Working Paper No.36

January 2025

Farm-level behavioural change towards building climate resilience: Insights from a mixed-methods study

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Farm-level behavioural change towards building climate resilience: Insights from a mixed-methods study.

Acknowledgements: A working paper commissioned by the Climate Change Advisory Council, Ireland. The authors would like to thank the farmers and advisors who voluntarily participated in the study. They are also grateful to participants of the knowledge exchange workshop who provided feedback on preliminary findings.

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Executive summary

Background: Farmers are increasingly exposed to climate change. To build farm and farmer resilience against climate change, and potentially capture any associated opportunities, new practices and processes leading to the development, dissemination, and adoption of mitigation and adaptation measures are needed. Whilst *mitigation* focuses on *reducing the sources or enhancing the capture or storage of greenhouse gases, adaptation is the process of adjustment to actual or expected climate change* (DAFM, 2019). Promoting farm-level adaptation, and thus supporting communities in building resilience, is a key objective and priority at international, European Union (EU), and national levels. Significant attention and support have been given to understanding and promoting mitigation measures, but there is less understanding regarding adaptation measures. Moreover, a deeper understanding of the social dimensions of climate adaptation is needed to inform the development, implementation, and evaluation of adaptation opportunities that support increased farm and farmer resilience.

Aim: The aim of this exploratory study was to examine farm-level resilience towards climate impacts and behavioural change responses to Ireland's current climate.

Method: The study applied a mixed-methods, system-based approach, including a scoping review of relevant academic and grey literature, followed by the collection and analysis of quantitative and qualitative data. This comprised a farmer survey, farmer and farm advisor interviews, and an advisor focus group.

Results: Both quantitative and qualitative data highlighted that farmers have experienced and been impacted by weather changes, including extreme weather events and atypical seasons. Most surveyed and interviewed farmers were uncertain about the opportunities presented by climate change, with only a few seeing opportunities. While farmers have always been attempting to adjust their farm work to weather fluctuations, the study showed that they now face new challenges, with more frequent disruptions to farming operations and resulting environmental, economic, and social impacts. Farmers viewed these changes as a fundamental shift that goes beyond the typical weather variations that they have managed in the past. Both quantitative and qualitative results showed that farmers understood the need to adopt adaptation practices that reduce the negative impacts of weather changes and increase resilience to future weather events. However, farmers were often uncertain about the type of practices that they could implement, notably due to the unpredictability of weather changes. The farmer survey revealed that as a consequence, farmers were at various stages of behavioural change, ranging from contemplating and actively preparing to adopt adaptation practices, to implementing and consolidating them.

Overall, the study showed that decision-making associated with farmers' climate adaptation decisions is complex and multi-faceted. In this study, it was particularly influenced by a combination of environmental, economic, social, and institutional factors, which at times triggered, delayed, and/or added pressure on farmer decision-making. Surveyed farmers reported low confidence in performing adaptation actions, low control over the negative impacts of weather changes and substantial difficulties in implementing adaptation actions. This indicates the need for tailored technical skills and knowledge exchange with other Irish farmers to effectively manage the negative impacts of climate change and successfully undertake climate adaptation measures. Key factors hindering these decisions included limited communication and knowledge sharing opportunities among farmers and with advisors, uncertainty about future policy development, and insufficient financial resources and support available. The qualitative research highlighted that farmers were particularly concerned with current and potential future changes to the Nitrates Directive.

The survey results indicated that social influences, especially from other farmers and farm advisors (two main social references reported by surveyed farmers), played a significant role in unlocking farm-level behavioural change. Nonetheless, the qualitative research showed that farm advisors reported limited practical information on climate adaptation being available to support farmers. For some farmers and advisors, it was not always easy to adjust to rapid policy changes, which could result in mixed messages and change fatigue. Moreover, financial support, such as the Targeted Agriculture Modernisation Schemes (TAMS) grant aid[1], could also support farmers in building resilience through capital investments, although they did not seem to be sufficient for more socio-economically vulnerable farmers. To reduce the risk associated with behavioural change, some farmers experimented with adaptation measures on their farm to ensure suitability to the local environmental, social, and economic contexts before incorporating them in the farm routine.

The qualitative study also indicated sustainability synergies and trade-offs arising from adoption decisions and the intersectionality of sustainability issues (e.g., flood and water management, biodiversity) in the context of climate adaptation. Moreover, cooperation among farmers was an important aspect of farm and farmer resilience, notably when feed supplies were low due to adverse weather events.

Conclusion and lessons learnt: Although not generalisable, this exploratory study revealed critical insights for strengthening the Irish agricultural sector climate adaptation strategy at the policy level and coordination of the agri-food industry, including the Agricultural Knowledge and Innovation System (AKIS)[2]. The publication of the next Agriculture, Forest and Seafood Climate Change Sectoral Adaptation Plan

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[1] TAMS are governmental schemes that provide grants to farmers to build and/or improve a specified range of farm infrastructure (i.e., buildings and equipment) (DAFM 2023).

[2] "The AKIS in Ireland is distinctive, with a significant portion of its activities centralised within Teagasc. The private sector also plays a crucial role in Ireland's AKIS. Other significant AKIS actors include universities and third-level institutions, which collaborate on research and education initiatives, and the media, which is instrumental in disseminating information to the farming community. Farmer representative organizations, such as the Irish Farmers Association (IFA) and the Irish Creamery Milk Suppliers Association (ICMSA), also play a key role in advocacy and knowledge exchange." (Maher et al. 2024). The involvement of key actors in sharing knowledge and experience is one of the key elements of the Irish Agricultural Knowledge and Innovation System (AKIS).

2025 provides an opportunity to further explore, and address key issues raised by this research.

While farmers in this study demonstrated high awareness of climate change and its impacts and understood the need to adapt, more work is needed to co-create adaptation solutions with relevant stakeholders. Where possible, farm-level solutions should have multiple objectives and benefits to leverage sustainability synergies, while reducing trade-offs. The research showed that some interviewed farmers were already developing creative adaptation solutions to adjust and redesign their production systems, but these need to be systematically studied, validated, and shared through formal research, extension, and education networks. Moreover, farmers' role in interrogating and experimenting with research-led innovations and practices that they have identified is paramount to test their suitability to local conditions and ensure sustained behavioural change. In environmentally sensitive areas where sustainability issues intersect, farm-level solutions may not always be applicable. A wider landscape or regional multi-actor approach may be needed.

A key study finding was the crucial role of social learning and peer-to-peer knowledge exchange to empower farmers, emphasising the need to expand climate adaptation discussions within existing support structures and extension programmes. In this context, community-based knowledge exchange, testimonial or storytelling approaches, and individual- and group-based advice could be used to foster change. The farmer interviews also indicated that some farmers may require help in planning for the future because of weather and price uncertainty. However, advisors may need additional training in climate adaptation to increase their knowledge and capacity in supporting farmers, as suggested by the qualitative research.

1 Introduction

Farmers are increasingly exposed to climate change and its negative impacts through the experience of weather events, including heatwaves, floods, droughts, storms and changes in the seasons (DAFM 2019; EEA 2019). These changes have led to environmental, economic, operational and social challenges at the farm level and thus greater climate vulnerability (Lee et al. 2023). To support building resilience against climate change, and potentially to capture any opportunities that arise due to climate change, behavioural change is required by farmers in Ireland, as well as globally, to adopt various adaptation measures (EEA 2019). This adaptation is essential for preventing, mitigating and coping with negative climate impacts and reducing climate vulnerability, while also leveraging any potential opportunities that climate change may present (Macken-Walsh et al. 2023; Mitter et al. 2019).

Promoting farm-level adaptation and thus supporting communities in building resilience, is a key objective and priority at the international level (IPCC 2023; UNEP 2023), at the European Union (EU) level (EC, 2020, 2023), and at the national level (DECC 2023, 2024; DAFM, 2019, 2022a, 2022b). To this end, it is essential to develop tailored policies, practical measures and knowledge exchange solutions to target the key barriers and facilitators of adaptation behaviours. This warrants the application of a systems-based approach to move beyond the partial and limited understanding of decision-making and to achieve a coherent explanation of behavioural change dynamics (Macken-Walsh et al. 2023).

There remains an urgent need at the policy level to encourage and support farmers to take immediate action in response to climate change (DAFM 2020, 2022; Lanigan et al. 2023), particularly through the adoption of 'mitigation' and 'adaptation' actions. According to DAFM (2019, p8), "*mitigation is a human intervention to reduce the sources or enhance the sinks of greenhouse gases*", while "*adaptation is the process of adjustment to actual or expected climate stimuli (changes in mean climate and climatic hazards) and its effects*". Both mitigation and adaptation are inherently connected, as successful and timely climate mitigation reduces the need to adapt in the future (UNEP 2023). Additionally, both concepts can contribute to climate resilience, defined as the capacity to absorb and respond to climate change by implementing effective adaptation planning and sustainable development to reduce climate impacts and benefit from opportunities (DECC 2024). Specifically in the case of adaptation, climate resilience can be enhanced by addressing risk factors such as vulnerability to weather events (EPA 2023a). To date, more efforts have been dedicated to climate mitigation rather than adaptation both at EU and national policy levels, notably within the EU Common Agricultural Policy (CAP) (EEA 2019; EPA 2023a). In the agricultural sector, while some mitigation actions can have adaptation benefits (DAFM 2019; EEA, 2019), a clearer distinction will ensure that climate adaptation is brought to the forefront (EEA 2019; EPA 2023a). Moreover, there is a need for a deeper understanding of the social dimensions of climate adaptation to inform the development, implementation, and evaluation of adaptation plans that support the reduction of climate vulnerability (EPA 2023a).

The numerous climate action policies, strategies, and plans available at EU and national levels highlight the clear existence of a ‘push demand’ in the agricultural sector. However, less is known about farmers’ ‘pull demand’, including their attitudes, perceptions, values, and norms. Thus, there is still a need for a deeper examination of such factors in the context of climate resilience (Doherty et al. 2021; Irwin et al. 2023; Macken-Walsh et al. 2023). These factors are formed collectively by interacting with the issue (e.g., an extreme climate change event or changes in seasonal growing patterns) and sharing knowledge and experiences with ‘important others’ (Burton et al. 2020), which are considered as key drivers of behavioural change. This understanding is crucial in aligning the ‘push demands’ to the ‘pull demands’ and ensuring that policy and knowledge exchange programmes enable farmers to adapt to climate change and build resilience.

This report was commissioned by the Climate Change Advisory Council (CCAC) and to conduct an exploratory study, which was carried out over 10 months from January 2024 to October 2024, to address the five primary research questions:

1. What do we understand now in regard to farm level resilience towards the impacts of climate change in an Irish context?
2. What behaviour change is occurring now in the context of farm adaptation practice/s?
3. What do we understand about farmer support structures, farmers’ trusted agents, level of understanding of adaptation to climate change, availability of resources to support building resilience, and decision-making timeframes, including critical reaction points and stressors?
4. What lessons can be learned from this research for policy makers who seek to enhance the resilience of farm business and farmers in the context of climate change?
5. How can policy best be developed to support farmers to scale up adoption of adaptation practices?

To address these questions, this research adopts a systems-based perspective (Macken-Walsh et al. 2023) to a mixed-methods study design focusing on farmers and agricultural advisors (Skamagki et al. 2024). Following the approach implemented in Holleman et al. (2020), the study design does not focus on climate change per se, but rather on climate variability and weather extremes for three reasons. Firstly, in Ireland, climate change is resulting in greater variability and an increase in extreme events (EPA 2023b). Secondly, what farmers experience on a daily basis is weather variations and extremes, while climate change occurs over an extended period of time (Holleman et al. 2020). Thirdly, all dimensions of farm work are potentially impacted in the short term by climate variability and extremes (Schattman, Caswell, and Faulkner 2021). Concretely, this meant that the primary data collection from farmers was framed in the context of weather changes, including extreme weather and atypical seasons.

Despite efforts to address all five research questions, it is important to note some study limitations. The study focuses on adaptation to current climate, as opposed to future climate. Moreover, the research was conducted in 2024, a year marked by unusually variable weather, including prolonged and wet winter and spring (Met Éireann 2024a, 2024b, 2024c). This may have influenced farmers' responses, particularly regarding the impacts of weather changes and their personal experiences. For instance, if the study had been conducted in 2019, following the summer drought of 2018, farmers' responses to such questions might have been different and influenced by their recent experience of drought. Data collection, as well as the scope and scale of the research, were constrained by the available time and resources. Additionally, while multiple research methods were used to ensure wide and diverse perspectives, the sampling processes applied did not result in a representative sample of farmers. Therefore, the findings from this research provide an initial indication of farm-level behavioural change dynamics and are not generalisable. In that regard, the research highlights essential areas to be addressed through further climate adaptation studies.

