy cattle farms: a process evaluation approach. animal 12, 1475-1483.
Embaye, W.T., Bergtold, J.S., Archer, D., Flora, C., Andrango, G.C., Odening, M., Buysse, J., 2018. Examining farmers' willingness to grow and allocate land for oilseed crops for biofuel production. Energy Economics 71, 311-320.
Environment Agency, 2019. Catchment Sensitive Farming Evaluation Report – Water Quality, Phases 1 to 4 (2006-2018). Natural England.
Escobar, M.P., Buller, H., 2014. Projecting Social Science into Defra's Animal Welfare Evidence Base.
Gerber, M., Durr, S., Bodmer, M., 2020. Decision-Making of Swiss Farmers and the Role of the Veterinarian in Reducing Antimicrobial Use on Dairy Farms. Frontiers in Veterinary Science 7.
Goldringer, I., van Frank, G., d'Yvoire, C.B., Forst, E., Galic, N., Garnault, M., Locqueville, J., Pin, S., Bailly, J., Baltassat, R., 2019. Agronomic evaluation of bread wheat varieties from participatory breeding: a combination of performance and robustness. Sustainability 12, 1-1.
Grant, C., Kaler, J., Ferguson, E., O'Kane, H., Green, L.E., 2018. A comparison of the efficacy of three intervention trial types: postal, group, and one-to-one facilitation, prior management and the impact of message framing and repeat messages on the flock prevalence of lameness in sheep. Preventive Veterinary Medicine 149, 82-91.
Hackett, R., 2019. New EnTrade scheme helps farmers protect Poole Harbour. WWT, https://wwtonline.co.uk/news/new-entrade-scheme-helps-farmers-protect-poole-harbour. [accessed 1 March 2020].
Hall, A., Turner, L., Kilpatrick, S., 2019. Understanding Tasmanian dairy farmer adoption of pasture management practices: a Theory of Planned Behaviour approach. Animal Production Science 59, 1941-1950.
Hansen, B.G., 2015. Financial extension that challenges farmers' thinking in discussion clubs helps farmers improve their problem solving abilities. Agricultural Systems 132, 85-92.
Hayden, J., Rocker, S., Phillips, H., Heins, B., Smith, A., Delate, K., 2018. The Importance of Social Support and Communities of Practice: Farmer Perceptions of the Challenges and Opportunities of Integrated Crop-Livestock Systems on Organically Managed Farms in the Northern US. Sustainability 10.
Hidano, A., Gates, M.C., Enticott, G., 2019. Farmers' decision making on livestock trading practices: cowshed culture and behavioural triggers amongst New Zealand dairy farmers. Frontiers in Veterinary Science 6, 320.
Hyland, J.J., Heanue, K., McKillop, J., Micha, E., 2018. Factors influencing dairy farmers' adoption of best management grazing practices. Land Use Policy 78, 562-571.
Islam, M.M., Renwick, A., Lamprinopoulou, C., Klerkx, L., 2013. Innovation in livestock genetic improvement. EuroChoices 12, 42-47.

