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Making sense of farmland biodiversity management: an evaluation of a farmland biodiversity management communication strategy with farmers

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Abstract
Biodiversity is a valuable resource that supports sustainability within agricultural systems, yet in contradiction to this agriculture is recognised as a contributor to biodiversity loss. Agricultural advisory services are institutions that support sustainable agricultural development, employing a variety of approaches including farmer discussion groups in doing so. This study evaluates the impact of a farmland biodiversity management (FBM) communication strategy piloted within Irish farmer discussion groups. A sensemaking lens was applied in this objective to gain an understanding of how this strategy could create an actionable space for FBM promotion amongst farmers. The strategy was piloted with six Irish dairy farmer discussion groups, after which focus groups were conducted with members of these groups. Additionally, baseline and endline surveys were completed by the members to determine their knowledge, attitude and on-farm practices relating to FBM. Analysis of the focus group data identified that the communication strategy supported the affordance of sensemaking with respect to FBM. Analysis of the data from the baseline and endline surveys relating to knowledge, attitudes and practices found that engaging with the communication strategy promoted farmers to improve their attitude in relation to FBM. Results from this study provide important lessons for agricultural advisory services to support farmers in incorporating FBM into the overall management of their farms and, in turn, to promote the improvement of farmland biodiversity and contribute to a sustainable future.

Keywords Biodiversity · Sustainability · Farmland Biodiversity Management · Sensemaking · Advisory Services · Communication

Introduction

Biodiversity refers to the variability among living organisms and their ecological complexes (UN 1992) and provides humankind with intrinsic, utilitarian, serendipic, and functional values (Sizemore 2015; Swift et al. 2004). These values, amongst other things, support the preservation and adaptability of ecosystems, which supply beneficial ecosystem services (MEA 2005). Biodiversity is, therefore, strongly linked with all pillars of sustainability, (i.e., environmental, economic and social sustainability) (FAO 2018; Niesenbaum 2019) and, as such, is a crucial component of sustainable agriculture (Calker et al. 2005). Sustainability within agriculture is essential to providing society with sufficient supply of food, while also reducing its negative impacts on the environment, especially those relating to climate change, water quality and biodiversity (Buckley et al. 2019). Biodiversity loss, however, has been experienced at increasing rates in recent decades, with agriculture contributing to this decline (Díaz et al. 2019; Eekeren et al. 2018). While the role of non-farmer landowners has been recognised in the development of more multifunctional landscapes that place greater emphasis on land use for biodiversity and amenity values alongside agricultural production (Groth-Joynt et al. 2020), Kuemmerle et al. (2016) observed relatively moderate land use change in Europe with stable or increasing land management intensity in western Europe. As such, the implementation of biodiversity management practices by farmers on farm is a strategy to address biodiversity

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loss associated with agriculture and maintain the rich values offered by biodiversity (Maas et al. 2021; Sizemore 2015).

Agricultural advisory services are pivotal in guiding agricultural practices and farm development towards agricultural sustainability (McDonagh et al. 2013; Wang et al. 2021). Within such services, farmer discussion groups are an established participatory approach to the delivery of farm management advice that support learning and practice change (Bogue 2013; Garforth et al. 2004). Discussion groups bring, on average, 12 to 15 farmers operating similar enterprises (e.g., dairy farms) together on a regular basis, usually on the farms of fellow members, to engage in discussion, knowledge sharing, problem solving, and practice observation and reflection (Bogue 2013; Läpple et al. 2013; Prager and Creaney 2017). As such, agricultural advisory services, more specifically farmer discussion groups, represent a means of both motivating practice change on farms and reaching a relatively large number of farmers in an efficient manner on the topic of farmland biodiversity management (FBM) (Garforth et al. 2004; Bogue 2013). This is particularly relevant given the importance of supporting farmers in implementing biodiversity-friendly management practices on their farms is continually increasing. For example, this can be seen in the recent restructuring of the European Common Agricultural Policy, which reflects an increased concern and focus on sustainability, including a focus on improved farmland biodiversity (Dupraz and Guyomard 2019).

Literature review

A need exists to strategically change the human behaviours from which threats to biodiversity arise (Maynard et al. 2020; Schultz 2011). Communication strategies that support knowledge exchange, skill development, and action implementation have been identified as a means of encouraging sustainable natural resource management (van de Fliert 2014). Within agriculture, encouraging positive biodiversity-related behaviour change amongst farmers has largely relied on legislation, regulation, and incentivisation, particularly in areas where intensive farming is commonplace (de Snoo et al. 2013; Kleijn et al. 2004; Rotchés-Ribalta et al. 2021). Literature on the impact of these incentives, in particular incentivised agri-environmental schemes (AES), has shown that although small increases in the richness or abundance of common species in local regions have been observed (Batáry et al. 2015), widespread increases in European farmland biodiversity have not been achieved (Stoeckli et al. 2017). Poor uptake among farmers of voluntary AES, as well as a lack of collaboration between farmers within these schemes have been identified as shortcomings (McGurk et al. 2020; Leventon et al. 2017). With that said, insights have been gained from agri-environmental schemes into how communication with farmers on the topic of biodiversity protection and enhancement can be achieved. Gabel et al. (2018) demonstrated that Swiss farmers who had been exposed to on-farm, biodiversity-focused advice from experts held positive attitudes and were of the belief that agriculture was responsible for protecting the environment and conserving and promoting biodiversity. Similarly, Chevillat et al. (2012) proposed that farmer willingness to implement subsidised biodiversity enhancement measures dictated by AES could be increased amongst those who receive on–farm biodiversity advice from biodiversity experts.

To enhance the effectiveness of these schemes, the establishment of communication platforms that impart conservation information and assist farm advice providers has been recommended (Maas et al. 2021). Furthermore, Maleksaeidi and Keshavarz (2019) recommend the implementation of educational programs to improve farmers' knowledge of biodiversity, its value and the approaches that can be taken to protect it on farm, while Ahnström et al. (2009) called for the embedding of biodiversity protection in the minds of farmers. Many authors have provided insights into the psychological considerations that should be made when engaging farmers on environmental management, as well as when attempting to encourage the application of biodiversity practices amongst farmers. For example, Wauters et al. (2017) emphasised the need to trigger farmers' self-identity and position biodiversity practices as a social norm within peer groups to bring about enduring change. Moreover, Mills et al. (2017) suggested the development of messages and advisory programmes that focus on the values and norms that influence farmer decisions to encourage sustainable environmental behaviour.

Moreover, insights into effective communication on FBM can be gained from previous studies that have focused on communication and behavioural change interventions with farmers on a variety of topics. In a communication campaign entitled "Cover Crop Champions", implemented in the USA by the National Wildlife Federation, farmers categorised as early practice adopters were trained to communicate with potential adopters by sharing their achievements, facilitating on-farm demonstrations, highlighting benefits, and using simple language to normalise cover cropping (Bressler et al. 2021). As a result, farmer networks and farmer mentoring were established, and the campaign was successful in positively influencing farmers' attitudes and behaviours (Bressler et al. 2021). In a European context, Lokhorst et al. (2010) found that a combination of bespoke information and public pledging resulted in an increases in conservation, areas of non-subsidised habitats, and time allocated to biodiversity protection by farmers. More recently, Velado-Alonso et al. (2021) have developed guidelines for efficient communication with farmers on biodiversity

integration. These include positive affirmation focused on solutions, placing an emphasis on practicality, ensuring that messages are clear, and encouraging cooperation. The development of plans has also been highlighted as a method of increasing farmer's positive biodiversity behaviours, with the integration of biodiversity considerations into farm planning being recommended by Small and Maseyk (2022). Moreover, facilitated farmer discussions and action planning as a peer group were reported to have enabled farmers to change their practices related to antimicrobials in the UK (Morgans et al. 2021), while frequent, short discussions on farm safety within farmer discussion groups were found by farmers to be more effective than less frequent, long discussions (O'Connor et al. 2021). While various insights into the development of an effective communication strategy on FBM for farmers can be readily derived from the literature, to the best of our knowledge no evaluation of the effectiveness of a FBM communication strategy in creating space for the promotion of positive FBM among members of dairy farmer discussion groups has been documented.