The remainder of this report is structured as follows: Section 2 provides a summary of relevant literature whilst Section 3 presents a synopsis of the methodology. The research findings are reported in Section 4. Finally, Section 5 provides the conclusion and areas for future research.

2 Relevant literature

The literature was reviewed to synthesise the previous work on farmer decision-making in relation to climate adaptation and adaptation strategies. In turn, this was used to inform the research approach and findings.

2.1 Identifying key factors influencing farmer decision-making related to climate adaptation

The findings of the scoping review illustrate that previous studies have primarily focused on identifying or understanding reactive and planned short-term adaptation intentions and actions that seek to enhance the resilience, i.e., coping capacity of the negative impacts of climate change in the near future (e.g., Hamilton-Webb et al. 2017; Wheeler and Lobley 2021; van Tilburg and Hudson 2022). A few studies have also considered longer-term adaptation actions, not only for coping, but also for taking advantage of opportunities presented by climate change (e.g., Nainggolan, Moeis, and Termansen 2023; von Gehren et al. 2023; Flemsæter, Bjørkhaug, and Brobakk 2018). This body of literature, using a variety of different methodologies, identifies or evaluates triggers of decision-making processes associated with climate change adaptation amongst farmers. The literature highlights the importance of interactions between biophysical and social environments in shaping experiences, and individual and community responses to climate change or extreme weather events. The social, economic, policy and governance, and environmental or place-based contexts associated with climate stimuli are considered important to understanding how beliefs, concerns, awareness, and risk perceptions are shaped as a result of direct experience, observation of impacts/changes, and communication of climate stimuli (e.g., extreme events or climate variability) (Wheeler and Lobley 2021; Hamilton-Webb et al. 2017; Käyhkö 2019; Mitter et al. 2019). Psychosocial factors that can affect adaptation intention and behaviour identified within the literature include social confirmation or 'peer pressure', climate change anthropogenic beliefs[3], awareness, concern, attitudes and self-efficacy, past direct personal and place-based climate change experiences, sense of place or place attachment, and farmers' self-identity (Niles et al. 2016; Hamilton-Webb et al. 2017; Robinson et al. 2018; Wheeler and Lobley 2021; Miller & MacNeil 2022; Villamor et al. 2023, Malakar et al. 2024; Roesch-McNally et al. 2018; Käyhkö 2019). Additionally, biophysical factors (land location and soil quality), personal factors (age, education, gender, and farming experiences), and business factors (farm size, infrastructure, type, ownership, and off-farm job) have been identified as indirectly influencing adaptation intentions and/or behaviours (Robinson et al. 2018; Wheeler et Lobley 2021; Mitter et al. 2019; Griffin, Wreford, and Cradock-Henry 2023; Malakar et al. 2024). Interestingly, the experience and perception of agricultural policy, contradictions between knowledge exchange and extension priorities, and lack of advisors' and other farmers' engagement in discussions of adaptation practices have been highlighted as potential barriers to adopting adaptation behaviours (Griffin, Wreford, and Cradock-Henry 2023; Robinson et al. 2018; Flemsæter, Bjørkhaug, and Brobakk 2018; Mitter et al. 2019). This arises due to their negative effects on farmers' perceived behavioural control (PBC) or self-efficacy.

Whilst this body of literature has been developed by social scientists from a variety of disciplinary backgrounds, it is, for the most part, focused on understanding individual decision-making within local to global social, economic, and environmental contexts. Even if the specific findings of this literature are diverse, reflecting their different research questions and methods, there is an overarching theme suggesting that adaptation actions by farmers are directly or indirectly influenced by their risk perceptions and the perception of vulnerability (severity and susceptibility). It is critical to note that the sense of 'risk' is socially and spatially constructed, i.e., factors such as education, training, experience, knowledge, and access to financial resources all shape how individuals conceive of their vulnerability to risk and, conversely, their capability to respond to opportunities. Therefore, the perception of likelihood of various climate change impacts, including on the environment, farm organisation and management, and well-being and quality of life, are assessed in this study. This approach ensures that the questions are tailored spatially, socially, and temporally to the Irish farming context, and aligned with the various dimensions of climate change impacts.

These literature findings indicate that changes in adaptation behaviours can be explained by self-interest theories, which consider risk perception and the perception of vulnerability (susceptibility and severity). The Theory of Planned Behaviour (TPB) has been extensively used, in both quantitative and qualitative research, to understand farmer behaviour, including behaviours relating to climate change. For the purpose of this research, we adapt a TPB model by including measures of perception of susceptibility to climate change risks. The hypotheses are set out based on the literature and examined through quantitative research (see Table A.1 and Figure A.1,

[3] Climate change anthropogenic beliefs refer to the extent to which an individual believes that climate change is mainly due to the human activities, e.g., farming activities (Mase et al. 2017).

Appendix A). They are designed to reflect the theoretical perspective outlined above and are deployed in a farmer survey.

2.2 Understanding adaptation strategies

Adaptation strategies can be broadly classified into two distinct categories: Reactive and anticipatory actions (Wheeler and Lobley 2021; Cradock-Henry 2021).

Reactive actions, shaped by past experiences, aim to mitigate similar future events (Linder and Campbell-Arvai 2021; McKenzie et al. 2024). Reactive measures are changes prompted by direct experiences, such as adjusting grazing practices, building larger slurry storage, and changing crop rotations (Wheeler & Lobley, 2021; Käyhkö, 2019). These measures yield visible economic, environmental, and social outcomes (Malakar et al. 2024; Griffin et al. 2023). Implementation of reactive measures is limited by factors like perceived negative social pressure, conflicting advice, financial constraints, and policy uncertainties (Davenport et al. 2022; Roesch-McNally et al. 2018; Skevas et al. 2022). In areas where climate change impacts are less evident, uptake is hindered by uncertainty, normalisation of climate change, and optimistic risk perceptions (Miller and MacNeil 2022; Villamor et al. 2023). This normalisation may lead farmers to feel naturally adapted or adopt a 'wait and see' approach (Griffin et al. 2023). As a result, some farmers take minimal-risk actions with low perceived costs (Käyhkö 2019). While reactive actions can build short-term resilience and contribute to long-term adaptive capacity, insufficient social support and engagement hinder broader adoption (Linder and Campbell-Arvai 2021).

Anticipatory adaptation refers to long-term measures addressing climate variability and less visible changes (Sardaro et al. 2021). These actions aim to prevent or mitigate long-term climate impacts or exploit benefits, such as growing new crops or extending grazing seasons (Woods et al. 2017; von Gehren et al. 2023). Anticipatory actions, less studied in the literature, are more common in regions where climate change is normalised or perceived as distant, such as Nordic countries and parts of Canada and the United Kingdom (UK) (Nainggolan et al. 2023; Ibrahim and Johansson 2021). Common anticipatory measures include land use changes, biodiversity actions, and farm diversification (Griffin et al. 2023; Linder and Campbell-Arvai 2021). These long-term actions may be consistent across farm types, especially in pasture-based systems like Ireland, where strategies include planting trees, expanding hedgerows, and implementing multi-species swards. Due to the perceived psychological distance of climate change (Trope and Liberman 2010), anticipatory actions may be influenced by farmers' sense of environmental and social responsibility, integrating biospheric and altruistic values with attitudes and social norms. Decision-making for long-term adaptation resembles that of climate mitigation efforts, such as agroforestry, where moral and self-interest theories intersect (Irwin et al. 2023).

Farmers' proactive long-term adaptation can be driven by a blend of social responsibility, peer influence, and positive attitudes towards sustainability. These elements foster actions that reduce greenhouse gas emissions and build resilience, aligning with mitigation goals. Ensuring engagement, tailored knowledge sharing, and supportive policies can enhance farmers' willingness to implement such anticipatory measures.

3 Methodology

3.1 Research Design[4]

This mixed-methods study follows a convergent design in which qualitative and quantitative data were collected simultaneously, independently analysed, and then merged to combine and compare results (Skamagki et al. 2024). It included a quantitative farmer survey, qualitative farmer interviews, and a focus group with farm advisors[5]. Each methodological component was weighted equally, allowing the researchers to contextualise quantitative findings with qualitative insights.

3.2 Study Sample

3.2.1 Quantitative Sample

The target population of the survey was Irish farmers or farm operators as the main 'decision makers' in considering taking climate change adaptation measures. The profile of surveyed farmers is presented in Table A.2, Appendix A.

3.2.2 Qualitative Sample

Qualitative data were collected from a sample of nine farmers and seven farm advisors from the Irish public advisory service (Teagasc) to capture a diverse range of perspectives. Farmers were selected through purposive sampling to ensure representation across age, gender, and different farm systems including an innovative farm system, an environmentally vulnerable farm and a mix of enterprise types, geographical locations, and soil types. Advisors, from varying regions, were chosen through convenience sampling, drawing on the researchers' existing networks of professionals who work with farmers through one-to-one advisory sessions, scheme related support, and/or discussion groups. A description of the interview and focus group sample can be found in Table A.3, Appendix A.

3.3 Data Collection

3.3.1 Quantitative data collection

Quantitative data was collected through an online survey, using a questionnaire. A stratified random sampling method was used to ensure a broadly similar proportion of farmers from across the main farm types based on the latest census of agriculture (Central Statistics Office 2020) (Figure A.2, Appendix A: Details about the methodological approach). To ensure farmers were included from different regions

[4] Ethical approval for this study was obtained from Teagasc's Social Science Research Ethics Committee (SREC).
[5] One tillage advisor was unavailable to participate in the focus group. As such, a supplementary interview was conducted, exploring the focus group topics.

based on NUTS2 classification[6], the printed questionnaire and online survey were distributed using a simple random sampling method via a convenience approach[7] in the following on-farm events:

a) Three Farm Discussion Groups (FDGs): Sheep farmers (mid-east); Beef/Cattle farmers (north-west); Dairy farmers (south).
b) Two farm walks/demonstrations: Tillage farmers (south-east).
c) Three Teagasc open days; Beef 24 (Teagasc, Grange, Co. Meath); Johnstown Castle (Teagasc, Co. Wexford); Dairy beef (Co. Tipperary).
d) The online survey (flyers with the survey barcode) (Figure A. 3, Appendix A: Details about the methodological approach) was published and shared with Teagasc beef advisory groups on X and farm advisors' WhatsApp groups (see Appendix A: Details about the methodological approach).

In total, 195 questionnaires were fully completed.

3.3.2 Qualitative Data Collection

Qualitative data were gathered through nine semi-structured in-person interviews with farmers, an online focus group with six livestock advisors, and a supplementary online interview with a tillage advisor. The interviews ranged in length between 45 minutes and 103 minutes. The focus group lasted 75 minutes. The semi-structured interview participants were asked questions about their beliefs and experiences of climate change, impacts of climate change on their farms, adaptation measures that they either were implementing or were considering implementing, their decision-making influences, and supports needed. The focus group was designed to discuss specific topics: perspectives of climate change and agriculture; understandings of adaptation; advisors' roles in supporting farmers in adaptation; and advisors' preparedness in fulfilling these roles. The interviews and focus group were audio recorded, transcribed verbatim and systematically anonymised.

3.4 Data Analysis

3.4.1 Survey Design and Quantitative Data Analysis

The questions assessing climate change beliefs, negative impacts of weather changes, risk perception (defined as the likelihood of experiencing these impacts in the future, assessed across all impact areas), and person and place-based experience of extreme events and unusual seasonal patterns were measured using either 5-point Likert scale or binary scales (Yes/No) (Table A.4, Appendix A: Details about the methodological approach). Following Ajzen's standard framework (Ajzen 2006), twelve 5-point Likert scale questions were included to capture farmers' attitudes, PBC

[6] . "Information Note for Data Users: revision to the Irish NUTS 2 and NUTS 3 Regions" available at: https://www.cso.ie/en/methods/informationnotefordatausersrevisiontotheirishnuts2andnuts3regions/

[7] The convenience approach refers to any effort to distribute the survey among farmers who are readily accessible (Israel, 1992). This approach was used to distribute the questionnaire to farmers attending Teagasc open days and farm discussion groups.