Kauppinen, T., Valros, A., Vesala, K.M., 2013. Attitudes of dairy farmers toward cow welfare in relation to housing, management and productivity. Anthrozoös 26, 405-420.
Kuhfuss, L., Préget, R., Thoyer, S., Hanley, N., 2016. Nudging farmers to enrol land into agri-environmental schemes: the role of a collective bonus. European Review of Agricultural Economics 43, 609-636.
Lahuerta-Marin, A., Brennan, M.L., Finney, G., O'Hagan, M.J.H., Jack, C., 2018. Key actors in driving behavioural change in relation to on-farm biosecurity; a Northern Ireland perspective. Ir Vet J 71, 14.
Lapple, D., Hennessy, T., 2015. Assessing the Impact of Financial Incentives in Extension Programmes: Evidence From Ireland. Journal of Agricultural Economics 66, 781-795.
Lapple, D., Hennessy, T., Newman, C., 2013. Quantifying the Economic Return to Participatory Extension Programmes in Ireland: an Endogenous Switching Regression Analysis. Journal of Agricultural Economics 64, 467-482.
Le Coent, P., Préget, R., Thoyer, S., 2017. Compensating environmental losses versus creating environmental gains: implications for biodiversity offsets. Ecol. Econ. 142, 120-129.
Lobley, M., Saratsi, E., Winter, M., Bullock, J., 2013. Training farmers in agri-environmental management: the case of Environmental Stewardship in lowland England. International Journal of Agricultural Management Volume 03, 12-20.
Macken-Walsh, A., Crosson, P., Murray, A., 2012. A qualitative study of Irish beef farmers' production decisions: summary and implications for extension, Teagasc: Ireland
Mankad, A., 2016. Psychological influences on biosecurity control and farmer decision-making. A review. Agronomy for sustainable development 36, 40.
Marier, E., Smith, R.P., Ellis-Iversen, J., Watson, E., Armstrong, D., Hogeveen, H., Cook, A.J.C., 2016. Changes in perceptions and motivators that influence the implementation of on-farm Salmonella control measures by pig farmers in England. Preventive Veterinary Medicine 133, 22-30.
Martin, G., 2015. A conceptual framework to support adaptation of farming systems - Development and application with Forage Rummy. Agricultural Systems 132, 52-61.
Merrill, S.C., Moegenburg, S., Koliba, C.J., Zia, A., Trinity, L., Clark, E., Bucini, G., Wiltshire, S., Sellnow, T., Sellnow, D., Smith, J.M., 2019. Willingness to Comply With Biosecurity in Livestock Facilities: Evidence From Experimental Simulations. Frontiers in Veterinary Science 6.
Mills, J., Gaskell, P., Ingram, J., Dwyer, J., Reed, M., Short, C., 2017. Engaging farmers in environmental management through a better understanding of behaviour. Agriculture and Human Values 34, 283-299.
Moravek, T., Nelson, B., Anderson, A., Reid, D., 2017. Quantifying the effectiveness of extension delivery methods on practice change - the experience of the Grazing BMP Extension Support Project. Rural Extension and Innovation Systems Journal 13, 70-75.
Morgaine, K.C., Langley, J.D., McGee, R.O., Gray, A.R., 2014. Impact evaluation of a farm-safety awareness workshop in New Zealand. Scandinavian Journal of Work Environment & Health 40, 649-653.
Morgans, L., Reyher, K.K., Barrett, D.C., Turner, A., Bellini, J., Elkins, P., Clarke, T., 2019. Changing farmer and veterinarian behaviour around antimicrobial use. Livestock 24, 75-80.
Morgans, L.C., Bolt, S., Bruno-McClung, E., van Dijk, L., Escobar, M.P., Buller, H.J., Main, D.C., Reyher, K.K., 2021. A participatory, farmer-led approach to changing practices around antimicrobial use on UK farms. Journal of Dairy Science 104, 2212-2230.
Naylor, R., Hamilton-Webb, A., Little, R., Maye, D., 2018. The 'good farmer': farmer identities and the control of exotic livestock disease in England. Sociologia Ruralis 58, 3-19.
O'Kane, H., Ferguson, E., Kaler, J., Green, L., 2017. Associations between sheep farmer attitudes, beliefs, emotions and personality, and their barriers to uptake of best practice: the example of footrot. Preventive veterinary medicine 139, 123-133.
Owen, W., 2017. Action Learning to enable organisational change in rural businesses. Studies in Agricultural Economics 119, 41-47.
Padel, S., Rubinstein, O., Woolford, A., Egan, J., Leake, A., Levidow, L., Pearce, B., Lampkin, N., 2018. Transitions to agroecological systems - farmers' experience. Organic Research Centre/GWCT.