Irish agriculture and biodiversity in context

In Ireland, the total land area used for agricultural purposes equates to 4.5 million hectares, with 135,037 farms having an average size of 33.4 ha (CSO 2020a). Farm type is dominated by livestock production with specialist beef, dairy, and sheep farms accounting for 54.92%, 11.34% and 12.91% of all farm types, respectively, with mixed grazing livestock, and mixed crops and livestock accounting for 7.6% (CSO 2020a). Tillage, field crops, and other farm types make up the remaining 13.2% of farm types (CSO 2020a). With specific regard to dairy farms, these are predominantly found in the southern regions of the country, with additional pockets found in the north-east and mid-east (CSO 2020b; Meredith and Crowley 2017). Dairy farms tend to be larger in size than the average Irish farm (CSO 2020a) and operate at a higher intensification of land use (Buckley and Donnellan 2020). As previously highlighted, a strong link between land use intensity and biodiversity loss exists (Tilman et al. 2001).

Intensively managed Irish farms, including dairy farms, retain nearly 10% of their agricultural holding as wildlife habitats, mainly in the form of linear features (i.e., hedges, watercourses, and field margins) and semi-natural woodlands (Larkin et al. 2019). Linear habitats, in some cases, may be the only habitat present on intensively managed farms (Keena 2020). Larkin et al. (2022) found that the majority of field margins on Irish dairy farms assessed in their study were either of low or very low quality. The majority of hedgerows, on a sample of intensive Irish farms, have also been reported as being of low ecological quality (Ó hUallacháin et al. 2019). In Ireland, a large proportion (46%) of the surface water bodies are of unsatisfactory ecological status, with agriculture being identified as a significant pressure on this (EPA 2022). As such, FBM practices that are most relevant to Irish dairy farms include those that promote the retention, maintenance, enhancement and creation of hedges, watercourses, and field margin habitats through the application of simple measures (Keena 2020; Teagasc 2020).

This paper presents an evaluation of the impact of a FBM communication strategy on the farmer members of dairy farmer discussion groups and their FBM practices. This evaluation focuses on four communication activities that constituted the FBM communication strategy. These activities, for which further detail is provided in Section "Methodology", were a biodiversity feature mapping activity, a FBM planning activity, FBM integration into discussion group meetings, and FBM integration into discussion group WhatsApp groups. This evaluation could provide foundational guidance to agricultural advisory services, who have an important role in communicating with farmers on sustainability issues (Wang et al. 2021) and, as such, are responsible for the development of an effective communication strategy for improved FBM on farms. To achieve this objective, we employ a sensemaking lens to gain an understanding of how the FBM communication activities can be leveraged to improve farmland biodiversity on farms through communication with farmers.

Theoretical framework

Sensemaking is a process of exploring and assigning meaning to experiences (Kramer 2017), when individuals in an organisation are triggered by an event that causes ambiguity around established meaning or practices. It is from this process that new meaning or practices may emerge (Apostol et al. 2021; Weick 1995). At the core of this process are seven interrelated properties identified by Weick (1995), the first of these being that sensemaking is grounded in identity construction with an individual's view of themselves, their experiences, and their interactions with others influencing their worldviews (Sneddon 2008; Helms Mills et al. 2010). Sensemaking is also retrospective, indicating that it is only after an action, thought or event has been experienced that meaning around it can be developed (Weick 1995; Sneddon 2008; Hayden et al. 2021). Thirdly, sensemaking is enactive of sensible environments, which means that by taking action a sensemaker develops their own reality that they label with meaning, making it sensible to themselves (Weick 1995; Sneddon 2008). Sensemaking is not a solitary activity because an individual's internal processes and what they do are dependent on interactions with others, as such sensemaking processes are social

(Weick 1995). Sensemaking is also characterised by its ongoing nature, which positions it as a process through which people notice and extract cues; cues are familiar structures that guide a sensemaker in developing a greater understanding of what is occurring by causing sense to break, generating new sense, and potentially leading to the establishment of new action (Weick 1995; Hayden et al. 2021; Huzzard 2004). Finally, sensemaking is driven by plausibility rather than accuracy, which means that a person will look for cues that appear reasonable and coherent, rather than seeking accuracy in the sensemaking process (Weick 1995; Helms Mills et al. 2010).

Previous agricultural studies have adopted sensemaking perspectives to gain deeper understandings of various topics which have, in turn, provided useful insights for policymakers and agricultural advisors in their role in supporting farmers. For example, Hayden et al. (2021) identified strong links between the seven properties of sensemaking and the factors influencing farmer's strategic farm expansion decision-making processes, and thus used sensemaking as an approach to develop a deeper understanding of the topic. Sneddon (2008) conceptualised sensemaking in an agricultural innovation context as a process in which farmers notice, bracket, and select cues to create a plausible story about a technology, which in turn guide's their actions towards it on-farm, with these authors placing a focus on farmer's personal identity and social context. Tisch and Galbreath (2022) explored farmer's sensemaking of climate change events through a lens that focused on factors believed to shape the sensemaking processes, such as natural materiality, routine experiences, and social learning.

This paper contributes to the sensemaking research carried out to date in the realm of agriculture by applying a sensemaking lens to gain insights that have practical implications for agricultural advisory services in relation to the FBM communication activities described in Section "Methodology". To do so, we adopt the work of Seidel et al. (2018) who identified key sensemaking activities required for understanding what sensemaking support systems should afford their users and how they should be designed in order "to prepare ground for action" on implementation of sustainable practices. The first of these sensemaking activities is that of "experiencing disruptive ambiguity and surprise" which relates to the initiation of sensemaking through a triggering event. The communication activities, that constitute the FBM communication strategy described herein, could be considered as a series of minor planned events with the potential to trigger discussion group members into sensemaking efforts associated with FBM (Sandberg and Tsoukas 2015). "Noticing and bracketing", and "labelling and categorising" (referred to hereafter as 'noticing and categorising') are based on the aspects of the sensemaking process that involve the extraction of cues and the development of a simple, credible story that can guide action (Seidel et al. 2018; Weick 1995; Weick et al. 2005). In the context of the FBM communication strategy, the cues could be the constituting communication activities. Sensemaking is not only concerned with the current situation, but also what comes next and as individuals become aware of an issue they can then begin to anticipate and plan their next action, as such 'action planning' is another sensemaking activity (Seidel et al. 2018). Action planning by farmers with regard FBM could be supported through the FBM communication activities of interest to this study. The final sensemaking activity relates to sense emerging via ongoing communication amongst individuals, who socially organise their thoughts and actions through conversation, and in turn, this provides a foundation for action (Taylor and Van Every 2000; Seidel et al. 2018). Building on the sensemaking activities of Seidel et al. (2018), this study further explores the notion of identity construction through the process of sensemaking. Weick (1995) notes that "what the [interrupted] situation means is defined by who I become while dealing with it or what and who I represent". As such, the sense made by individuals when triggered to do so is strongly influenced by the identity developed in the context of that event (Weick 1995). The affordance of identity construction associated with biodiversity would be a key component of a FBM communication strategy for farmers that aims to bring about positive FBM change, with Groth-Joynt et al. (2020) highlighting that Australian rural landowners who identify as full-time and part-time farmers assign a lower priority to biodiversity than those that identify as hobby farmers and non-farmers. van Dijk et al. (2016) in their paper on the factors underlying farmers intentions to perform unsubsidised agri-environmental measures refer to farmer self-identity as "the extent to which the performance of a certain behaviour is considered as being part of the self" (Terry and Hogg 1996a, b; Terry et al. 1999a, b in van Dijk et al. 2016). Conceptualisation of farmer identity construction in the context of the FBM communication strategy relates to the process of self-questioning by farmers on the position of FBM within the management of their farms (Weick et al. 2005).

The communication activities piloted with farmer discussion groups in this study are conceptualised as having the potential to afford farmers with the various sensemaking activities identified by Seidel et al. (2018) and Weick (1995). To do so, the current study embraces the concept of affordances, which are the action potentials (e.g., practice changes) offered by an object (e.g., an information system) to a user (Gibson 1979; Seidel et al. 2018). As the aim of the communication strategy itself is to support farmers to take action on FBM on their own farms,

sensemaking offers a theoretical lens that aligns with the interpretative and subjective characteristics of the study (Hayden et al. 2021).