(e.g., perceived effectiveness, challenges, costs, and time constraints), beliefs about climate change, and main normative influences (i.e., important others' views, thoughts and beliefs) (Table A.4). Three workshops were organised to assess the content and face validity[8] of the questionnaire items. To minimise optimism and social desirability bias, several strategies were implemented. First, farmers were assured of their anonymity at every stage of the study. A consent letter, which included a brief overview of the study objectives and discouraged responses aimed solely at social acceptability (Steenkamp, De Jong, and Baumgartner 2010), was attached to both the online and printed versions of the survey. Additionally, a panel of experts reviewed the questions in the questionnaire to assess and reduce potential sensitivity, further minimizing optimism and social desirability bias (Nankervis, Rowley, and Salleh 2016). The online survey format also allowed farmers to respond privately and comfortably. Statistical analyses were performed using SPSS (version 27) for the descriptive analysis, and RStudio and LISREL (version 8.8) for causal correlational, Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM) analysis. SEM was employed to investigate the direct and indirect influences of internal and external factors on farmers' decision-making (Sok et al. 2021).

3.4.2 Qualitative Data Analysis

Data from the interviews and focus group were analysed using an inductive thematic analysis approach guided by Braun and Clark (2006) using NVivo 12 and Microsoft Excel. Analyses were performed through the collaboration of two researchers to support the reliability of data interpretations. Both researchers regularly reflected on their positionality and potential influences on the interpretation of the data to mitigate potential biases and maintain rigor. Preliminary results were presented to the wider research team to refine and validate the findings.

3.5 Integration of Data

In line with the convergent design, quantitative and qualitative findings were analysed separately and then integrated at the interpretation phase. The integration of the findings was conducted iteratively through regular meetings among the qualitative and quantitative researchers. These meetings allowed for an ongoing process of comparison. Through detailed discussions, areas of convergence and divergence were identified. This iterative integration process enabled the researchers to continuously refine their interpretations, ensuring that the full complexity of the phenomena was captured.

4 Research findings

The quantitative and qualitative results are presented in an integrated manner, identifying key findings that emerge across both datasets and pinpointing any

[8] Feasibility, readability, consistency of style and formatting, and the clarity of the language used (Taherdoost, 2016) was discussed and confirmed to be understood by the target population (i.e., Irish farmers).

significant divergences in findings from the datasets. Farmers' beliefs, experiences and perceived impacts of climate change are presented first, followed by their farm-level adaptation responses. Decision-making timeframes, farmer support structures and trusted agents, and pathways towards climate adaptation follow. The focus is on farmers' perspectives, but advisory perspectives complement the farmer perspectives in a number of sections.

4.1 Beliefs and experiences of weather changes

Key messages:

- All farmers studied were aware that weather changes were occurring. In the farmer interviews, these were often associated with climate change.
- Farmers viewed these weather changes as a fundamental shift that went beyond the typical weather variations that they had managed in the past.
- All farmers reported experiencing extreme weather events and non-typical seasons.
- The majority of farmers were uncertain about the opportunities presented by climate change.

4.1.1 Beliefs associated with weather changes

Farmers' beliefs regarding climate change were assessed in the survey (Figure 1 and Table B.1, Appendix B: Additional tables and figures). Farmers generally believed that weather had changed noticeably in their region in the last 10 years (average agreement score 3.25), and that extreme weather events (3.76) and non-typical seasons (3.24) were occurring more frequently than in the past (Table B.1). Approximately one third (34.4%) of farmers did not believe that the weather had changed noticeably in the past 10 years whilst 29.7% believed that extreme weather events were occurring no more frequently than ten years ago (Figure 1). Unsurprisingly, 61.6% of respondents either agreed or strongly agreed that the seasons were less typical than they were 10 years ago. Notwithstanding this, 41.5% of respondents expressed a normalised view on the occurrence of floods, droughts, and storms. This may be explained with reference to the respondents being asked to reflect on the 'recent' past rather than a 10-year timeframe.

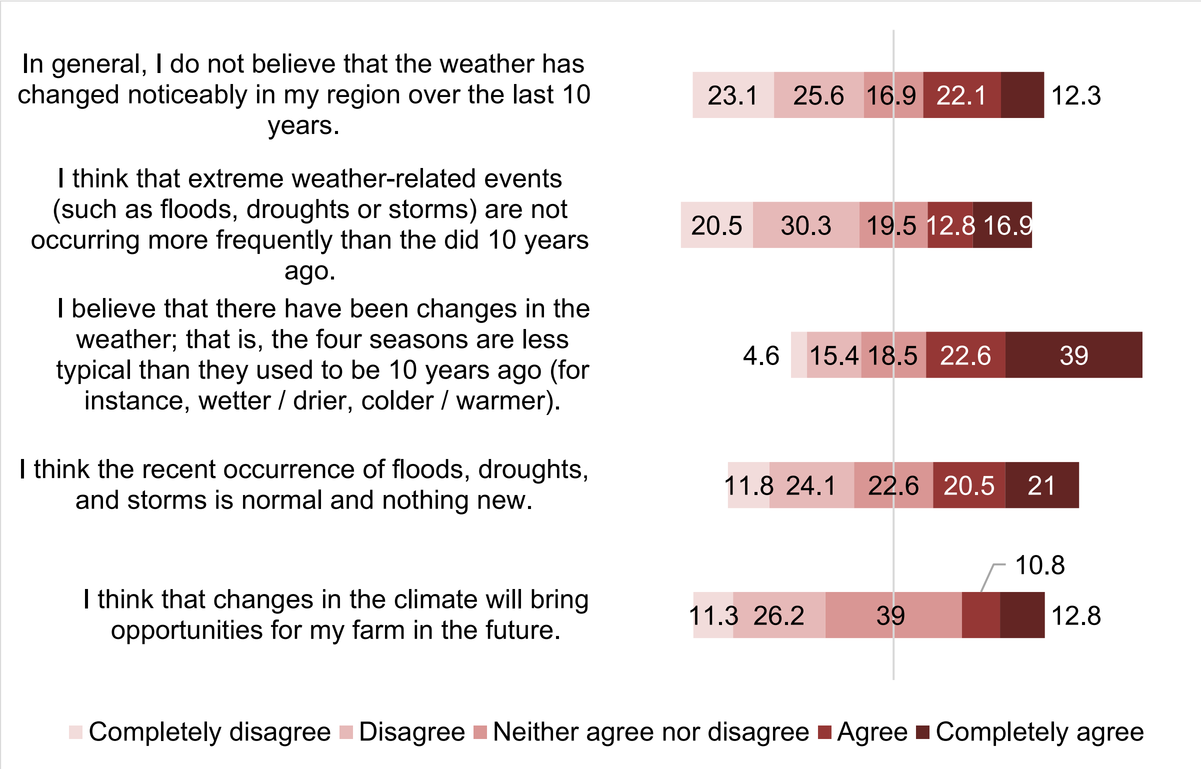

Figure 1: Weather change beliefs reported by surveyed farmers, % (n = 195).

The qualitative data reinforce these findings in that all interviewed farmers recognised that changes to usual weather patterns were occurring and that these were beyond the typical weather variations that they had managed in the past. Although interview questions referred to 'weather changes', many participants independently connected these changes to climate change. For example, the non-derogation dairy farmer (F5) stated:

> *"Climate change is real, it is happening, the whole planet is warming up."* (F5)

The derogation dairy farmer (F2) expressed surprise at the rapid pace of these environmental changes and believed that there was now a growing acceptance of it by other farmers:

> *"I don't think we thought the rate of change would've been so fast as it is. I think there's farmers this year now who were completely against climate change and who are now starting to believe in it"*. (F2)

Considering farmers' perceptions of the possible opportunities presented by climate change, only 23.6% of farmers included in the survey believed that it would bring opportunities for their farms in the future (Figure 1). A sizeable proportion of respondents indicated that they neither agreed nor disagreed with the statement that climate change would bring opportunities to their farm in the future. This points towards a high level of uncertainty regarding the implications of climate change amongst many farmers.

The qualitative results, however, indicate that most interviewees did not identify opportunities for their farms associated with climate change. There were exceptions to this finding. For example, the milk sheep farmer (F7) reflected on a potential opportunity from broader climate shifts negatively impacting producers in Southern Europe that may create additional market opportunities within the sector (see Section 4.6.2). The non-derogation dairy farmer (F2) suggested that the additional grass growth last winter (2023), resulting from mild weather, could be considered an opportunity, although they also realised that a "*good Spring*" would be needed in order to utilise this grass. In both instances, these can be considered 'conditional' opportunities, i.e., outside the direct control of the individual farmer.

4.1.2 Experiences of weather events

Survey results (Table 1) establish that a substantial proportion of respondents reported experiencing one or more extreme weather events. These included droughts (70%), non-typical seasons (62%), floods (59%), and storms (45%).

Table 1: Experience of weather events by surveyed farmers over the last five years (n = 195).

	Yes		No	
	n	%	n	%
Drought	137	70.3	58	29.7
Non-typical seasons (for instance, wetter/ drier, colder/ warmer)	120	61.5	75	38.5
Flood	114	58.5	81	41.5
Storm	88	45.1	107	54.9

In the interviews, farmers describe a variety of experiences with weather events and changes. Non-typical seasons were described at length across all farming systems, using terms such as "c*onstant spring*" (F1). The sheep farmer (F9) highlighted how the traditional markers of seasons no longer held true:

> "*Summertime, look it, what's summer anymore?*" (F9)

The milk sheep farmer (F7) described how seasons had changed over time:

> *"My idea of the spring and winters would've been a more benign view in the past... as less severe you know, but like definitely [it's] more severe in the last seven or eight years, most years. At key times, you know in the springtime, or you know early, you know in January, February, March, April, May. I would find it to have, it has a huge effect on our business do you know. And it has affected our decision-making, yea definitely." (F7)*

In the qualitative farmer interviews, insights into the impact of non-typical seasons and associated weather events, e.g., droughts or summer floods were linked not just to disruption of the farming calendar but also to uncertainty or unpredictability that impacted on decision-making. Interviewees with different types of farm enterprises also reported experiences of drought that had detrimental effects on the growth of grass and crops:

> *"Yeah, the crops didn't grow… like that, they needed rain to grow, and they just simply didn't get it."* (F6)

Except for the derogation dairy farmer (F2), the term "*storm*" did not arise within the interviews. However, concerns were focused on the intensity and volume of rain falling within short periods. The tillage farmer (F3) gave a graphic account of his experience of one weather event on his newly planted crops:

> *"Like there was one field in particular there was beans in it and the bean seed was actually washed out onto the laneway. And they were planted four inches deep, like you know in certain areas like you just, yea you'd just get torrential* rain." (F3).

4.2 Impacts of weather changes

Key messages:

- Farmers reported a wide range of environmental, work organisation, social, and economic impacts from weather events and weather changes.
- For farmers, climate change impacts on farming systems could be direct, indirect, and cumulative.
- Farmers' views and experiences indicated that environmental, work organisation, social and economic impacts of weather changes on farming systems are interconnected ("*knock-on effects*"), and so the effects of an impact cannot be understood completely in isolation.
- Surveyed farmers reported a high expectation of weather change impacts across the studied dimensions in the next five years.

Weather changes have a cascading effect across various aspects of farming, deeply affecting farmers' lives. Environmental impacts, particularly altered soil conditions and unpredictable crop or grass growth, directly challenge farm operations. These disruptions then lead to economic pressures, as reduced production and increased costs directly impact farm income. Furthermore, the increased complexity of managing these uncertainties intensifies farmer stress and affects mental wellbeing. The results presented in this section highlight the interconnections between these impacts and indicate how change spurred by weather events can set off a series of "*knock-on effects*" across ecological, operational, and personal domains, making farming more challenging and intensifying the pressure on farmers.

Surveyed farmers reported on whether several measured areas of farming had been impacted by weather changes (Table 2). It is important to note that these impacts are not listed in any particular order regarding severity or frequency. Impacts identified by interviewed farmers are reported in Table 3. These findings corresponded with the survey results, which demonstrated that areas of impacts were correlated with each other (Figure 2). Overall, insights from the advisor focus group aligned with the impacts reported by farmers, additional insight did emerge related to farmer wellbeing and is reported in Section 4.2.2.

Table 2: Experience of negative impacts of weather-related events reported by farmers in the survey (n = 195).