Pates, R., Hindle, R., 2020. Evaluation of the Knowledge Transfer, Innovation and Advisory Services Programme. Cardiff: Welsh Government, GSR report number 14/2020.
Pickering, J., Hong, J., Hong, D., Kealley, M., 2017. Applying behavioural science to the Queensland sugar cane industry and its relationship to the Great Barrier Reef. Rural Extension and Innovation Systems Journal 13, 1-10.
Prager, K., Creaney, R., 2017. Achieving on-farm practice change through facilitated group learning: Evaluating the effectiveness of monitor farms and discussion groups'. Journal of Rural Studies 56, 1-11.
Promar International Ltd, University of Reading, 2013. An evaluation of the factors affecting the utilisation of genetic information by GB dairy farmers. Promar International Ltd.
Research, B., 2108. BMG - Farmbench: Audience market research.
Reyher, K.K., 2016. Mastitis management: increasing the uptake of veterinary advice. Veterinary Record 178, 446-448.
Richens, I., Houdmont, J., Wapenaar, W., Shortall, O., Kaler, J., O'Connor, H., Brennan, M.L., 2018. Application of multiple behaviour change models to identify determinants of farmers' biosecurity attitudes and behaviours. Preventive veterinary medicine 155, 61-74.
Riley, M., 2016. How does longer term participation in agri-environment schemes [re] shape farmers' environmental dispositions and identities? Land Use Policy 52, 62-75.
Roche, S.M., Jones-Bitton, A., Meehan, M., Von Massow, M., Kelton, D.F., 2015. Evaluating the effect of Focus Farms on Ontario dairy producers' knowledge, attitudes, and behavior toward control of Johne's disease. Journal of Dairy Science 98, 5222-5240.
Roesch-McNally, G.E., Basche, A.D., Arbuckle, J.G., Tyndall, J.C., Miguez, F.E., Bowman, T., Clay, R., 2018. The trouble with cover crops: Farmers' experiences with overcoming barriers to adoption. Renewable Agriculture and Food Systems 33, 322-333.
Rose, D.C., Keating, C., Morris, C., 2018. Understanding how to influence farmers' decision-making behaviour: a social science literature review. Agriculture and Horticulture Development Board.
Saikai, Y., Hurley, T.M., Mitchell, P.D., 2021. An agent-based model of insect resistance management and mitigation for Bt maize: a social science perspective. Pest management science 77, 273-284.
Sausse, C., Le Bail, M., Lecroart, B., Remy, B., Messéan, A., 2013. How to manage the coexistence between genetically modified and conventional crops in grain and oilseed collection areas? Elaboration of scenarios using role playing games. Land Use Policy 30, 719-729.
Scrase, A., Reyher, K., Motivational interviewing-a communication strategy to promote the uptake of advice on mastitis management. The Dairy Group, pp. 29-38.
Skaalsveen, K., Ingram, J., Urquhart, J., 2020. The role of farmers' social networks in the implementation of no-till farming practices. Agricultural Systems 181, 102824.
Stock, M., 2020. High Impact Extension Programming with Instagram. HortTechnology 30, 654-658.
Sumner, C.L., von Keyserlingk, M.A., Weary, D.M., 2018. How benchmarking motivates farmers to improve dairy calf management. Journal of dairy science 101, 3323-3333.
Svensson, C., Emanuelson, U., Bard, A.M., Forsberg, L., Wickstrom, H., Reyher, K.K., 2019. Communication styles of Swedish veterinarians involved in dairy herd health management: A motivational interviewing perspective. Journal of Dairy Science 102, 10173-10185.
Swinkels, J.M., Hilkens, A., Zoche-Golob, V., Kromker, V., Buddiger, M., Jansen, J., Lam, T., 2015. Social influences on the duration of antibiotic treatment of clinical mastitis in dairy cows. Journal of Dairy Science 98, 2369-2380.
Thomas, E., Riley, M., Spees, J., 2019. Good farming beyond farmland–Riparian environments and the concept of the 'good farmer'. Journal of Rural Studies 67, 111-119.
van Dijk, W.F.A., Lokhorst, A.M., Berendse, F., de Snoo, G.R., 2015. Collective agri-environment schemes: How can regional environmental cooperatives enhance farmers' intentions for agri-environment schemes? Land Use Policy 42, 759-766.

Vande Velde, F., Charlier, J., Hudders, L., Cauberghe, V., Claerebout, E., 2018. Beliefs, intentions, and beyond: A qualitative study on the adoption of sustainable gastrointestinal nematode control practices in Flanders' dairy industry. Preventive Veterinary Medicine 153, 15-23.

Wheeler, R., Ingram, J., Nye, C., Gaskell, P., Mills, J., Lewis, N., Wilkinson., T., Lobley, M., 2021. Collaboration and Incentives – Achieving environmental benefits at large spatial scales through Environmental Land Management. Report for Defra

Wright, B., Jorgensen, B., Smith, L., 2016. Development of behaviour change strategies for animal disease surveillance and reporting.