Methodology

To explore the opportunity presented by farmer discussion groups as an approach to supporting farmers to protect and enhance biodiversity on farm through the adoption of FBM practices, a FBM communication strategy was piloted with dairy discussion groups. This pilot was carried as part of a wider participatory action research study and was informed by insights gained from a previous cycle of action research involving the trialling of FBM communication activities with demonstration farmers and by a phase of multi-actor co-design with relevant stakeholders including farmers, agricultural advisors, and industry representatives. The pilot was carried over the course of a 12-month period (January 2022 to December 2022) with 6 dairy farmer discussion groups (referred to as intervention groups) in the south-east of Ireland. The focus of this paper is on the evaluation of the four communication activities included in the communication strategy pilot, which are described below:

1. **Biodiversity feature mapping:** This activity was a group activity incorporated into the agenda of a regular discussion group meeting for each intervention group between January and April 2022. Group members were provided with a copy of their own farm boundary maps, a clipboard, coloured markers and a pen, and were guided in highlighting their farm habitats on their maps by the researcher (i.e., the first author).
2. **FBM planning activity:** This activity was incorporated into the agenda of regular discussion group meetings between April and June 2022. A FBM planning worksheet, which included digitised biodiversity maps (specific to each farmer), a FBM self-assessment section (Keena 2020), and a target and action identification section, was provided to each group member. The planning activity was facilitated by the researcher. The output from this was a poster outlining the farm specific FBM plan and biodiversity feature maps created in activity one (an example of this output is provided in Appendix 1).
3. **FBM integration into discussion group meetings:** FBM was integrated as a topic into three regular group meetings for each intervention group between June and July 2022, August and September 2022, and October and December 2022. During these meetings, a minimum of 10 minutes was set aside for the inclusion of FBM, but this time was flexible and was dictated by the groups and the discussion that transpired. FBM integration into the discussion group meetings was facilitated by the researcher.
4. **FBM integration into discussion group WhatsApp groups:** FBM was integrated as a topic into the pre-existing WhatsApp groups associated with each of the intervention groups from January to December 2022. This was identified as an activity with the potential to support communication on FBM during the time intervening physical group meetings. WhatsApp group posts, which included messages, videos, infographics, and articles, were curated by the researcher, and were distributed by the advisors associated with each group.

Following the conclusion of the 12-month pilot, focus groups were carried out with the farmers involved in the intervention groups. Output from these focus groups formed the basis of the sensemaking evaluation of the communication strategy. An outline of the focus groups, along with their analysis is provided in Section "Focus groups". Baseline surveys were carried out before the communication activities were piloted, with endline surveys conducted prior to the focus groups. Both surveys assessed farmer knowledge, attitude and practices associated with FBM. The surveys were conducted with farmers who were involved in the FBM communication strategy pilot (i.e., intervention groups) and farmers who were not involved in the pilot (i.e., non-intervention groups); this process is explained further in Section "Knowledge, attitude and practices survey". As highlighted by Morris (2003) participatory campaign evaluations have a dual focus, one which evaluates the achievement of specific development goals and one which evaluates the process. Similarly, the current study grapples with a twofold evaluation. The first of these assesses the achievement of the desired outcome, namely the assessment of changes in farmers' knowledge, attitude, and practices associated with FBM brought about by the communication strategy. The second of these was an evaluation of the processes that potentially mediate those outcomes, namely the FBM communication strategy, its associated activities, and their affordance of sensemaking to farmers. As such two methods, namely surveys and focus groups, were employed to, respectively, evaluate the outcome and processes of this study. Past studies have also adopted dual methodologies when evaluating their respective programs (Abu-Taleb and Murad 1999).

Focus groups

Focus groups provide an opportunity to study the ways in which individuals collectively make sense of an event and develop meaning around it (Bryman 2012). One focus group per intervention group (i.e., a total of six focus groups) was carried out. These were incorporated into the agenda of a meeting of each intervention group between January and

April 2023. In total, 44 farmers participated in the focus groups out of a potential 85. The focus groups were facilitated by the researcher, with the advisor associated with each discussion group also present. All focus groups were audio recorded, with the participants' consent.

A 30-min focus group guide, adapted from Seidel et al. (2018), was developed. The first section of each focus group was an introductory section to encourage balanced participation and outline the structure and purpose of the focus group (Bryman 2012). In section two of the focus group guide, participants were provided with a sheet outlining the piloted FBM communication strategy. The group members were encouraged to reflect on their initial feelings towards the introduction of the strategy into their discussion group. For sections three and four of the focus group guide, posters summarising the communication activities were displayed to assist reflection on each activity. In section three, participants outlined the communication activities that were important to them. To complete section four each participant completed a Sensemaking Affordance Evaluation Instrument, the development for which is outlined in Section "Development and implementation of the sensemaking affordance evaluation instrument". Participants were guided through the evaluation instrument. In section five of the focus group guide, participants were asked for suggestions to improve the communication strategy.

Development and implementation of the sensemaking affordance evaluation instrument

The development of the nine statements representing the sensemaking activities that formed the Sensemaking Affordance Evaluation Instrument was guided by those employed by Seidel et al. (2018) and adapted to the context of the current study (Appendix 2). The statements were validated by the research team, with the acceptability of the statements tested through piloting the instrument with a small number of farmers not involved in this study. The Sensemaking Affordance Evaluation Instrument included a cover page followed by four evaluation pages (i.e., one for each communication activity). The evaluation pages included a written summary of the activity, with associated images to further support participant reflection. The participating farmers also had the option to identify anything else that they felt each of the activities had afforded them by answering an open-ended question.

Focus group analysis

The focus groups' discussions were transcribed by the researcher who checked the accuracy of these against the recordings. As previously stated, the objective herein was to evaluate the impact of the communication strategy on farmers and their decision to make FBM practice changes, for which a sensemaking lens was applied to gain an understanding of the communication strategy's effectiveness. Given this 'sensemaking lens', manual deductive analysis was employed to analyse the focus groups, in which the coding of the transcript data, carried out by the researcher, focused on participants responses as they related to the sensemaking activities. These activities were derived from the theoretical framework of this study, which itself was based on an in-depth review of the associated literature.

Knowledge, attitude and practices survey

Knowledge, attitude, and practice (KAP) surveys were developed with the aim of providing insight into what is known (knowledge), believed (attitude) and done (practiced) by farmers in the context of FBM (Andrade et al. 2020; Fan et al. 2018). As such, the surveys also provided a further means of measuring the effectiveness and impact of the communication strategy. Baseline (i.e., pre-pilot) and endline (i.e., post-pilot) KAP surveys were administered to the farmers who were involved in the FBM communication strategy pilot (i.e., farmers in the six intervention groups) and to farmers not involved in the pilot (i.e., farmers in 12 non-intervention groups). Demographic information for the intervention and non-intervention participants included in the associated analysis for the KAP surveys is provided in Table 1, which reveal that both the intervention and non-intervention groups were of varying demographics. Similar to the demographic information presented herein (Table 1), O'Connor (2020) previously described Irish dairy discussion as being male dominated, and consisting of farmers that vary in age, education, and herd size. Prior to administering the surveys with the participants, the surveys were piloted with farmers not involved in this study. All farmer discussion groups whose members participated in the KAP surveys were based in a common advisory region. The baseline KAP surveys were administered between October and November 2021, with the endline KAP survey administered between November and January 2022/23 at famer discussion group meetings. Surveys were anonymous, paper-based and administered by the researcher.

KAP survey analysis

The answers provided by participants in the KAP surveys were used to generate a knowledge score, an attitude score, and a practice score for individual participating farmers, both at the baseline and endline of this study. To form the knowledge score, the answers were converted to numeric scales, with incorrect answers or answers of 'I don't know' given a numeric value of 0. All correct answers were given values of 1, except for seven questions regarding whether

Table 1 Demographic information for participants included in the analysis of the knowledge, attitude, and practice scores