Negative impacts of change in the weather over past 5 years	**Yes**		**No**	
	n	**%**	**n**	**%**
A. Environmental				
A1. Soil condition (soil temperature, moisture, and compaction)	165	83.1	33	29.7
A2. Grass or crop establishment and growth	176	90.3	19	9.7
B. Work Organisation & Management				
B1. Unable to fertilise or spread slurry as planned	172	88.2	23	11.8
B2. Needed to house animals for longer during the housing season (over the late autumn, winter, and early spring period)	159	81.5	36	18.5
B3. Unable to harvest crops (including fodder) on time	152	77.9	43	22.1
B4. Unable to plough or till when planned	135	69.2	60	30.8
B5. Unable to sow crops on time	131	67.2	64	32.8
B6. Fodder reserve	129	66.2	66	33.8
B7. Needed to rehouse animals during other times of the year when they would normally be outside	128	65.6	66	33.8
B8. Farm infrastructure (barns, farm sheds, tree falling, etc.)	97	49.7	98	50.3
C. Wellbeing and Quality of Life				
C1. Work-related stress or depression or anxiety due to the impacts of weather events on your farm	146	74.9	49	25.1
C2. Compromised personal activities or hobbies due to the need to undertake more work in response to recent weather events	139	71.3	56	28.7

Table 3: Key impacts of weather changes identified from the farmer interviews.

Impact category	Areas of impact
Environmental impacts	Soil water logging Damage to soil structure: Compaction, Poaching, Erosion Soil fertility Grass, Growth, Quality, Utilisation Biodiversity loss Paddock recovery Crop damage Delayed crop Yield loss Water quality Summer flooding of grazing land and silage/hay grounds Unseasonably cold temperatures

Work organisation & management	Farm management and calendar:
	• Slurry spreading
	• Land access and trafficability
	   ○ Field operations and grazing
	• Animal housing pressure
	   ○ Animal housing space
	   ○ Slurry storage
	Import ban on some animals from mainland Europe because of climate-induced displacement of vector-borne disease
	Shorter windows of good weather:
	• Reliance on contractors

Social impacts (including wellbeing and quality of life)	Farmer wellbeing: Worry; Stress; Workload Farm worker wellbeing and retention Animal health and welfare
Economic impacts	Financial loss Additional cost Global influence on grain price Poor return on rented land

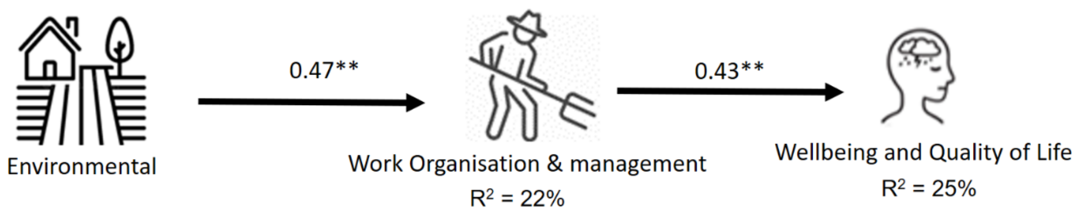

Figure 2: Knock-on effects of environmental impacts on farm work/farm management impacts and thus psychological/well-being impacts (n = 195).

4.2.1 Environmental impacts

The survey results indicate that common impacts that farmers associate with weather changes include soil conditions, and grass and crop establishment/growth (Table 2). Interviewed farmers described occurrences of poaching, compaction, waterlogging, and soil erosion. At times of prolonged rain or flooding, farmers commented that waterlogged soils left the land inaccessible to machinery and livestock because of the need to avoid causing further damage to the soil. This had direct implications including an inability to utilise grass (grazing and making fodder), planting and harvesting of crops, and overall quantity and quality of crops or grass. The derogation dairy farmer (F2) explained the consequences for his soil as follows:

> "*a lot of land is obviously after getting more damaged this year like. So that's caused more poaching and compaction of the soil. It's just trying to get cows out, trying to get out with fertilizer or slurry like, do you know, the site is waterlogged, so it's definitely after causing more damage. It's impacted, I suppose, our soil free draining.*" (F2)

The survey results revealed a relationship between soil type and the experience of negative climate change impacts on soil conditions (soil temperature, moisture, and compaction) (item A1 in Table 2) ($P<0.001$). For example, almost 93% of farmers working on heavy soils reported that their soils were affected, compared to nearly 65% for farmers working on free-draining soils. It is important at this point to remind the reader that these data were collected during 2024 when farmers in many parts of the country experienced elevated levels of rainfall over a prolonged period. In the interviews, farmers also made a distinction between outcomes, both positive and negative, on different soil types. This highlighted the relationship between individual farm contexts and climate impacts. For example, the pig-tillage farmer (F6) reported on the ability of free-draining soil to withstand traffic without damage during a wet weather event:

> *"It was drier land, so they were never going to leave a mark on the ground. They could actually drive over crops and never damage them."* (F6)

The beef farmer (F1) with "*heavy ground*" compared soil types and described how easily the heavy soil could become damaged (waterlogged) through poaching and compaction:

> "*Some of the rented ground I have over, it's a good bit away, would be very, very dry but it's only a small amount of ground. So, the rest of it is all that heavy, very high in clay content. It's fantastic grass growing in warm dry weather, but once it sees water, the water just, it just won't let it down through it. So, it just gets wetter and wetter and wetter and the more [cows] walk on it the more, the wetter it gets*" (F1)

Conversely, when describing the impact of drought, the non-derogation dairy farmer (F5) on free draining soil was particularly affected:

> *"It's free draining ground, I [my land] get[s] burnt out very easily. So, like I run out of grass when it's too dry because I've no moisture there to grow grass."* (F5)

Echoing the survey results, impacts of weather changes on grass growth rates were reported across the interviewed livestock farmers. Grass growth impacts resulted from instances of drought, increased rain volume, or low soil temperatures. The non-derogation dairy farmer (F5), who measured grass, reported a substantial decline of grass growth over the last number of years:

> *"Purely back to the fact I can't grow grass. And that's 100% weather related, it's not like the soil fertility, I'm addressing it. I know where I stand with soil fertility. I'm not saying it's perfect but it's better now than it was two or three years ago when I was well able to grow grass. I am grass measuring, it's all recorded, I can show you figures from grass I was growing this time last year, this time two years ago, three years ago. [...] I'm exactly half what I should be."* (F5)

Farmers reported concerns about the impact of high volumes of rain on grass quality and its knock-on effect on animal weight and production costs. For the sheep farmer (F9), this resulted in delays with lamb finishing:

> "*all they are getting is a drink of water in the grass. There's no power in the grass now, it's very hard to finish them. And you are relying on supplementation to do it. Whereas before you could finish them off on the grass, now it's very difficult to. And it's leading to added costs trying to get them finished.*" (F9)

Floods have led to the loss of biodiversity, as reported by the Shannon Callows farmer (F8). This farmer has been involved for many years in agri-environmental schemes targeted specifically at the Callows, with the aim of protecting ground-nesting birds. The farmer described how, in the early 2000s, repeated summer flood events wiped out the Corncrake population from the Shannon Callows:

> *"And it flooded the Corncrakes in their nests and it flooded the young birds. They were just washed away down the river. And the Corncrake population has never recovered since. The older adult Corncrakes you know that survived that episode, they never came back." (F8)*

Currently, floods hamper the farmer's ability to utilise the land and maintain the landscape, thus threatening the habitats of remaining bird species:

> "*in order for the wildlife to survive in the Callows, the Callows need to be farmed. [...] I mean last year for farming here I mean I lost of all my meadow land [to flooding] in the Shannon Callows last year [2023]. [...] And it was the same in the grazing areas, we lost all the grazing.*" (F8)

Based on the farmer's experience in the area, he expressed the risk of losing further wildlife and farmland if summer flooding events were to continue or intensify.

Impacts of climate change on water quality also arose in other interviews. The derogation dairy farmer (F2) recognised the potential impact of insufficient slurry storage on water quality. He described how ample slurry storage allowed for more flexibility to spread in suitable conditions:

> "*And even again for slurry storage is another huge issue for water quality. Because if you've enough slurry storage then you can obviously store it for longer.*

And you don't have to go out spreading slurry too early in the year in January or February. You can hold on to it, when the weather is actually [...] more suitable and the soil conditions are right." (F2)

The milk sheep farmer's water quality concern was from nutrient run-offs resulting from animals grazing on the land in adverse weather conditions:

"The driest of land when you get high rain in winter and spring, you know, the water just can't go anywhere. It might be dry in a few days' time again. But in that time, it's severe, do you know. And there's no hiding from it. And if you're forced to put your animals out into that conditions, well then sure [...] you're going to have runoff." (F7)

4.2.2 Work organisation and social impacts

The survey data and interviews highlighted how uncertainty and unpredictability related to weather conditions led to work organisation challenges, which, in turn, impacted on animal health and welfare, and working conditions, and wellbeing of farmers and farm workers (Table 2 and Figure 2).

Surveyed farmers reported impacts on management activities such as being unable to sow crops on time (67.2%), plough or till when planned (69.2%), harvest crops (including fodder) on time (77.9%), and fertilise or spread slurry as planned (88.2%). These findings were corroborated by the farmer interviews. Specifically, work organisation was directly affected (and sometimes delayed) due to inclement weather, and indirectly due to soil conditions reducing trafficability:

"Then the Spring came, the ground was very wet, very waterlogged. Trying to travel with our sprayer for crop protection was impossible. The land just wasn't suitable for a tractor to drive across it. So that was late being applied. Our fertiliser then as well, the weather, the ground was waterlogged, couldn't travel, don't want fertiliser going in wet weather. Cold weather as well, we really want fertiliser going on when the crop is ready to grow and ready to absorb the fertiliser. But that was late because of the cold weather". (F6)

Livestock farmers who were interviewed reported pressure on their farming infrastructure due to climate change, which contributed to additional work demands. Traditionally, livestock are housed for a fixed period as per the farming calendar, aligning with seasonal expectations of soil and ground conditions. However, interviewed farmers described how they needed to house livestock beyond originally planned timeframes and, at times, rehouse unexpectedly. This result was also reflected in the findings of the survey, with 81.5% of farmers reporting housing animals for longer and 65.6% rehousing them unexpectedly. Consequently, interviewed farmers faced issues with space in animal sheds and slurry storage capacity. The slurry storage issue was further compounded by poor soil and ground conditions, which affected the accessibility of the land to spread slurry during the open spreading season. The beef-sheep farmer (F4) described the reality of this:

"[animals are] in for the Wintertime and you just feed them and… but then you have that thinking "Oh God, this thing [slurry storage] is filling up now, it'll have to

> *go somewhere" with nowhere to go with it. That's the hardest part, yeah, and that's definitely a climate… a weather problem*" (F4).

Interviewed livestock farmers raised animal health concerns associated with extended housing, including increased lameness and problems with breeding. The beef farmer (F1) reported finding it more difficult to spot cows in heat when housed for longer. Their natural behaviour of 'rising' was thwarted due to a fear of falling in the shed. The beef-sheep farmer (F4) told the story of how the breeding-related behaviour of cows from neighbouring farms were impacted by extended housing:

> "*I was okay, I was lucky but a lot of my neighbours had problems this year getting cows to come in season because they were so long in the sheds and so late getting out that everything was kind of… their whole system was upset so things weren't… it wasn't normal, you know.*" (F4)

The milk sheep farmer (F7), in contrast, reported animal health benefits due to extended housing. From his perspective, it allowed for closer monitoring of animals and thus identification of any changes in their health status. This farmer had invested heavily in appropriate housing and systems to enable him to house his sheep for long periods.

Animal health and welfare concerns were not just confined to extended housing, suggesting trade-offs when making decisions to modify housing/grazing dates. Interviewed farmers also described negative impacts of weather changes on livestock health and welfare during the outdoor grazing season. They reported lower weights and a lack of "*thrive*" (F4). In addition, interviewed farmers that stocked sheep reported impacts such as "*issues with sore feet*" and "*scalds*" due to the "*constant rain*" (F9).

Animal disease also impacted on farm operations indirectly. Climate change at a global level was facilitating the spread of vector-borne diseases and hindering operations. The milk sheep farmer (F7) explained how he faced an import ban when trying to purchase sheep in Continental Europe:

> *"But we actually got hit with a disease restriction. So, Spain, France, UK, Netherlands are all, where the dairy sheep are in particular, we cannot import from any of those countries at the minute. Because of various diseases. So France, like there's a disease called EHD [epizootic haemorrhagic disease] and that is also a weather effect. It's [the transmission of EHD] midges coming up from Africa. [...] The midges are just moving further and spreading. And [...] that's another effect."* (F7)

Another impact reported by farmers was the reduced time available for key farm activities due to changed weather patterns. Shorter operational windows put additional pressure on farmers and farm workers to complete necessary field and farm management tasks within compressed timeframes:

> "*Before you would always have bigger windows and now we don't. The window for spreading slurry, the window for sowing crops just seems to be getting shorter and shorter. [...] So having to spray more at nighttime because the weather was good, that we went out at nighttime and sprayed but then you were ending up with longer days and just it was tougher going for the workers."* (F6)

The potential consequences of shorter operational windows on farmer safety and wellbeing were emphasised by the organic tillage advisor (A7):

> "*Because farmers are now generally rushing, they're under more pressure. And these are all things people don't consider, I think the social aspects. And there's a reason sometimes why accidents sometimes happen, it's because you're rushing. You're under pressure; you're not thinking, you know you're not just able to think things out logically. And I do think when harvests get pushed into September instead of August, because daytime length is shorter, you know you're trying to do the same amount of work*" (A7)

Alongside the impacts on wellbeing, according to interviewed farmers, if the farm was reliant on contractors for field operations, this could present further delay and potential risk to the crop as contractors faced reduced flexibility to accommodate all clients within the shortened timeframe.