Appendix: Rapid Evidence Assessment Protocol

The aim of the assessment is to review evidence that helps to answer:

- What behavioural change methods are used and work in practice?
- What sorts of outcomes are achieved?

These primary questions, specifically in relation to AHDB's target audience of farmers and growers across its six sectors, will underpin the protocol for the REA and the PICO framework.

PICO (Population, Intervention, Comparator, and Outcome)

- Population: farmers, farm businesses
- Intervention: behavioural change approaches, interventions and methods
- Comparator: absence of behavioural change approaches, interventions and methods
- Outcomes: behavioural change (individual and group), shift in social norms, learning, capacity building, improved performance (productivity, efficiency, welfare, environmental and economic) according to a number of indicators,

Search strategy

Key words and search strings

The key words used by Rose et al. (2018) will be moderated and extended to reflect terms used to describe the method/intervention such as knowledge exchange, communication, social norms referring to the behaviour factors AHDB use for behaviour analysis. Different key words are combined in the search strings. These combinations are tested iteratively and refined. The intention is to find evidence particularly relevant to the question.

In a pilot, different key words were tested in a number of search strings. Through an iterative process some key words are retained and others removed on the basis of number, relevance of search results (judged on title and abstract) and research team's knowledge of the literature. Common synonyms are identified, no qualifiers are necessary.

This pilot tested different terms used to denote: behaviour change, such as adoption, uptake, learning; intervention type, such as those AHDB use for behaviour analysis; intervention impact such as, effectiveness and benefits. The five terms denoting: animal health and welfare, integrated pest management (IPM), genetics (plant/livestock), farm business management and the environment were also tested.

A final set of key words and search strings was agreed after discussion in the team. These were found to capture all the relevant papers (additional key words not leading to any additional records). The numbers of papers in Web of Science after refinement (year and country) was on average 100 for livestock and 50 crops searches. After the REA draft was completed a further search was added to identify evidence relevant to genetics (highlighted in Table) The final key words and search strings are set out in Tables 1 and 2.

Table 1: Keywords selected for the REA

***Keywords related to the population**:* farmer, land manager Livestock, dairy, beef, sheep, pigs Cereal, arable, wheat, barley, oats, rye, oilseed*, potato*, horticulture
***Keywords related to the intervention**:* gaming, communication, framing, knowledge exchange, engagement, campaign, evaluation
Keywords related to the comparator: *additionality* Comparator key words are intended to provide a reference case to capture additionality, which in this case would be 'minus' the intervention. During the test it was evident that it was not possible to express this in key words, but rather that any additionality would be captured in the search results from the main components: population and intervention.
Keywords related to the outcomes: N/A Behavio* decision-making, adoption, practice change
Keywords related to genetics: genetics, breed*, AI, fertility for livestock and breeding, varieties for crops

Table 2: Final search strings used to identify relevant literature

Livestock
(TS=(Farmer* or "land manager") AND TS=(behavio* or adoption or "decision-making" or "practice change") AND TS=(gaming or communication or framing or "knowledge exchange" or campaign or engagement or evaluation) AND TS=(livestock or dairy or beef or sheep or pigs)) REFINE by Language: English and Document types: Article and Country/Regions: Exclude developing and Asian countries Timespan: 2013-2021
(TS=(Farmer* or "land manager") AND TS=(behavio* or adoption or "decision-making" or "practice change") AND TS=(gaming or communication or framing or "knowledge exchange" or campaign or engagement or evaluation) AND TS=(genetics or breed* or fertility or breeding or varieties) REFINE by Language: English and Document types: Article and Country/Regions: Exclude developing and Asian countries Timespan: 2013-2021 (highlighted area denotes shows additional search for genetics topic terms)
Google scholar "Farmer behaviour" AND livestock adoption OR "decision making" OR "practice change" OR engagement OR gaming OR communication OR framing OR "knowledge exchange" OR campaign OR evaluation -policy
"Farmer behaviour" AND dairy adoption OR "decision making" OR "practice change" OR engagement OR gaming OR communication OR framing OR "knowledge exchange" OR campaign OR evaluation -policy
"Farmer behaviour" AND beef adoption OR "decision making" OR "practice change" OR engagement OR gaming OR communication OR framing OR "knowledge exchange" OR campaign OR evaluation -policy
"Farmer behaviour" AND sheep adoption OR "decision making" OR "practice change" OR engagement OR gaming OR communication OR framing OR "knowledge exchange" OR campaign OR evaluation -policy