	Intervention Group			Non-Intervention Group		
	Knowledge ($n=21$)	Attitude ($n=22$)	Practices ($n=23$)	Knowledge ($n=26$)	Attitude ($n=26$)	Practices ($n=28$)
Gender	Male ($n=21$)	Male ($n=22$)	Male ($n=23$)	Male ($n=26$)	Male ($n=26$)	Male ($n=28$)
	Female ($n=0$)	Female ($n=0$)	Female ($n=0$)	Female ($n=0$)	Female ($n=0$)	Female ($n=0$)
Average Age (Years)	46.52	46.59	45.91	48.46	48.73	48.86
	(Range: 26–57)	(Range: 26–57)	(Range: 26–57)	(Range: 28–64)	(Range: 28–64)	(Range: 28–64)
	(SD[b]: 7.38)	(SD: 7.88)	(SD: 8.34)	(SD: 8.06)	(SD: 8.19)	(SD: 7.94)
Average Years Farming	26.90	27.05	26.30	29.12	29.04	29.07
	(Range: 4–41)	(Range: 4–41)	(Range: 4–41)	(Range: 4–48)	(Range: 4–48)	(Range: 4–48)
	(SD: 8.46)	(SD: 9.11)	(SD: 9.56)	(SD: 9.68)	(SD: 9.58)	(SD: 9.35)
Highest Education Level	Primary ($n=2$)	Primary ($n=2$)	Primary ($n=2$)	Primary ($n=1$)	Primary ($n=1$)	Primary ($n=1$)
	Secondary ($n=3$)	Secondary ($n=3$)	Secondary ($n=3$)	Secondary ($n=8$)	Secondary ($n=8$)	Secondary ($n=9$)
	Post-Secondary Diploma ($n=14$)	Post-Secondary Diploma ($n=15$)	Post-Secondary Diploma ($n=16$)	Post-Secondary Diploma ($n=16$)	Post-Secondary Diploma ($n=16$)	Post-Secondary Diploma ($n=17$)
	Degree/Masters/PhD ($n=2$)	Degree/Masters/PhD ($n=2$)	Degree/Masters/PhD ($n=2$)	Degree/Masters/PhD ($n=1$)	Degree/Masters/PhD ($n=1$)	Degree/Masters/PhD ($n=1$)
Formal Agricultural Qualification	Yes ($n=21$)	Yes ($n=22$)	Yes ($n=23$)	Yes ($n=25$)	Yes ($n=25$)	Yes ($n=27$)
	No ($n=0$)	No ($n=0$)	No ($n=0$)	No ($n=1$)	No ($n=1$)	No ($n=1$)
Average Owned Farm Size (Hectares)	61.91	61.14	62.70	62.96	64.09	62.69
	(Range: 32–105.20)	(Range: 32–105.20)	(Range: 32–105.20)	(Range: 18.20–141.20)	(Range: 18.20–141.20)	(Range: 18.20–141.20)
	(SD: 19.73)	(SD: 18.04)	(SD: 19.10)	(SD: 29.47)	(SD: 29.58)	(SD:28.95)

[a] Participants included in the analysis had matched samples from pre- and post-pilot surveys and were not identified as outliers. Demographic data was extracted from baseline information provided by these participants. [b] SD = Standard Deviation.

given plant species were considered noxious weeds in Ireland, for which each correct answer was given a value 1/7; this meant that the questions regarding noxious weeds held an equal weighting to all other knowledge questions in the formation of the knowledge score. For the attitude score, answers were converted from Likert scales to numeric scales ranging from 1 ('Strongly disagree') to 5 ('Strongly agree'). Finally, for the practice score, answers were again converted to numeric values, with answers corresponding to the implementation of a given practice in the management of a farm given a value of 1. The practice questions were broken down into the subcategories of questions regarding practices for hedgerows, watercourses, field margins and non-farmed areas. For each subcategory, the numeric values for each associated question were divided by the total number of questions in the subcategory to ensure an equal weighting within the formation of the practice scores. The knowledge, attitude and practice scores were subsequently formed as the sum of the numeric values associated with the corresponding questions in the baseline and endline separately. Higher scores represented a better knowledge of farmland biodiversity, and its management, a more positive attitude towards farmland biodiversity and its implementation of a greater number of FBM practices.

Taking the generated score data, boxplots were generated, with values greater than 1.5 box-lengths from the edge of the box identified as outliers, which were deleted from the data sets. After removal of outliers, 21 matched samples for knowledge score, 22 matched samples for attitude score and 23 matched samples for practice score, remained for the farmers in the invention discussion groups. For farmers in the non-intervention discussion groups, 26, 26 and 28 matched samples, respectively, remained for the knowledge, attitude, and practice scores. All scores were normally distributed as assessed by the Shapiro–Wilk's test of normality ($p > 0.05$), with the exception of the endline knowledge score ($p = 0.015$). Even though a single violation of the assumption of normality was detected in the dataset associated with knowledge, a two-way mixed analysis of variance (ANOVA) was still used to examine the interaction effects of time (i.e., baseline/endline) and group (i.e., participation of farmers in intervention or non-intervention groups) on the knowledge, attitude and practice scores. The robustness of

ANOVA methods to violations to the assumptions of normality has been highlighted by Blanca Mena et al. (2017, 2023). There was homogeneity of variances ($p > 0.05$) and covariances ($p > 0.001$) for all scores, as assessed by Levene's test and Box's M test, respectively. In the case that a significant interaction was detected, simple main effects were further examined using repeated measures ANOVAs.

Findings and discussion

This study focuses on outcomes associated with farmer sensemaking and farmers' knowledge, attitudes and practices regarding farmland biodiversity and its management following the piloting of a FBM communication strategy. Analysis of the KAP surveys provides an indication of the impact of participation in the piloting of the strategy had on farmers. Moreover, exploration of the sensemaking afforded to farmers by the communication strategy provides a deeper understanding of the impact of the strategy on farmers and their FBM, and also uncovers insights that provide foundation for the enhancement of communication on FBM within agricultural advisory services. The sensemaking afforded through each of the communication activities, is presented and discussed from Sections "Farmland biodiversity mapping" to "Comparing and contrasting the communication activities". In Section " Sensemaking throughout the farmland biodiversity management communication strategy", the focus expands to the communication strategy as a whole when a sensemaking lens is applied to the discussion that arose in the focus groups. Section "Impact of the communication strategy on farmers knowledge, attitudes and practices relating to farmland biodiversity" presents the KAP findings.

Farmland biodiversity mapping

The majority of farmers identified that this activity afforded them with all sensemaking activities of interest (Fig. 1). The mapping activity particularly allowed the participants moments of realisation in relation to the biodiversity areas for improvement on their farms and the practices that they could easily adopt to do so. Moreover, this activity allowed a high proportion of participating farmers to notice and categorise the quality of their current FBM practices (Fig. 1). These findings align with previous research in the areas of geospatial participatory modelling, which highlighted the tailoring of connections to problems and solutions as a benefit of participatory mapping approaches (Vukomanovic et al. 2019).

The mapping activity also allowed a high proportion of farmers to engage in open and inclusive communication

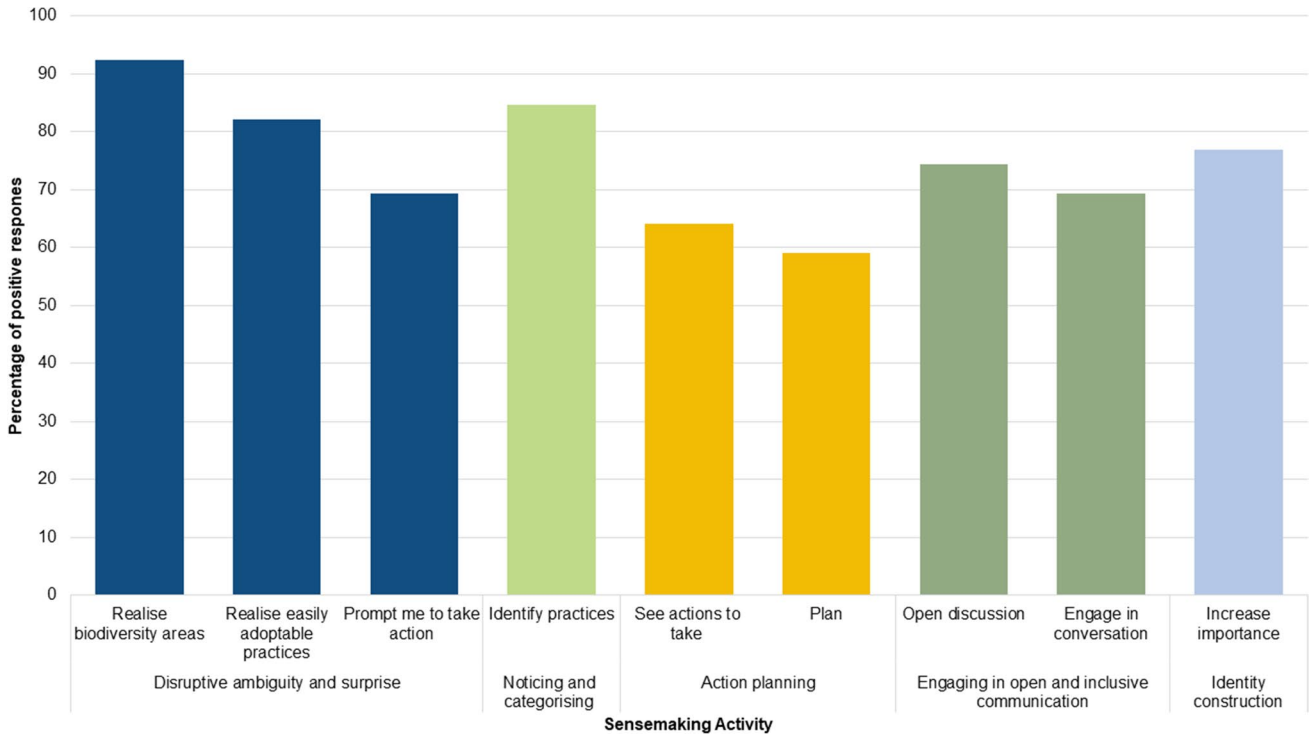

Fig. 1 The proportion of intervention dairy discussion group members ($n = 39$) who positively identified the affordance of each sensemaking activity through the biodiversity feature mapping activity