Results from the survey and the interviews underscore the detrimental impacts of climate events on farmer wellbeing and quality of life. The survey showed a high proportion of survey respondents reporting work-related stress, depression or anxiety due to the impacts of weather changes (74.9%) and needing to compromise personal activities or hobbies due to the need to undertake more work in response to weather changes (71.3%) (Table 2). Increased workload, worry, and stress emerged across the interviews as farmers navigated unpredictable weather, rising costs and the uncertainty of the future. The beef-sheep farmer (F4) described how, for her, it was a constant struggle:

> "*say now, this year with cold and wet you're putting on fertiliser and it's not working and you're putting a couple of thousand euros down the drain. You have no return from it. So yeah, no, I don't know. It's hard to know. I'm not very optimistic. Maybe a younger farmer would be, but yeah, it's kind of, it's a hard slog all the time. You're kind of fighting against it all the time. You know, you get up in the morning, "is it raining? Ah God, it's raining, I can't do that". Do you know?"* (F4)

The survey findings also suggest a relationship between environmental impacts and work organisation and management impacts, and well-being and quality of life impacts (Figure 2). Specifically, they indicate that greater environmental impacts intensify work-related pressures, ultimately negatively impact farmers mental health and well-being (Figure 2). It should be noted that lower levels of well-being may reduce the *capacity* (resources and knowledge needed to carry out recommended adaptation actions) or *capability* (practical ability to implement these actions effectively on the farm in real time) of farmers to adapt to weather events and climate change.

4.2.3 Economic impacts

Farmers who participated in the interviews described a wide range of production and economic impacts including reduced income and higher operational costs resulting from weather changes and events. The Shannon Callows farmer described the direct economic impact of summer flooding: there are also intimations of the stress associated with additional financial commitments:

> "*fodder was really scarce; it was very, very difficult to get fodder last year. But I did buy; I bought a lot of stuff last year. [...] I mean our local merchant here in [Town 5] to be honest; I only squared up with him there back about a month ago. It frightened me what I owed him. Because I was drawing meal the whole winter and trying to supplement the fodder that I had and trying to supplement the fodder that I was buying. And it was a costly winter I can tell you. And do you know this year I mean whatever money I make from farming is just simply going to pay bills that I acquired, I accumulated last year.*" (F8)

Likewise, the financial impact of weather changes was recognised by the advisors and was raised during the focus group. One of the advisors highlighted how unseasonably low temperatures had affected grass growth, leading to increased input costs that, according to him, particularly burdened the drystock sector:

> "*...financially is the biggest impact it's having on, especially on drystock, farms. Because you take the month of June and July which should be the peak growing grass season in this country. And with the cold weather they're having to go out with an additional round of fertiliser. Compared to the dairy which they have their round of grazing. But for drystock they're depending on the weather now for June and July for your peak growing season.*" (A1)

Alongside the direct financial impact, the pig-tillage farmer noted an indirect impact created by wider climate change effects. Climate change affecting grain-growing regions worldwide influenced the global grain market, which then raised feed costs for the pig sector in Ireland:

> "*and then, of course, then the weather globally probably affects the price of our grain. They have a drought in some areas, floods in other areas. It has become very unpredictable over the years what will the price of grain be from one year to the next. The volatility has been so much over the last ten, twenty years and a lot of it probably is weather related*" (F6)

The economic impacts reported by farmers, in the main, resulted from other impact categories (e.g., soil conditions, grass growth, delayed yield) and they were often cumulative. For example, the milk sheep farmer (F7) reported how he had rented land to supply the feed for his animals, and had been doubly impacted economically:

> "*And we're paying a lot for rented land. And you know we could go, there was a period of summers where there was droughts do you know and poor grass growth. And again you're relying on the farm to produce some feed for you; you're paying on a monthly basis for the farm, to use it. And then you're having to buy in*

feed because the farm isn't giving you what you planned it would give you do you know." (F7)

In addition, poor grass growth, trafficability, and bad weather at key times in the farming calendar created shortages in winter fodder and bedding, leaving farmers more reliant on other farmers or sectors for their needs. The shortfall was typically met by buying in from other livestock farmers who have a surplus of feed or from the tillage sector. The beef farmer interviewed for this study (F1) reported how shortages of these materials can create price increases as demand outstrips supply:

"*I was buying bales for we'll say sixty Euros which would be the big square four by threes. And when I went looking they were looking for a hundred for them. And I think they went as far as a hundred and twenty. [...] I know neighbours of mine who found it very hard to get straw because they were so scarce. And they had such a poor growing season, last year the straw was very short*" (F1)

This created additional costs and stress as farmers struggled to source necessary supplies.

The survey found that farmers, in general, reported greater likelihood of the negative environmental, farm organisational and management, and well-being impacts by weather-related events in the future (Figure 3 and Table B.2, Appendix B). The highest likelihood of negative impacts was reported in relation to the impact of weather changes on 'not being able to spread slurry/fertiliser as planned', followed by the 'grass or crop establishment and growth' and the 'need to house animals for a longer period' (Figure 3 and Table B.2). A slightly lower likelihood of negative impacts on 'farm infrastructure' was indicated by surveyed farmers compared to farm work/farm management and thus psychological/well-being impacts. As shown in Table B.4, the reported likelihood impact was strongly linked to having direct experience of disruptive/extreme weather event. These data also indicated a greater perception of the likelihood of similar incidents occurring in the next five years (Figure 3 and Table B.2).

Looking to the future, when the farmers participating in interviews were asked how they thought the weather would evolve in the next ten years. Overall, they were of the opinion that the weather was going to become wetter, with more extremes:

"*Wetter, I definitely think it's going to be wetter. I don't necessarily see us having warmer summers, definitely warmer winters. [...] But I think we'll definitely get more extreme events. But in general I think the trend will be we'll just get wetter I think that's going to be the big thing for around here anyway. You know while the south of the country maybe [will] get more drier conditions."* (F1)

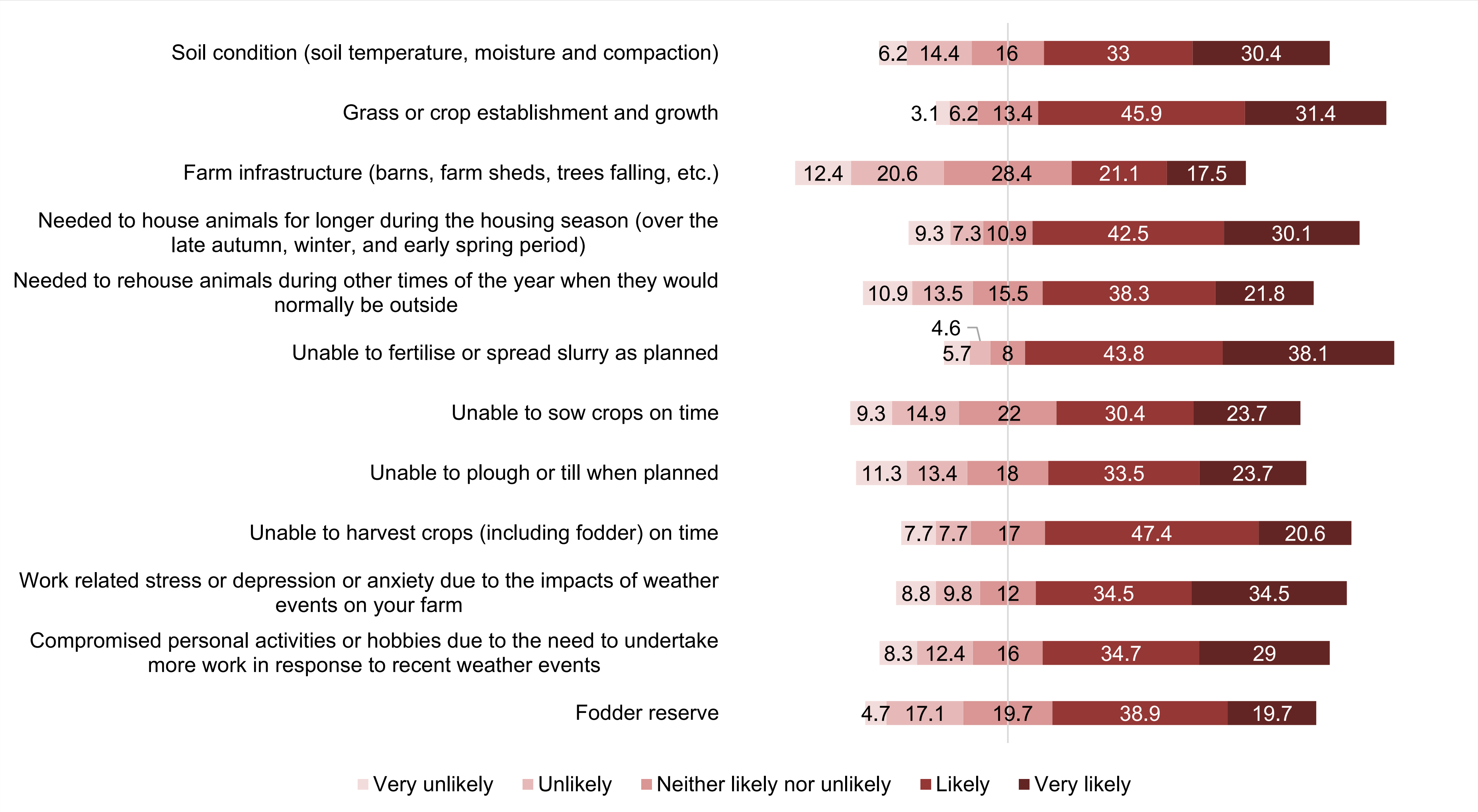

Figure 3: Likelihood of experiencing negative impacts of changes in the weather in the next five years, reported by surveyed farmers, % (n = 193-194).

4.3 Farm-level adaptation responses

Key messages:

- Farm-level adaptation measures were aimed to reduce the impacts of adverse weather events (reactive practices) and/or to reduce vulnerability to future weather events (proactive practices). In this way, these measures supported climate resilience building.
- Farmers were at various stages of behavioural change depending on the practice, ranging from contemplating change, actively preparing it, to implementing and consolidating it.
- Farmer adaptation responses were influenced by many factors, including experience and unpredictability of weather events, compliance with the Nitrates Directive, farm economic viability, succession, expected benefits of the change, cost and time constraints, perceived behavioural control, and subjective norms.
- Farmers adopted multi-objective practices that served various purposes including climate adaptation.
- Farmers reported moderately positive attitudes toward implementing adaptation measures, indicating a recognition of the importance and necessity of adapting to climate change, extreme events, and atypical seasons.
- For the most part, practices recommended by advisors aligned with those identified by farmers.

4.3.1 Adaptation measures implemented, or actively planned, by farmers

The wide array of adaptation measures that interviewed farmers had implemented, or were actively planning to implement, on their farms are compiled in Table B.3, Appendix B: Additional tables and figures. Some of these are habitual practices that farmers have been implementing for years. However, they also function as adaptation actions. Practices are not listed in any particular order, as the table is intended to portray the breadth of adaptation measures, as opposed to frequency. Based on the qualitative data, a typology of measures was drawn (Table B.3). Adaptation measures were broadly classified into six main types: farm management, capital infrastructure and equipment, risk management, engineering solutions, and redesign of current production systems. In this section, we present the results of the research to illustrate the use of these types of measures and point out key motivators and barriers to their on-farm implementation. Please note that the practices gathered in Table B.3 are not described individually in the text.