"Farmer behaviour" AND pigs adoption OR "decision making" OR "practice change" OR engagement OR gaming OR communication OR framing OR "knowledge exchange" OR campaign OR evaluation -policy
"Farmer behaviour" AND adoption OR "decision making" OR "practice change" OR engagement OR gaming OR communication OR framing OR "knowledge exchange" OR campaign OR evaluation –policy AND genetics or fertility or breeding or varieties (highlighted area denotes shows additional search for genetics topic terms)
Crops
(TS=(Farmer* or "land manager") AND TS=(behavio* or adoption or "decision-making" or "practice change") AND TS=(gaming or communication or framing or "knowledge exchange" or engagement or campaign or evaluation) AND TS=(Cereal or arable or wheat or barley or oats or rye or oilseed * or potato* or horticulture)) REFINE by Language: English and Document types: Article and Country/Regions: Exclude developing and Asian countries Timespan: 2013-2021
Google scholar Farmer* AND behavio* AND Cereal* adoption OR "decision making" OR "practice change" OR engagement OR gaming or communication OR framing OR "knowledge exchange" OR campaign OR evaluation OR arable OR wheat OR barley -policy
Farmer* AND behavio* AND oilseed* adoption OR "decision making" OR "practice change" OR engagement OR communication OR framing OR "knowledge exchange" OR campaign OR evaluation- policy
Farmer* AND behavio* AND potato* adoption OR "decision making" OR "practice change" OR engagement OR communication OR framing OR "knowledge exchange" OR campaign OR evaluation -policy

Sources and search locations

Peer reviewed papers are identified using searches conducted in Web of Science and Google Scholar. These are complementary and the research results do not overly duplicate each other (as shown in the test). Web of Science is a more authoritative source for peer reviewed papers, while Google Scholar is a good source in terms of identifying some grey literature as well as peer-reviewed titles.

Grey and unpublished literature including reports and evaluation documents from agricultural and horticultural research, innovation and development programmes will also be reviewed. These provide more practice-orientated agricultural research. Sources include:

Relevant specialist organisations in the agricultural and horticultural industry as identified by the review team: Farmer-Led Innovation Network (FLIN) e.g. ADAS (YEN), Innovative Farmers, Innovation for Agriculture, Farming Connect in Wales, BOFIN (British ON-Farm Innovation Network), RISS, PFLA, LEAF and FWAG; as well as Nuffield Scholars, GWCT, Defra and Natural England ELMs team; and partners in EU funded projects and initiatives associated with the European Innovation Partnership (EIP AGRI) (e.g. operational groups).

These will be sourced through personal contacts and manual searches on websites by navigating through the site 'Publications' sections, if available, or by using any automated search facility with a number of key search terms.

Screening strategy

All Web of Science papers are screened. Due to large numbers of hits from Google Scholar only the first 5 pages are taken forward to the screening stage. Inclusion and exclusion criteria are derived based on the key words and other factors such as source (UK or international literature) and publication date. This stage ensures that only the most relevant findings are taken to the evidence synthesis stage. All retrieved articles were assessed for relevance using the following inclusion/exclusion criteria:

- Relevant to the topic assessed with reference to the PICO established for the study and the REA question and aims (with an emphasis on what works in practice).
- Geographical reference: national (UK) and international studies (in a developed world context). (These are refinements at the search stage where possible).
- Date restrictions: 2013-present (these are refinements at the search stage where possible).
- English language only.
- Reviews and secondary data, modelling studies included but theoretical, thought piece/viewpoints or conceptual studies excluded.

A two-phase process is used to filter out non-relevant articles according to these criteria.