on FBM, while also increasing the importance of FBM in the overall management of their farms (i.e., identity construction; Fig. 1). Action planning, on the other hand, was afforded to the lowest proportion of farmers out of all the sensemaking activities evaluated under this activity. Nonetheless, participatory mapping activities have been previously identified to provide beneficial information for management planning (Eadens et al. 2009). The finding regarding the affordance of action planning by the mapping activity in this study could be reflective of the fact that this activity was the first implemented activity in the FBM communication strategy. Moreover, closer inspection within the affordance of disruptive ambiguity and surprise reveals a decline in the follow through of moments of realisation to prompts to action for the farmers (Fig. 1); this was a common trend observed across all other communication activities (Figs. 2, 3 and 4). Given the farmers response regarding the affordances associated with the mapping activity, it appears that this activity acted within the overall strategy as a guiding and instigative element, but one that may require the accompaniment of ancillary activities to ensure that planning and action on FBM are afforded.

Farmland biodiversity management planning activity

The planning activity also strongly afforded the majority of farmers with sensemaking on FBM (Fig. 2). Similar to the mapping activity, the planning activity particularly allowed farmers moments of realisation in relation to biodiversity areas for improvement and easily adoptable practices, with a reduced proportion (but a still a majority) highlighting that this translated to a prompt to action (Fig. 2). The benefits of participatory action planning around biodiverisity management, namely transparency, sense of ownership and a democratic process, have been highlighted by Laušević and Bartula (2016). On the other hand, Laušević and Bartula (2016) also highlighted the requirement for incentives for the widespread implementation of such plans. Of the communication activities assessed, the FBM planning activity afforded action planning to the largest proportion of farmers. This emphasises its place within the overall strategy, particularly as a complimentary next step to the mapping activity.

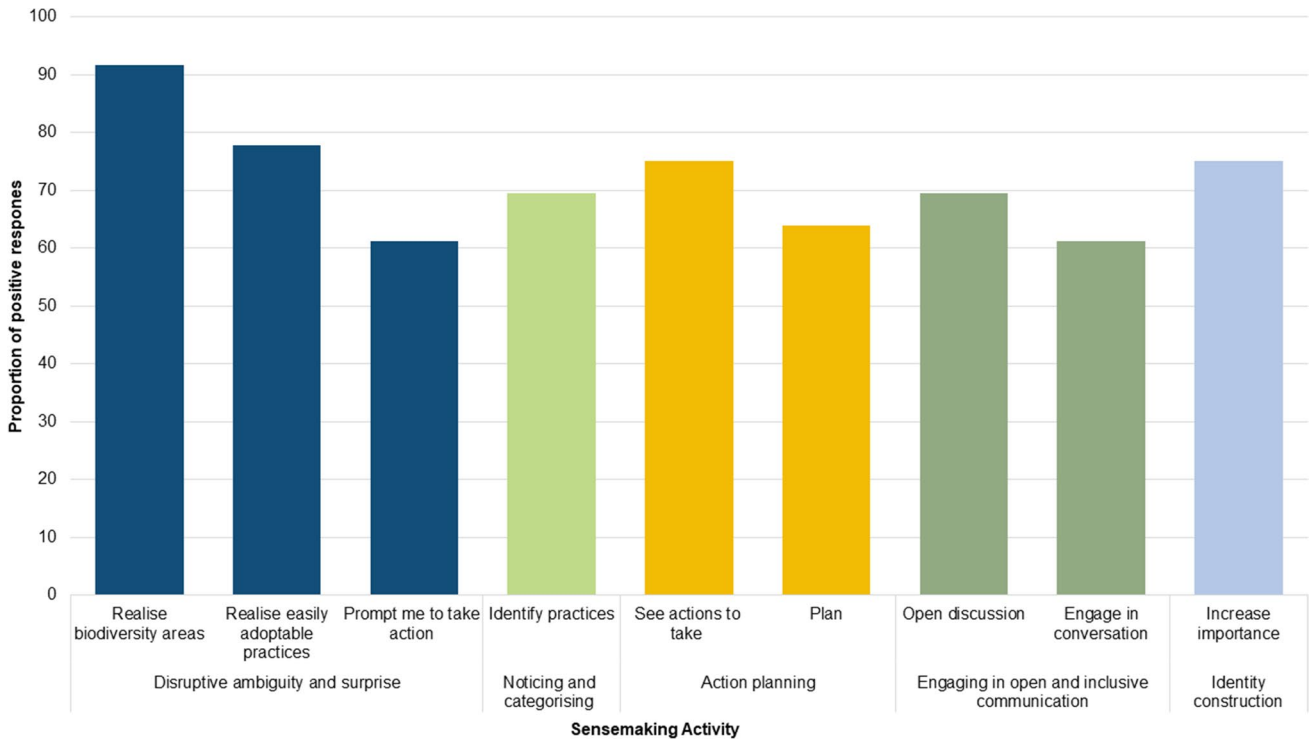

Fig. 2 The proportion of intervention dairy discussion group members ($n=36$) who positively identified the affordance of each sensemaking activity through the farmland biodiversity management planning activity

Farmland biodiversity management integration into discussion group meetings

The integration of FBM into discussion group meetings again afforded the majority of farmers with the sensemaking activities of interest (Fig. 3). Nonetheless, compared to the mapping and planning activities, the integration of FBM into discussion group meetings generally provided a lower proportion of farmers with the affordance of the various sensemaking activities. Compared with the corresponding affordances by all other communication activities, the integration of FBM into discussion group meetings afforded the lowest proportion with action planning.

Moreover, within the sensemaking activity of action planning, the integration of FBM into discussion group meetings afforded the lowest proportion of farmers to see actions that can be taken to improve biodiversity (i.e., adoptable practices that are not currently implemented, but could be implemented, on the individual's farm). This could highlight the lack of novel FBM practices and features presented on the host farms on which the meetings were held. In this case, this communication activity could benefit from planning discussion group meetings to be held on host farms on which novel biodiversity practices and features are present. The benefits of 'natural material objects' and 'ecological artefacts' in the sensemaking processes of farmers has been previously identified by Tisch and Galbreath (2022).

Farmland biodiversity management integration into discussion group WhatsApp groups

FBM integration into discussion group WhatsApp groups is the only communication activity for which the majority of farmers were not afforded sensemaking activities, namely noticing and categorising and engaging in open and inclusive communication. With this being said, FBM integration into WhatsApp groups did afford the majority with the ability to experience disruptive ambiguity and surprise, action planning, and also identity construction in relation to FBM. With specific regard to identity construction, the use of WhatsApp has previously been found to support the construction of professional identity amongst farmers in transitioning to more sustainable farming (Prost et al. 2022).