4.3.1.1 Farm management

Farm management practices presented in Table B.3 were targeted at various management areas, including grassland and pasture management, cropland management and cropping choices, livestock management, and the enhancement of high value nature farmland[9]. The practices were used to reduce impacts during or immediately after adverse weather events (reactive practices), and/or to reduce vulnerability to future weather events (proactive, anticipatory practices). For example, the following quote from a livestock farmer illustrates reactive practices relating to pasture management and rehousing during the grazing season:

> "*They were moved out onto grass, four times they were brought back into slats because they were just cutting up the place […] it looked like we were going to get dry weather for a while and then all of a sudden rain. And there was too much rain, there was downpours after downpours. We had to bring the animals back in again, into the shed.*" (F3)

The beef-sheep farmer (F4) provided an example of a proactive practice, explaining that she sheared her breeding ewes before the housing season to protect lambs from adverse weather conditions during the following grazing season:

> "*So when my sheep go out, they don't have the big fleece of wool. […] so the mother, she doesn't like the rain. Then because she feels it, she'll tend to go to the shelter where the ewe with the wool will stand in the middle of the field because she doesn't notice it and the lamb is out then beside her and he's getting wet. But the ewe that is sheared will go for the shelter in the ditch and bring the lambs with her.*" (F4)

The planning or implementation of farm management practices were often motivated by the farmer's experience of previous weather events and impacts, which encouraged learning about and experimentation with these practices. This can be illustrated by the experience of the tillage farmer (F3), who pointed out that "*a lot of ground can be moved either by wind or by runoff water then coming in on October*". He highlighted that he had started experimenting with cover crops[10] and that "*with the cover crop, it's just holding everything together*", with "*fields […] [not] get[ting] anywhere near the damage that the stubble fields get*".

It is worthwhile to mention that many practices related to grassland, cropland, and livestock management were habitual practices, embedded in an overall farm routine. Interestingly, one of the interviewees (F4), after having described the different practices that she was implementing on her farm, said "*I can't think of anything that I've done*" to cope with weather changes. This illustrates that farmers may not realise that they are actively adapting to climate change by implementing these adaptation measures.

4.3.1.2 Capital infrastructure and equipment

Farm-level adaptation measures relating to capital infrastructure and equipment corresponded to long-term, anticipatory capital investments in farm facilities and machinery. Interviewed farmers were not always motivated by a need to adapt to

[9] It is worthwhile to mention that some of the practices considered under the farm management category are nature-based solutions, whose contributions to climate adaptation have been widely acknowledged in the literature (EEA, 2019; Molloy, Collier, and Buckley 2024).
[10] Please refer to Section 4.4.1.2 for more detail about the trialling of on-farm adaptation measures.

climate change when making these investments; however, they recognised that these helped reduce vulnerability to future weather impacts, notably through an improved use of farm resources (e.g., storage and use of farm-produced organic fertiliser, flexibility to house animals when needed).

In the case of investments in housing infrastructure and slurry storage, farmers aimed to alleviate the increasing pressure put on current farming infrastructure (e.g., tighter space for animals in sheds, fuller slurry tanks due to weather changes). While the current farm set-up matched the 'typical' farming calendar and ensured compliance with policies such as the Nitrates Directive, it was not always adequate as suggested by the following quote: "*On paper, I've enough slurry storage*." (F5). In some cases, farmers raised concerns about the inadequacy of their infrastructure to cope with the need to store slurry in larger quantities and for longer time periods (see Section 4.2.1.2).

The extent to which climate adaptation was a motivator to invest in infrastructure or equipment varied across interviewees. For some, the need to adapt was a key reason for investing. For example, the sheep farmer (F9) was making plans to upgrade his housing facilities because of the need to have "*extra space to finish lambs*" indoors without "*hav[ing] to worry about having to have them gone by the end of December*". This farmer was finding it increasingly difficult to finish lambs from grazed grass in a timely fashion because of poor weather conditions in the autumn. As a result, he was having to house them for finishing, with consequences in terms of competing for space with the breeding ewes in the winter months. Hence, upgraded housing was required to "*leave a bit of flexibility*" around his farm work so that all animals could be housed simultaneously. In other cases, capital investments were motivated by multiple reasons, of which climate adaptation only played a small role. Interviewed dairy farmers (F2 and F5), who operated at higher levels of intensity than other interviewees, notably highlighted compliance with the Nitrates Directive and speculation around future policy updates as the main drivers of the decision to build additional slurry storage.

The two farmers who had a mix of tillage and monogastric farming enterprises mentioned enhanced soil fertility and health as a dominant motivator to invest. Investments in equipment and infrastructure enabled them to store and spread their own farm-produced organic fertilisers on cropland and thereby get better yields through improved circularity. The pig-tillage farmer (F6) underlined that prior to investing in an umbilical slurry spreading system, "*[he was] actually losing the value of that slurry by not putting it on [his] own growing crop*". The tillage farmer with a poultry house (F3) shared similar feelings, which motivated him to build adequate storage for his poultry litter. He described that prior to the investment, having to export the litter off farm was "*a disgrace*" as it was "*nearly being treated as waste product compared to its high nutrient value*".

In the case of the non-derogation dairy farmer (F5), the decision to invest in an automatic milking system with automated gates was not driven by the need to adapt to climate. The farmer had converted to dairy production from a sheep enterprise and directly "*started with robots*". However, the farmer recognised that the system gave him flexibility to decide at any point of the day, depending on the weather, if the cows could be let out to graze:

> "*it's just a click of a button here to let cows out. […] I have the fences set up so you could literally decide, I don't need to be here, I can decide on my phone. I could be half an hour away, I could be somewhere else and the day could change completely. The sun might come out or it might be a lovely dry afternoon compared to a wet morning. And you can decide "right, I let the cows out", and if I land back two hours later, they could have gone out and all be back in again.*" (F5)

He further explained that "*in a conventional parlour, you can't do that as easily alright. You milk the cows in the morning, you probably have to decide "am I going to let the cows out today or not"*". For this reason, he acknowledged "*tak[ing] [his] system for granted*" when making these reactive grazing decisions.

Investment in capital infrastructure and equipment depended on two main factors. First, the profitability and viability of their farm system played an important role. In this context, the pig-tillage farmer (F6) expressed concerns about the capacity of farmers relying solely on a tillage enterprise to invest in machinery. He highlighted that "*it wasn't income from the tillage that actually bought [his] machinery […] but in the profitable years [he] used the profits from the pigs to invest in machinery for the tillage*". According to this farmer, the umbilical slurry spreading system was "*quite a big investment up front […]. But it's just [that] money is not there for tillage farmers to do this themselves, [as] a tillage farmer is really just trying to make money to grow next year's crop*". Second, farmer age profile and succession plans were important considerations in investment decisions. On the one hand, the data suggests that younger farmers were willing to invest, notably due to the long-term horizon:

> "*you could never have enough [slurry] storage really anyway. So we'd still invest in it, because we know again, myself and [my partner] are here. And we know we have, I suppose a clear path to, say we're going to be here for the next hopefully thirty or forty years. So it's going to be a long term investment, so yea like we're happy to invest even though it's, it's obviously a big investment.*" (F2)

On the other hand, the absence of an identified successor was identified as a barrier to investment by the beef-sheep farmer (F4) when discussing the option of building a new slurry tank:

> "*I wouldn't consider putting that kind of money into, because I don't know if any of my kids are going to do it and it'll be all just sitting there. So that's a thing you have to think about as well. [...] Putting in, putting all this expense into something and there's no one… all these concrete tanks in the ground and in 20 years' time there mightn't even be anybody using them. So no, I don't, I wouldn't even consider it. I'd sell half the cows before I'd, yeah, no.*" (F4)

4.3.1.3 Risk management

Interviewees implemented a range of risk management practices to reduce the impacts of and vulnerability to future weather events in a proactive, anticipatory manner. Many of the interviewed livestock farmers expressed concerns around the presence of adequate feed supplies on their farms. A fodder reserve was identified as beneficial to buffer feed animals during the grazing season in the event of adverse weather, and to feed animals for longer periods during an extended housing season. Interviewees outlined that they could either produce more fodder, or purchase it from other farms, and that building up fodder supplies was an important risk management practice:

> "*you have to make, try and make more fodder because of the unknown. Like you could have cattle in from August until the first of May, which is a very long winter. So you can imagine the amount of extra feed you need. […] every year now I always have three months extra from what I think I need. Just to cover for that.*" (F1)

The derogation dairy farmer (F2) highlighted that he was learning from experience and "*trying to be proactive*" by purchasing grass and maize silage for this winter, to "*build back up supplies*" after a particularly wet year. He mentioned the 2018 drought as a learning experience to ensure that he manages feed in proactive rather than reactive manner. According to him, "*[he is] normally self-sufficient but […] it was such an exception in the year, [he] had no choice but to buy in the feed*".

The importance of being proactive in managing feed supplies was also highlighted by the milk sheep farmer (F7). This farmer felt that he could "*actually achieve slightly higher levels of performance*" by "*planning for the, a poor spring in advance and having [his] feed stocks in place*" instead of "*get[ting] hit with reacting to the weather in a hurry*". For this farmer, having a forward cropping contract with a tillage farmer provided a useful means to plan and purchase a specified fodder quantity at a guaranteed price, enabling him to reduce risk[11]:

> "*we have contracted some of our, you know, our supply. So like you know a base amount contracted, so it gives a bit of certainty. [...] But it's just… I'm just more happy that we're going to have a level of security now.*" (F7)

This farmer was particularly aware of and concerned with the issue of "*weather volatility*", which motivated him to "*put in volatile situations into [his] business plan*" and stress test it against weather and price volatility.

4.3.1.4 Engineered solutions

Four farmers mentioned drainage as an anticipatory solution to reduce waterlogging in fields and thereby to "*give you back that ten acre or twenty-acre field that you mightn't have been able to use for the last number of years*" (F3). Expected benefits from this practice included "*longer grazing period[s]*" and the possibility of "*put[ting] a spring crop*" in fields that were usually wet (F3). Nevertheless, two of these farmers were aware of the environmental challenges associated with drainage systems, indicating a sustainability trade-off that needed to be taken into consideration in their implementation:

[11] Insights from a tillage farmer on this specific measure would be needed to gain a more comprehensive understanding about its role in climate adaptation.

> *"I know it's all kind of with environment and stuff, they don't want you to clean drains because you're upsetting… but you know, I think a certain amount has to be done to keep it, it all has to be balanced out."* (F4)

In this context, the beef farmer (F1) explained that continued policy support for this adaptation measure was unlikely:

> *"I don't really think we're going to be paid to do any of that. […] It might be the other way; they might pay you not to do it so"* (F1)

However, the efficiency of draining can depend on the actions of neighbouring farmers as a collective action. The beef-sheep farmer (F4) expressed frustration because of the impact of a lack of action from neighbouring farmers on her land; other farmers may not have been affected to the same extent for a range of reasons and hence have different motivations to act:

> *"I have two fields that will be kind of wet… they hold water in the Winter, say there's… there's drains off them but a lot of the farmers don't clean their drains anymore so the water is all backing up. So if you have a lot of rain it sends back into the field. […] mostly in the lower part of our farm, I think there's four other farmers that come to meet us and none of them clean… and then drains are just full of, you know, is it watercress, that weed, and it's just… the water just sits there. […] And we had drained, we had shored the land so that the rain, if it falls on the field, it'll drain away but that's been a waste of time because there's nowhere for it to go. Just all backed up."* (F4).

4.3.1.5 Redesign of current farming systems

Following the experience of multiple poor spring seasons, with adverse effects on the farm business, the milk sheep farmer (F7) had proactively decided to transition from a purely grass-based system to an indoor-outdoor system. In this way, the farmer was *"moving away from dependence, exposure to weather"* and unpredictability to "*be able to manage without the spring*" *by "budget[ing] and plan[ning] for a bad spring every year*". The farmer explained that "*resilience [was] definitely not grass only, or low, low cost in [his] opinion anymore*" and that "*all in all, that dependency [on good grass growth] ha[d] been damaging*" and stressful. He described the new system as "*a big change*" and "*a more robust system going forward*".

To implement this systemic change, the milk sheep farmer had conducted a series of adjustments in his farm management and infrastructure based on a new business model. These included, among other changes, a transition to a "*higher input animal*", the building of new housing sheds, and the stockpiling of higher-energy feedstock purchased off farm. This farmer considered that while the transition to a production system less dependent on spring grass "*ha[d] added significant cost*", it could provide "*a better […] [and] more stable income*".