- The first phase screening includes reading only the title or headline of the evidence found. The evidence sources are then marked (in database) as: clearly relevant, clearly not relevant or uncertain. If the evidence is found to be clearly relevant or uncertain at this first stage it is obtained in full.
- The second phase screening involves reading the abstract or first paragraph (or full paper in some cases) of the clearly relevant or uncertain evidence to identify those that meet the inclusion/exclusion criteria and will be used in the evidence extraction and synthesis phases.

Following this screening, the Web of Science and Google Scholar results are combined and duplicates removed (by EndNote).

Search results from organisational web sites are also screened using the same criteria. Those that passed the inclusion criteria are then examined at abstract/full text level by following the web links to retrieve the full document. Evidence referred to by expert sources is screened in the same way.

Following this stage, the search results will be checked against expert knowledge of the team to ensure no key papers are missing. This stage will also cross check against the gaps identified in the previous report to ensure that any papers that can address these are identified and included; if not, a further search will be considered.

EndNote library

Records, abstracts, and where possible pdfs, are downloaded to an online EndNote library. Livestock and crops libraries are amalgamated at the end of the process in order to delete duplicates.

Search record database

Searches are recorded for each search type/string. Decisions at each phase are recorded on a spreadsheet showing search source, terms, number of hits, number excluded/included according to the criteria, and number of full text pieces of evidence to be included in the critical appraisal.

Extraction strategy

This entails developing a template for information extraction. This ensures that the extraction is done in a way that was consistent for each piece of evidence. Again, this is refined progressively through team discussion throughout the REA process.

Critical appraisal

In the critical appraisal stage the screened papers and reports are read and subjected to a full text analysis. Each piece of evidence is coded against a set of factors guided by the primary questions (i.e. indicators of 'what works').

This critical appraisal also assigns scores to each piece of evidence according to relevance and robustness criteria. Scoring and criteria for quality of evidence includes a ranking of each piece of evidence from 1-3 based on the following (one single score is assigned):

Box 1: Relevance

<u>*Scoring and criteria for relevance*</u>
Each piece of evidence was ranked from 1-3 on the basis of the following (one single score was assigned):

- The relevance of the research method used to the REA question
- The relevance of the evidence to the target subject/population of the REA
- The relevance of the outcome measured

Score 3: Fulfils criteria and includes studies that assess the outcomes of different behavioural change approaches, methods, interventions (i.e. what works) in terms of farmers' behaviour change and other indicators
Score 2: Partially fulfils criteria in that some aspects of the study are not relevant
Score 1: Fulfils few criteria in that few aspects of the study are relevant
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Box 2: Robustness

Category of type of evidence

A: Quantitative studies e.g. numbers participating before-after or matched to a control population; numbers of species monitored In a longitudinal survey

B: Qualitative studies e.g. interviews, case studies to collect data on attitudes, behaviour, hypothetical studies to assess potential behaviour, behavioural intentions (e.g. theory of planned behaviour)

C: Reviews e.g. literature reviews, summarises, desk based analysis, workshop and conference outputs

D: Evaluation of projects and programmes including methods above

Scoring and criteria for robustness

Each piece of evidence is ranked from 1-3 on the basis of the following (one single score is assigned):

- The methodology used is clearly and transparently presented
- Peer reviewed
- Numbers and types of farmers and/or stakeholders involved suit the studies research aims (n=>20)
- Sampling methods and analysis are reliable
- Conclusions are backed up by well presented data and findings

Score 3: Fulfils criteria and includes studies interviewing, surveying or consulting farmers and/or stakeholders where numbers and sampling method provide a largely representative rather than illustrative number (n= >20).

Score 2: Partially fulfils criteria (for example non-peer reviewed study with reliable methodology);

Score 1: Few criteria fulfilled and /or analysis from desk studies, interpretations, expert knowledge, or inferences from previous studies.

A minimum quality appraisal level was set that defined those articles to be included and those of insufficient quality for use in any synthesis.

Synthesis of the results

The final narrative synthesis stage, provides:

- A critical analysis of the factors that determine 'what works' (answers the REA question)
- A description of the volume and characteristics of the evidence found by the review and discusses the adequacy of the overall evidence base to answer the primary REA question. This stage combines the scoring of relevance and robustness with a view to giving greater weight to higher scored pieces of evidence.

An EndNote library and a 'map' (classification sheet) are produced.