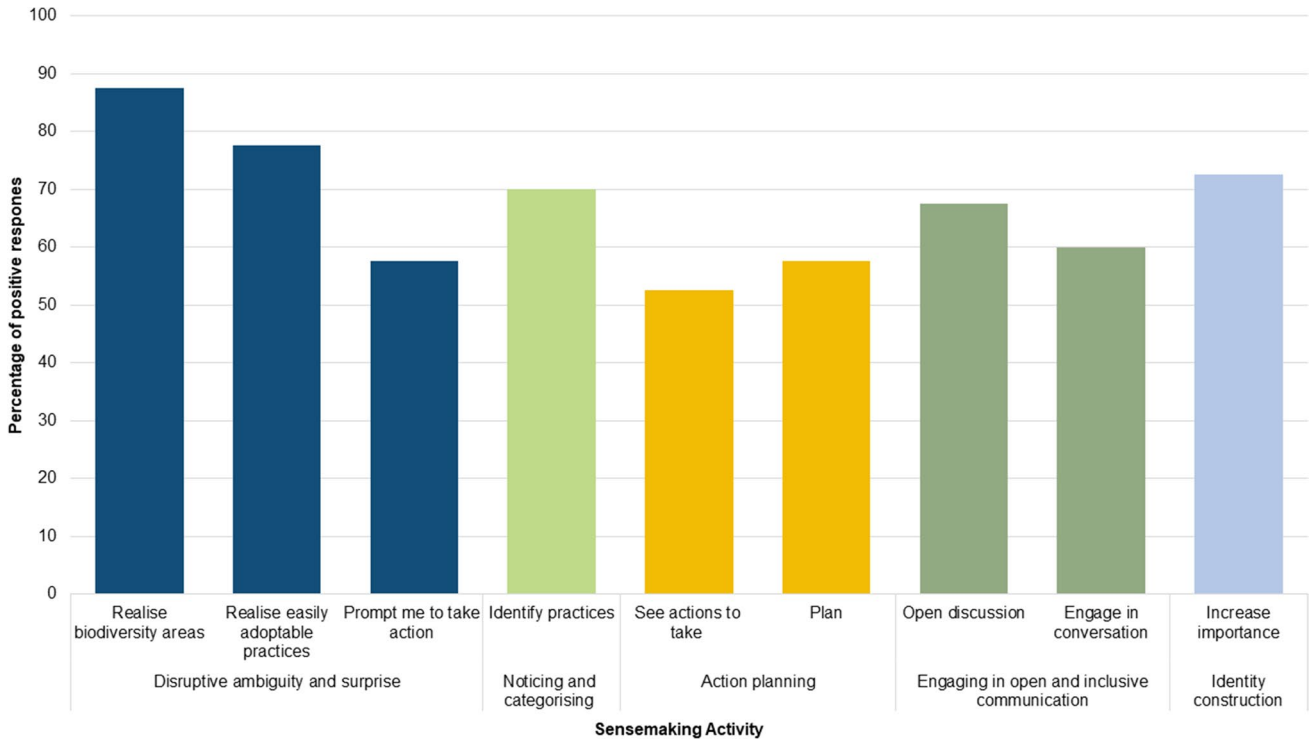

Fig. 3 The proportion of intervention dairy discussion group members ($n=40$) who positively identified the affordance of each sensemaking activity through the farmland biodiversity management integration into discussion group meetings

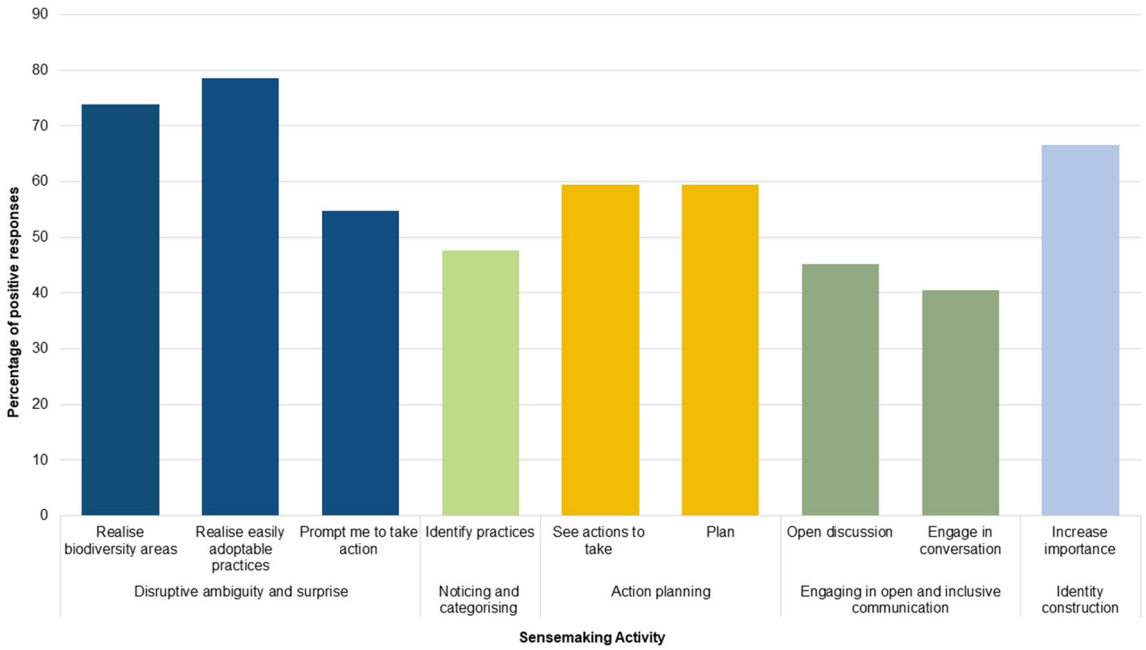

Fig. 4 The proportion of intervention dairy discussion group members ($n=42$) who positively identified the affordance of each sensemaking activity through the farmland biodiversity management integration into discussion group WhatsApp groups

Comparing and contrasting the communication activities

The sensemaking results of the FBM communication activities provide a useful insight into the effectiveness of the FBM communication strategy as a whole in supporting the process of sensemaking (Fig. 5). These results highlight that, on average, all of the sensemaking activities were afforded to the majority of farmers. For instance, disruptive ambiguity and surprise were afforded to the largest proportion of farmers across all of the communication activities, which signifies that the strategy as a whole acted successfully as a triggering event (Sandberg and Tsoukas 2015). In comparison, while the majority of farmers were afforded engagement in open and inclusive communication, this sensemaking activity was afforded to the lowest proportion (Fig. 5). With discussion and communication identified as key to the process of sensemaking (Seidel et al. 2018), as well as to knowledge creation (Cecez-Kecmanovic et al. 2003) These results signify the need to further encourage farmer-led discussion and conversation on FBM within the communication activities of interest, with group discussion previously reported by Morgans et al. (2021) as enabling practice change amongst farmers.

More specifically, comparing and contrasting the sensemaking results associated with the individual communication activities can inform the development of the communication strategy. For example, FBM integration into the WhatsApp groups, in general, afforded the lowest proportion of farmers with the sensemaking activities of interest (Fig. 4). This could signify that the WhatsApp centric activity is of a lower value in creating actionable space on FBM for farmers when compared to the other activities. Before definitively eliminating a communication activity on this basis, however, other considerations must be made. For example, consider the return on sensemaking afforded for the resources (e.g., time) inputted into the delivery of the WhatsApp communication activity. The integration of FBM into the WhatsApp groups required considerably less time to implement in comparison to the other communication activities and, as previously highlighted by Bogue (2018), was an efficient communication activity to implement. These are important considerations in the context of the delivery of agricultural extension (Dunne et al. 2019). As such, for the WhatsApp group activity, there would be value in further developing this communication activity to better afford sensemaking. In comparison, communication activities, such as the mapping and planning, involved a substantial outlay of resources, particularly in terms of preparation and implementation time, and so further development that maintains or further improves their ability to afford sensemaking, while reducing inputs should be explored.