The milk sheep farmer was the only farmer who had implemented a transformative change of this scale in the sample. However, the need to redesign current production systems due to weather changes was acknowledged by another interviewee, the beef-sheep farmer (F4), despite her not knowing how to go about it:

“if it stays like this, like we can’t keep going […] I don’t know, obviously if it stays like this, will I be doing it in ten years? I don’t know. You know, struggling to get slurry out, you know, struggling to get silage made. That kind of thing, to get the weather good enough to make good silage and get it in for your animals. And just, lambing season, dealing with it just… with bad weather and you have complications […] it’s just, yeah, a disaster. […] It’s not going to help us if it continues this way. The way we’d farm would have to completely change. How? I don’t know but it’s going to be very different.” (F4)

4.3.2 Level of behavioural change according to selected practices

In the survey, the level of farm-level behavioural change was measured over a set of practices identified from the literature and expert opinion. The scale of measurement was derived from the stages of change model (please refer to Table 4, Figure B.1, and Figure B.2 in Appendix B: Additional tables and figures for a detailed description of the stages).

The stages of behaviour change reported by the livestock farmers in the survey regarding 16 adaptation actions indicated that adaptation behaviour change has been triggered (Figures B.2 and B.3, Table 6). Overall, surveyed farmers reported adaptation actions at various stages of change. On average, livestock farmers indicated their level of adaptation behaviour (averaged across 16 actions) primarily at the ‘contemplation’ stage, with some actions reaching the ‘preparation’ stage (Table 4, Figure B.2). Tillage farmers reported their level of adaptation mainly at the ‘preparation’ stage on average. These results are not comparable however due to difference in sub-sample sizes (livestock farmers (n = 181) and tillage farmers (n = 14)) and the relevance of various adaptation actions in the different sectors.

As shown in Figure B.2 and Table 4, livestock farmers were largely at the contemplation stage, with nine out of sixteen actions reported at the ‘contemplation’ or ‘contemplation to preparation’ stages. This showed that livestock farmers were considering and thinking about taking most adaptation actions, particularly mid- and long-term ones such as planting multi-species swards, decreasing stocking rates, and breeding lighter animals. However, they may be struggling to actively plan and perform these actions (Figure B.2 Table B.3). Livestock farmers reported being at the ‘preparation’ or ‘preparation to action’ stages for actions such as checking the weather forecast, walking the field before letting animals out, and checking soil trafficability. These actions were part of the routine farm work and are considered practices that can function as ‘habitual’ adaptation actions. Therefore, farmers were at advanced stages of behaviour change for these actions, and with support, they can quickly consolidate and sustain them. However, livestock farmers were still struggling to move from ‘considering/thinking’ to actively planning and performing adaptation behaviours that primarily lead to long-term resilience (e.g., planting trees/hedgerow, planting multi-species swards, letting hedgerow grow tall and wide), as indicated in Figure B.2 and Table 4.

The results in Table 4 and Figure B.1: Behavioural change over set of selected practices, surveyed tillage farmers, % (n = 14). indicated that over half of the surveyed tillage farmers were either performing or consistently maintaining six out of twelve actions (at the action and maintenance stages), integrating these as part of their daily farm routines and habits. Interestingly, some of these actions, such as checking the weather forecast and assessing soil trafficability, were at similar stages of behaviour change among livestock farmers (preparation-action). As such, two good farming practices that function as adaptation actions have become routine for these farmers, regardless of farm type. In addition, actions, such as using adjustable machinery and adapting sowing dates to weather and soil conditions, were among the habitual adaptation actions reported by tillage farmers in the survey (Table 4, Figure B.1). The majority of tillage farmers indicated their level of behaviour change at the preparation and action stages for actions such as using no- or minimal-till farming, implementing crop rotation, and lengthening crop rotations (Table 4, Figure B.1). Similar to livestock farmers, tillage farmers reported lower levels of behaviour change for most mid- and long-term adaptation actions, such as planting trees and/or hedgerows and allowing hedgerows to grow wider and taller. Tillage farmers were at the contemplation and preparation stages for these actions, indicating that, while they are considering or thinking about performing these actions, they are still unable to actively plan and implement them (Table 4, Figure B.1). Furthermore, tillage farmers indicated their level of behaviour change towards planting cover or catch crops and legumes at the preparation stage, showing that while they are interested and willing to take such actions, they are not yet performing them (Table 4, Figure B.1).

Attending advisory meetings or knowledge training in response to adverse weather was an action reported by both livestock and tillage farmers at the 'contemplation' and 'preparation' stages (Table 4, Figure B.1, and Figure B.2). This shows that farmers are considering and thinking about attending tailored advisory and knowledge exchange programs but are not yet able to participate. This may be due to limited access to dedicated advisory and knowledge exchange support, as reported by advisors participating in the focus group.

Table 4: Level of adaptation behaviours reported by livestock and tillage farmers in the survey (n=182).

Adaptation behaviours (livestock farmers) (n=181)	Mean[1]	SD	Stage of behaviour change
Adaptation behaviour	2.83	1.21	Contemplation-Preparation
Action1. Plant multispecies swards (n=181)	1.88	0.94	Contemplation
Action2. Decrease stocking rate (n=179)	2.04	0.99	Contemplation
Action3. Breed lighter animals in order to minimise poaching (n= 179)	2.28	1.17	Contemplation
Action4. Build larger slurry storage (n= 160)	2.36	1.10	Contemplation
Action5. Prefer an umbilical dragline slurry system over the slurry tanker (n=157)	2.63	1.35	Contemplation-Preparation
Action6. Plant trees and/or hedgerows (n=158)	2.71	1.24	Contemplation-Preparation

Adaptation behaviours (livestock farmers) (n=181)	Mean[1]	SD	Stage of behaviour change
Action7. Let hedgerows grow wide and tall (n=166)	2.76	1.26	Contemplation-Preparation
Action8. Attend advisory meeting/ knowledge training in response to the bad weather (n=177)	2.80	1.26	Contemplation-Preparation
Action9. Measure grass growth (n=173)	2.87	1.44	Contemplation-Preparation
Action10. Improve grazing infrastructures (including paddock system and roadway network) (n=174)	2.99	1.29	Preparation
Action11. Build fodder reserve (n=176)	3.07	1.30	Preparation
Action12. Implement or improve rotational grazing (n=177)	3.24	1.31	Preparation
Action13. Avoid overgrazing (grazing less than 3.5 cm) (n=177)	3.31	1.44	Preparation
Action14. Check soil trafficability before spreading slurry, dung stead manure or fertiliser (n=176)	3.32	1.58	Preparation
Action15. Walk the field before letting the cows out to assess soil conditions (n=169)	3.37	1.5	Preparation
Action16. Look at the weather forecast before field operations (n=178)	3.71	1.45	Preparation-Action
Adaptation behaviours (tillage farmers) (n=14)	**Mean[1]**	**SD**	**Stage of behaviour change**
Adaptation behaviour	3.61	1.14	Preparation-Action
Action1. Plant trees and/or hedgerows	2.76	1.09	Contemplation-Preparation
Action2. Let hedgerows grow wide and tall	3	1.22	Preparation
Action3. Attend advisory/knowledge training to response to the bad weather	3	1.15	Preparation
Action4. Plant cover or catch crops	3.15	1.06	Preparation
Action5. Plant legumes	3.17	0.98	Preparation
Action6. Use no- or min-till farming	3.62	1.12	Preparation-Action
Action7. Lengthen the crop rotation	3.69	1.18	Preparation-Action
Action8. Implement a crop rotation	3.84	1.14	Preparation-Action
Action9. Check soil trafficability before field operations	4	1.35	Action
Action10. Use adjustable machinery (adjustable steering wheel, etc.) when necessary	4.15	1.46	Action
Action11. Look at the weather forecast before field operations	4.38	0.96	Action
Action12. Adapt sowing date to weather and soil conditions	4.53	0.87	Action-Maintenance

1. Ranging from one (Pre-contemplation) to five (Maintenance).

The primary focus of the survey was to understand farm-level behaviour changes by examining the effects of farmers' risk appraisal framework, particularly susceptibility to negative impacts of change in the weather, climate change beliefs, attitudes, subjective norms[12], and PBC (self-efficacy) on farm-level adaptation behaviour change regarding selected adaptation actions (Table A.4: Items measuring psychosocial factors in the survey. Then, the role of the risk appraisal framework (susceptibility to negative impacts of changes in the weather) (reported in Sections 4.1 and 4.2) in farmers' climate change beliefs, attitudes, and ultimately their level of behaviour change was investigated based on the research hypotheses (details in Section 2). Moreover, the causal links between the external barriers and limitations reported by farmers and perceived behaviour control and finally the level of farm level behaviour change was explained.

On average, farmers reported slightly positive attitudes towards the implementation of adaptation measures (Table 5, Figure B. 3). This indicates that farmers recognise the importance and necessity of adapting in response to climate change, extreme events, and atypical seasons. Supporting this, most farmers indicated that it is always their priority to implement adaptation actions to mitigate the risks and impacts of weather changes (Table 5, Figure B. 3). This aligns with the predominant reported stage of behaviour change, which is ‘contemplation’. It indicated that farmers are considering adaptation actions to implement in response to the negative impacts of climate change, although they are not yet able to plan and perform most of the selected actions (Table 4, Figure B.1, Figure B.2). Conversely, on average, farmers slightly agreed that the adoption of such actions might be time-consuming, costly, or unnecessary due to uncertainty about the occurrence of such events in the future (Table 5, and Figure B. 3). Nonetheless, the average attitude was slightly positive, primarily due to the belief in the importance of performing these actions to mitigate risks, rather than due to considerations of cost-effectiveness or time efficiency, or certainty about future events (Table 5, Figure B. 3).

Farmer-to-farmer interactions are essential for sharing experiences about climate change impacts and adaptation practices. These interactions shape farmers' beliefs about how effective these practices are, what challenges they might face, and how others in their community view adaptation efforts. Other farmers and farm advisors were the two main social reference cohorts that influence farmers' decision-making towards adopting adaptation measures (details in Section 4.5). Therefore, the views, thoughts, and perceptions of both cohorts, as well as the behaviours of other farmers toward adopting adaptation measures, are assumed to influence farmers' attitudes, particularly through shaping self-efficacy and the climate change uncertainty beliefs that are formed in social farming environments. The views and experiences of farmers who are performing adaptation strategies can also contribute to lowering the difficulties perceived by farmers and raising confidence in performing the same actions. Additionally, farmers' views, thoughts, and perceptions of advisors and their

[12] Subjective norms refer to the extent to which farmers believe that key social references (e.g., other farmers and farm advisors) approve or disapprove of performing adaptation actions. These norms are shaped by both injunctive (what important others approve of or think) and descriptive (what important others do) beliefs (Ajzen 2020). Subjective norms reflect the perceived social confirmation/acceptability, and social pressures regarding the implication of adaptation actions.

influence on knowledge exchange play a key role in enhancing farmers' beliefs regarding efficiency, skills, and knowledge-related barriers, leading them to be more competent and confident in taking action.

On average, subjective norms were reported at a ‘passive level’, which suggests that most farmers did not know what other farmers think or do regarding the selected actions. Likewise, no social influences from other advisors regarding the benefits of selected adaptation actions were perceived by surveyed farmers (Table 5, Figure B. 4). Also, slightly negative normative beliefs regarding the adaptation strategies and their efficiency, along with uncertainties about future events, were reported by farmers. This indicates that farmers had not perceived any social support or confirmation regarding the necessity of implementing the selected adaptation actions and the effectiveness of such measures (Table 5, Figure B. 4). It also shows that farmers lack clarity about what their key social groups, particularly other farmers, are doing regarding the selected adaptation actions or whether they view these actions as important, effective, and cost-efficient strategies. Notably, as seen in Figure B. 4 and Table 5, farmers largely reported no social confirmation or slightly negative social influences regarding selected adaptation actions, which highlights the need for proactive communication and the exchange of views, thoughts, and experiences related the selected actions.

Farmers reported slightly negative or low perceived control and confidence over taking selected adaptation actions (Table 5, Figure B. 5). Most farmers identified perceived difficulties in implementing adaptation strategies, due to cost and time constraints, no control over weather related changes, and low confidence and technical competency due to a need for necessary skills or knowledge (Table 5, Figure B. 5).

Table 5: Level of attitudes, subjective norms, and perceived behavioural control regarding the adaptation actions reported by livestock and tillage farmers in the survey (n=195).