Looking across the communication activities and their affordance of the sensemaking activities reveal varying degrees of complementarity amongst the communication activities (Fig. 5). For instance, while the biodiversity

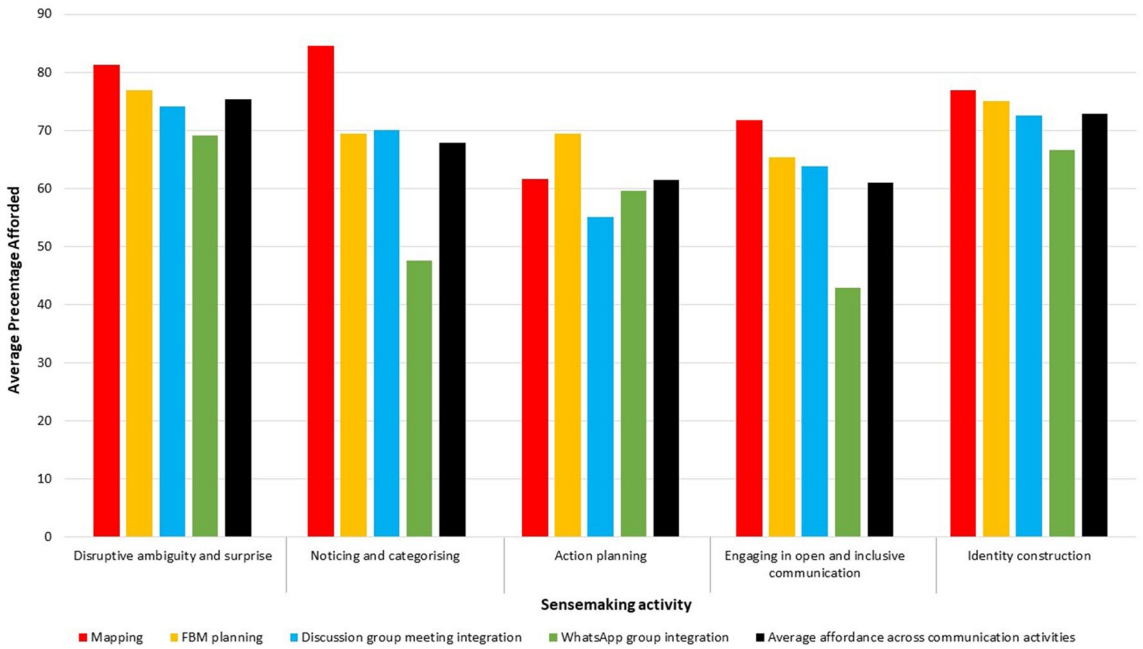

Fig. 5 Average affordance of the sensemaking activities for farmland biodiversity mapping activity (Mapping), farmland biodiversity management planning activity (Planning), farmland biodiversity management integration into discussion group meetings (Discussion group meeting integration), and farmland biodiversity management integration into discussion group WhatsApp groups (WhatsApp Group Integration) as well as the average affordance of the sensemaking activities across all of the communication activities

feature mapping activity afforded the highest proportion of farmers with the majority of the sensemaking activities of interest, it was the FBM planning activity that afforded action planning to the largest proportion of farmers. Similarly, Morgans et al. (2021) previously highlighted that facilitated discussions using both mapping and benchmarking were the "foundation for the action plans and provided farmers with confidence to change and adapt practices". As such, comparing and contrasting the affordance of sensemaking by the communication activities informs us on their strengths and weaknesses, but also allows us to consider their collective impact on the farmers' sensemaking.

Sensemaking throughout the farmland biodiversity management communication strategy

Applying a sensemaking lens to the discussions that took place during the focus groups provided further insight into the sensemaking afforded through the FBM communication strategy. Looking firstly to the sensemaking activity of disruptive ambiguity and surprise and, in particular, the eye-openers, stand-outs, and surprises referred to during the focus group discussions go further into highlighting the power of the communication strategy in sparking moments of realisation amongst the farmers. This is especially evident in the references made by the participants to the mapping activity.

> You look at the maps back there a year ago and you got us to draw out all the different things we had, … our own hedges and streams and habitats and that's the only thing, to see it in front of yourself that you discover what you have. **DG4**

Participatory mapping has previously been identified as an approach that can promote correct natural resource management within agricultural production through the bottom-up development of empowerment (Hossen 2016). In previous studies, which have employed participatory mapping approaches, the mapping process has been highlighted as being as valuable as the map itself (Levine and Feinholz 2015). Similarly, the map outputs in this study, along with the FBM indicators that emerged from the mapping and the FBM planning activity created realisation for the farmers around the extent of biodiversity on their farms and the need to do more in relation to FBM.

> When you see it on the printout, and you realise oh god I could be doing this, or I could be doing that. It's the first time actually I settled down and looked exactly what would be on our place … you actually think about it a bit and even when you're going out

> on the fields doing something on the tractor or something you'd be looking … **DG3.**

Contextualisation of information that is targeted to the environmental setting of an individual's farm is an important factor in promoting the voluntary adoption of conservation practices by that individual, as per Reimer et al. (2012). Additionally, making farmers aware of their environmental performance and acknowledging their efforts in a social setting has been previously noted as a useful tool to further encourage sustainable farming practices (Dessart et al. 2019).

Perhaps the reason we see a reduction in the proportion of farmers afforded with prompts to action on FBM, relative to the proportion afforded moments of realisation (Figs. 1, 2, 3 and 4), through the communication activities can be explained by the surprise amongst some of the participating farmers around the extent of biodiversity already present on their farms. Thus, creating a realisation that they already unintentionally had a variety of features and FBM practices in place.

> I was kind of surprised at how much I had done unbeknownst to myself **DG5**

Nonetheless, farmers were still prompted into taking on practices for the improvement of farmland biodiversity on their farms.

> I'd say the mapping was the most interesting. Definitely now this year all the internal hedges were cut on both sides but not on top. I just cut them too low, it was madness **DG1.**

Discussion in the focus groups also alluded to the sensemaking activities of noticing and categorising, with the FBM communication strategy prompting some farmers to take note of features and practices on their own farms and on other's farms that they might not have necessarily paid heed to in the past.

> When you go somewhere else, and you see something even though you could be looking at it at home every day and you see it on someone else's farm or [in] town or wherever you go, you pick up on something different completely **DG6.**

Two of the farmers who had received preparatory host farm visits (visits carried out by the researcher to host farms before discussion group meetings on their farms) also provided an indication that this supplementary aspect of the FBM integration into discussion group meetings promoted the affordance of noticing and categorising as it allowed them to view features and practices on their farms in a different light.

> When you walked the farm, you were picking what I call weeds off along the dikes. You said they're flowers, they're doing something right to have them there. **DG1**

The sensemaking activity of action planning also emerged from the focus group discussions with the planning activity being highlighted here, as well as the mapping and FBM integration into discussion group meetings.

> [In relation to the planning activity] … where you really applied it to your own farm, and you could really see clearly your own strengths and weaknesses and you could see as well how such small changes could make such a huge difference **DG5.**

The observation of real examples of biodiversity features and FBM practices was linked with what was interpreted in the focus group discussions as the affordance of communicative engagement.

> Talking about the hedges, the shape of them, what should be left, buffer zones and reseeding and keep out from the base of the hedge for wildlife purposes and that. You know you physically have to see what you're talking about **DG4.**

Seidel et al. (2013) found that engagement in communicative actions relating to the theme of environmental sustainability allows individuals to evaluate, communicate on and modify their current situations.

When we look at the focus group discussion relating to the affordance of identity construction as it relates to FBM and its position within the management of the participants' farms, many contrasting indicators emerge. From farmers' reflections on their initial reaction to the introduction of FBM into their discussion group, a set of mixed feelings emerged. For some, a sense of trepidation and vulnerability within their identity as farm managers created by the FBM communication strategy was revealed. This was reported alongside fears of a potential increased workload that the adoption of FBM practices would require and a fear of the impact of these on their ability to continue to operate productive farms.

> I suppose the first initial thoughts were that's drawing more work or something like that … we have enough already on our plates **DG2.**

Similarly, frustrations amongst participants, in one focus group in particular, relating to the legacy of past policies that promoted production, as well as a poor perception of farmers by the public was also noted.

> I do think that we were brought to where we are by governments or whatever ... so now we have to change … everyone has decided now that it's the wrong way **DG2.**

On the other hand, other farmers reflected on feelings of openness to the introduction of the FBM communication strategy into their discussion group. This was endorsed by a sense that communication on FBM would be advantageous given the increasing relevance and focus on FBM within agriculture, as well as a perceived need for more knowledge in this area.

> It was kind of time because we were listening to an awful lot about it, but we weren't kind of doing anything or knowing anything that was relevant to our situation **DG5.**

Indications that the communication strategy elevated initial apprehensions towards farmland biodiversity and the introduction of FBM within their discussion groups were put forward within the focus groups.

> It helped us rather than being a kind of heavy-handed thing **DG4.**

Moreover, farmers highlighted that they found the communication strategy to be a learning opportunity, as well as an instigator of practice change on their farms.

> We've farmed all our lives with our parents and we were always scraping back to the last bit you could get … it took a bit of a turn around to realise maybe that we should let things grow a little bit more so I suppose we've learned a bit …I know the children and everyone have learned a bit with the few things I would have brought home … they'd read them and saying oh yeah that's the way to do it **DG1**

Van Dijk et al. (2016), highlighted the importance of farmer self-identity in determining their intention to perform unsubsidised agri-environmental measures. Van Dijk et al. (2016) also stressed the need to increase the focus on farmer identity in order to increase farmers' willingness to implement biodiversity protection-focused practices, suggesting commitment making and emphasising positive traits relating to biodiversity as supports to this. The communication strategy of interest to this paper did, and could be further enhanced to, provide a means for commitment making, through the planning activity, as well as emphasising positive farm traits, through the mapping activity and the integration of FBM in discussion group meetings and WhatsApp groups.

Impact of the communication strategy on farmers knowledge, attitudes and practices relating to farmland biodiversity

Analysis was conducted on the knowledge scores, attitude scores and practice scores to determine the presence of significant differences in these scores between the baseline and endline based on whether participants were in an intervention or a non-intervention group. In other words, the purpose of the analysis was to detect the presence of significant interactions between time (i.e., baseline/endline) and group (i.e., intervention/non-intervention). No statistically significant interaction was detected for knowledge score, ($p = 0.203$) or for practice score ($p = 0.261$). On the other hand, a statistically significant interaction was detected for attitude score ($p = 0.005$). This signifies that the change in attitude score between the baseline and endline is different depending on whether participants were in an intervention or a non-intervention group. Looking at the intervention and non-intervention groups, the mean difference between the endline and baseline attitude scores was larger in the intervention groups (mean difference = 3.09) than in the non-intervention groups (mean difference = 0.57). This suggests that there was a bigger gain in attitude score amongst members of discussion groups that were engaged in the FBM communication strategy, compared with those who were not. With regard to the simple main effects, there was a statistically significant difference in attitude score of intervention and non-intervention groups at the baseline ($p = 0.046$), with the intervention groups having a lower mean baseline attitude score (31.00) than that of the non-intervention groups (32.65). In addition, there was a statistically significant effect of time on attitude score for the intervention discussion group ($p < 0.001$). No other significant simple main effect was detected. The simple main effects signify that the baseline attitude scores of the non-intervention groups were significantly higher than those of the intervention groups, but there was no significant change in the attitude scores of the non-intervention groups between the baseline and endline. On the other hand, the simple main effects also signify that between the baseline and endline there was a significant increase in the attitude scores of the farmers in the intervention groups (i.e., those who engaged in the FBM communication strategy).

These results provide us with an alternative view of the effectiveness of the FBM communication strategy by examining its impact on the three successive stages of behaviour change (i.e., acquiring knowledge, developing attitudes, and adopting practices) (Morris 2003). On a positive note, attitude change for the farmers in the intervention discussion groups significantly improved. The attitude change observed

aligns with the sensemaking results outlined in the present study (i.e., that the communication activities, in general, afforded sensemaking to the majority of participants), with Seligman (2000) highlighting that sensemaking provides a basis for adoption attitudes. Nonetheless, attitude is recognised as the second step towards practice change in accordance with the knowledge, attitude, behaviour continuum, with knowledge being the foundation for attitude change (Fan et al. 2018). Participation in the FBM communication strategy herein did not exhibit significant knowledge change, relative to the non-participants. While no significance could, in fact, be present between the groups, knowledge involves more than a simple awareness of facts, with knowledge also including subjective evaluations, perceptions, beliefs, and values (Garforth et al. 2004; Garforth 2004). As per Moss (2008), knowledge is multifaceted and complex, extending beyond explicit knowledge to include tacit knowledge (e.g., knowledge embedded in the actor's understanding of the situation in which it is produced (Gasson 2005)). As highlighted by Cecez-Kecmanovic et al. (2003) tacit knowledge is shared and externalised through dialogue, from which new concepts are created. The results of the evaluation carried out using the sensemaking lens suggest that the processes (i.e., affording open and inclusive communication) required for the creation of tacit knowledge were afforded to the majority of farmers through the mapping, planning and integration into group meetings activities. Therefore, the type of knowledge (i.e., explicit) evaluated in the KAP survey does not wholly link to the knowledge that leads to attitude change and, in turn, brings about practice change (Morris 2003). On the other hand, the lack of knowledge change in the given study could signify that the communication strategy needs to be re-evaluated to better allow the partition of explicit FBM knowledge to farmers. Nonetheless, similar to this study, an education intervention program that aimed to promote rice farmers' knowledge, attitude and practices relating to pesticide use was found, by Sharifzadeh and Abdollahzadeh (2021), to have brought about significant attitude change even though it had not led to significant knowledge change.

With regard to practice change, it has previously been noted that positive environmental attitudes do not always result in specific environmental management behaviours being adopted (Valle et al. 2005), which was also the case in this study. This is particularly interesting given that all of the communication activities of interest afforded the majority of intervention farmers with the sensemaking activity of action planning. This may indicate a need for the incorporation of plan monitoring or farmer check-ins throughout the communication strategy rather than at the end, as well as increased accountability amongst the farmers (Rare and The Behavioural Insights Team 2019). This, however, should not be at the sacrifice of farmer autonomy and ownership regarding the actions taken on their farms (Cechin et al. 2013). On the other hand, the lack of observed practice change could also point to the short timeframe over which practice change was evaluated in this study. As highlighted by Kuehne et al. (2017), "time to peak practice adoption" by farmers can take between six and 22 years. Additionally, Gomes and Reidsma (2021) identified a "temporal dilemma" faced by farmers relating to both the time needed to change practices, and the pressure to do so quickly. As such, the impact of the FBM communication strategy on practice change may take longer than a year, which would suggest that ongoing communication on FBM should be incorporated. Moreover, repeating the KAP analysis conducted herein with a larger sample size could also be useful in detecting the true differences between the intervention and non-intervention groups following the communication activities (Case and Ambrosius 2007), particularly given the mean difference between the pre- and post-intervention practice scores of intervention and non-intervention participants, as well as the sample size used in this study. The mean difference for the intervention group was 0.42 and 0.22 for the non-intervention group.

Conclusion

In conclusion, the results from this study suggest that the piloted communication strategy affords sensemaking around the topic of FBM to farmers, while also promoting farmers to improve their attitude in relation to this topic, with attitude change being a key step on the path to practice change (Morris 2003). This shows that the FBM communication strategy could form the basis of an effective advisory approach to communication on FBM. On the other hand, the present study was, due to logistical considerations, confined to a relatively small sample of farmers located in a region of Ireland, all of which were in discussion groups associated with a single agricultural enterprise (i.e., dairy). Extending the study to a larger subset of farmers located throughout Ireland or in different countries where discussion groups are employed, as well as to discussion groups associated with different enterprises (e.g., beef or cereal production) would be useful to determine if the observed effectiveness persists across geographical regions and enterprises. Moreover, the timeframe associated with this study was relatively short (i.e., one year). Therefore, conducting the study over a longer period of time would be useful to capture the communication strategy's long-term effect on sensemaking affordance, as well as on farmers' knowledge, attitudes,

and practices. In addition, determining the causative effects associated with the results presented herein would be of value to inform the further development of the communication strategy.

As a whole, the communication strategy has been highlighted as a triggering event for farmers on FBM. On the other hand, results herein highlighted the fact that reduced proportions of farmers (relative to the proportion afforded with the other sensemaking activities of interest) were prompted to act with regard to FBM, with no statistical difference detected in the extent of practices implemented between the baseline and endline by discussion group members. This could be reflective of the short timeframe associated with the study, or the need to refine the communication strategy to better prompt farmers to act. This could form the basis for further research and for further iterations of the FBM communication strategy within agricultural advisory services. Sensemaking is an on-going, iterative process, and similarly the refinement of this communication strategy should be too. Nonetheless, the communication strategy, and the associated activities, provides a foundation upon which agricultural advisory services can build to support farmers in incorporating FBM into the overall management of their farm systems. The incorporation of FBM by farmer into the management of their farms would contribute, in turn, to sustainable agricultural development.

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Author contributions **Aoife Leader:** Conceptualisation, Methodology, Project administration, Investigation, Data curation, Formal Analysis, Writing – original draft, Writing – review & editing.

James Kinsella: Conceptualisation, Methodology, Supervision, Writing – review & editing.

Richard O'Brien: Conceptualisation, Methodology, Supervision, Writing – review & editing.

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Declarations

Competing interests The author(s) have no conflicts of interest to disclose.

Ethical approval Ethical approval for this study was granted by the Human Research Ethics Committee of University College Dublin, Ireland (LS-E-20–24-Leader-Kinsella). Written and verbal informed consent was obtained from participants prior to their participation in the study.

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