TPB constructs	Mean[1]	SD
Attitude (ATT) (four items)	3.38	1.11
ATT1. It is always my priority to implement actions (mentioned on the previous page) to mitigate the risk and impact of weather changes on my farm.	3.55	1.10
ATT2. It is not important for me to implement these actions (mentioned on the previous page) as they are costly (reversed scale).	3.32	1.12
ATT3. It is not important for me to implement these actions (mentioned on the previous page) as they are time-consuming (reversed scale).	3.41	1.04
ATT3. I think it is not necessary to implement these actions (mentioned on the previous page) as who knows how the weather might be next year (reversed scale).	3.26	1.15
Subjective Norms (SN) (four items)	2.98	1.19
SN1. People who are important to me think that I should not implement these actions as who knows how the weather will be next year (reversed scale).	3.03	1.30

SN2. People who are important to me always implement these actions if they are not sure how the weather will be next year.	2.93	1.06
SN3. People who are important to me think that I should not implement these actions, as they are costly and/or time-consuming (reversed scale).	2.95	1.21
SN4. People who are important to me always implement these actions (mentioned on the previous page) to manage the risk of weather changes.	3.01	1.18
Perceived Behavioural Control (PBC) (four items)	2.77	1.23
PBC1. It is not always possible to implement these actions, as they are costly (reversed scale).	2.66	1.29
PBC2. I feel confident that I can implement these actions (mentioned on the previous page) as I have the necessary skills or knowledge.	2.93	1.03
PBC3. It is difficult to implement these actions, as they are time-consuming (reversed scale).	2.86	1.34
PBC4. It is difficult to take actions (mentioned in the previous page) as changes in weather are out of my control (reversed scale).	2.64	1.25

1. Ranging from one (Completely disagree) to five (Completely agree).

Almost all surveyed farmers reported uncertainty about future policies and regulations (91.1%), the lack of financial resources (81.3%), and insufficient communication and sharing of experiences by other farmers and advisors (77.1%) as the three main external barriers. The first two barriers are associated with the concept of "push demand" and should be addressed at the policy and institutional level. Meanwhile, the third barrier highlights the need for effective engagement and communication regarding weather-related issues, experiences of such incidents, and the adaptation actions taken. Conversely, the majority of farmers did not indicate that 'biophysical and structural limitations' as an important external barrier constraining their adaptation actions (Table 6).

Table 6: External barriers and limitations towards the selected adaptation actions reported by farmers in the survey (n=195).

External barriers and limitations	**Yes**		**No**	
	n	**%**	**n**	**%**
Uncertainty of future policies and regulations	175	91.1	17	8.9
Lack of financial supports/subsidies	156	81.3	36	18.7
Lack of proper communication and share of experiences by other farmers and advisors	148	77.1	44	22.9
Lack of clear and transparent policies and regulations	134	69.8	58	30.2
Lack of proper technical knowledge and proper advisory support	121	62.7	72	37.3
Lack of practical solutions tailored to your farm	98	51	94	49
Biophysical and structural limitations	36	18.7	156	81.3

4.3.3 Climate adaptation responses from the perspective of agricultural advisors

Information about the farm-level adaptation measures mentioned or recommended by agricultural advisors was collected during the advisor focus group and the organic tillage advisor interview. While some areas of focus overlapped with farmers' views, others emerged from the data.

4.3.3.1 An efficiency-based approach

During the focus group, many advisors focused predominantly on Key Performance Indicators (KPIs) as a means to gain efficiency and achieve outcomes that "*not only helping the climate but obviously […] help from a profitability point of view*" (A1). In this way, farmers could reduce environmental pressure and thus climate vulnerability. This was a key departure from the farmer data, as farmers did not mention reaching KPIs nor gaining efficiency as farm-level adaptation strategies.

Advisors did not describe efficiency-based practices in depth, but they underlined the use of decision-support tools to inform farmers' efficiency decisions and assist them in their roles. For example, soil analyses could be used to support fertiliser and nutrient management. HerdPlus from the Irish Cattle Breeding Federation (ICBF) could inform breeding and reproduction decisions to increase suckler cow productivity, thereby reducing the number of cows needed to achieve production targets.

> "*at the moment, you could have someone that has twenty cows and they might only be producing fifteen calves. They might be calving all year round. So if you can engage with [ICBF data] and get a tighter calving pattern, get them calving maybe in the spring time, less calving interval. So instead of maybe keeping twenty two or three cows, you might be able to keep eighteen cows. And they're as profitable, if not more profitable, and they've less animals. Which you know from a climate change point of view is a plus.*" (A1)

4.3.3.2 Proactive, anticipatory planning and changes

During the focus group, advisors discussed farm-level practices that would support proactive, anticipatory planning to better cope with and prepare for adverse weather events. Overall, these practices aligned with farmers' views and areas of focus outlined in **Error! Reference source not found.**. Some advisors recommended three k ey adaptation measures, including fodder budgets, "*slurry storage calculation[s] to make sure that [farmers] have sufficient storage there for if a wet winter comes around*" (A6), and "*multi-species swards that are more drought resistant*" (A5).

One of the advisors (A2) explained that in the case of his clients, the traditional practice of "*making one cut silage […] [was] not enough now*" to feed animals during the longer winters. He highlighted the need for farmers "*to budget for their grass and see if they can come up with a surplus at any point during the summer, to get extra bales in*". In this context, this advisor was trying to get his clients to subscribe to PastureBase Ireland "*to start kind of measuring grass to plan ahead*". In his view, this decision-support tool could be used in the spring to measure grass and identify surpluses to make more silage and build the fodder reserve.

Additionally, some advisors spoke about reduced stocking rates in dairy and beef production systems. On the one hand, one of them (A3) explained that the 2023-24 poor weather conditions had led to "*a massive realisation*" among dairy farmers that their land could not necessarily support the herds that it did in the past. The "*massive* *inconsistency*" around grass growth was questioning the system, with some "*lads cutting back*". On the other hand, another advisor (A1) spoke about the reduction in suckler cow numbers specifically in the context of heavy soils. He highlighted that in recent years, the experience of wetter conditions had revealed vulnerabilities in suckler beef production due to the mismatch between stocking rates and land type[13]. As a result, lower stocking rates were considered as a path forward for these farmers:

> "*what guys are finding is that maybe you know where you were able to keep twenty and thirty cows, the land type now with the way the weather has changed, it's just getting harder and harder. Like this year in particular there's so much ground cut up and poached that you know keeping less cows is easier. It's just it's hard to farm them larger numbers that we were able to do a number of years ago. So that is having an impact, so I suppose you're advising guys on how to do that. And how to get the most out of their farm while they're doing it.*" (A1)

In the organic tillage advisor interview, the advisor (A7) raised some of the same practices as those gathered in **Error! Reference source not found.** for the tillage s ector. Specifically, he highlighted the use of more adapted crops and a mix of autumn and spring crops as farm-level adaptation measures. Nevertheless, he provided more detail concerning the reasons why these measures were attractive to farmers. For example, he explained that due to weather impacts, "*farmers [had] lost [...] confidence in growing certain crops*", with a subsequent impact on their cropping decisions:

> "*Your choice of your cropping programme is being influenced, because you've had you know some very, very bad years with crops that are more sensitive to drought. So I've seen a slight change in I suppose cropping programmes from farmers and what they've decided to grow. And to grow a more resilient crop*" (A7)

Similarly, the organic tillage advisor pointed out that "*autumn sown cereal crops, those crops had deeper root systems*" and thus "*weren't as affected by the drought*" in 2018. He explained that farmers that relied heavily on spring crops were more impacted. As a result, "*it was a lesson for a lot of farmers, [as] they realised they shouldn't just have spring-only sown crops, that they should have a mixture*". According to him, "*after seeing the impact that [the drought] had, farmers [were] definitely more conscious of spreading the risk and not putting all your eggs in the one basket*". Interestingly, the advisor recognised that the Common Agricultural Policy (CAP) greening rule introduced in 2015, which required farmers to grow a larger diversity of crops, had contributed to the move away from spring crop-only systems. Nonetheless, he thought that "*even if that policy measure [had not been] there, [...] it was going to happen inevitably because of climate change*".

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[13] It is worthwhile to mention that the issues raised by the beef advisor were the reason why the suckler farmer (F1) decided to trial the dairy calf-to-beef system and potentially move away from suckler farming in the future. Please refer to Section 4.4.1.2 for more information about this.

Additionally, the organic tillage advisor (A7) mentioned the use of short-term and long-range weather forecasts to provide advice to his clients and influence their decision-making[14].

Finally, during the focus group, an advisor underlined that in recent years, farmers had "*more of an openness to change or to adapt new technologies that will help*" (A4). However, one of the advisors (A6) was of the opinion that many changes were happening at once, thus making it difficult for farmers to adopt a proactive approach to climate adaptation:

> *"there's maybe so much being thrown at farmers and a challenging year this year and stuff like that. It is even to… maybe some of them being more reactive than proactive. Do you know they're trying to deal with the challenges as they come up as opposed to maybe thinking more long term and planning for that. Because there's enough kind of, there's enough to be dealing with at the minute, without having to worry about what could be happening in four or five years' time."* (A6)

4.3.3.3 The potential role of organic farming in building resilience

In his interview, the organic tillage farmer (A7) proposed organic farming as a potential farm-level adaptation measure. In his view, climate change was leading to a delay in crops (late harvests) and a reduction in windows to perform field operations. He emphasised the pressures and "*knock-on effect*" on farmers, including increased workload and "*workload being in a tighter space, tighter window*", the lack of labour availability, and difficulties in affording labour due to the "*little margin*" in tillage. According to him, these were key motivators for farmers to "*change the way they're doing things*", "*tak[e] a step back from […] the intensive farming model*", and go "*down the route of organic farming*". He highlighted that this transition was "*a lifestyle choice*" for "*social reasons*", not necessarily to have more free time as an individual, but rather to reduce time pressures:

> "*do you want to be bursting and tearing the whole day long to make what, you know very little money at the end of it all. You can be maybe… are you better off taking the payment from the organic farming scheme for example and producing less, but having more time to do it, you know? You're not under the same pressures.*" (A7)

The organic tillage advisor identified some positive effects of organic production systems on farmers' stress reduction and wellbeing:

> "*once they sow their crop they're closing the gate and they're not putting out fungicides or fertilizers. And then they're just waiting until the crop is ripe and they're prepared to put up with a few weeds and a few diseases in the crops. You know and they seem to be far happier, far more positive minded. And I would say they are less stressed about the impacts of climate change.*" (A7)

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[14] It is interesting to note that the tillage farmer (F3) also spoke about the role of weather forecasting in informing decisions around field operations. However, he specifically referring to the need of improving technology and weather predictions to "*be able to work a bit better on working around the weather instead of trying to fight it on a daily basis*" in the future.

Notably, this was due to differences in production costs of conventional and organic crops, and the associated reduction in risk for organic crops. When thinking about conventional crops in a drought scenario, the advisor explained that they "*can't take up all that fertilizer that you've spent the money on*" and "*are just senescing through natural stress of being in drought*". He compared the production cost of spring oats between both conventional and organic systems, with a "*cost [of] seven hundred Euros a hectare to grow*" for the organic crop and "*fifteen hundred Euros a hectare*" for the conventional crop. Notwithstanding that conventional crops could yield higher returns in typical weather years, overall, his conclusion was that because climate change can significantly challenge crop yields, lower-input systems such as organics could be more resilient and less stressful to the farmer:

> "*So they're both going to yield badly I said. It doesn't matter where it's conventional or organic I said. They're still getting the same weather. So which is more resilient? […] they're both going to lose at least half their yield anyway. But are you not more resilient with a much lower input system? […] but the low input system you have less to lose I suppose you know. You don't have all this money tied up and the stress that that brings as well on farmers' health, having that amount of money.*"

However, interviewed farmers did not consider organic farming as a farm-level adaptation measure. This may be because none of them had transitioned, or were planning to transition, to an organic production system. More research is needed to gain insights from organic farmers regarding the capacity of such a production system to reduce climate impacts and vulnerability.

4.4 Decision-making timeframes

Key messages:

- Decision-making associated with farmers' climate adaptation decisions was complex and multi-faceted.
- Farmers experimented with adaptation measures on their farm. Experience with a measure and suitability with individual farm conditions and farmer objectives determined if it was fully incorporated into the farmer's routine.
- The adoption of adaptation measures could be triggered by climatic factors, including the experience of weather events or increased occurrence of extreme weather. Their effect can interact with other factors such as (speculation around) changes in the Nitrates Directive, loss of confidence, sustainability issues, and staffing difficulties.
- The adoption of adaptation measures could also be delayed by lock-ins, such as path dependency related to dairy expansion and uncertainty of future weather.
- Farm-level decisions were influenced by environmental, economic, social, and institutional stressors, which were outside of the farmers' control and added pressure on farm-level decision-making, highlighting the need for continued support.

4.4.1 Moving through the stages of change and dis-adoption: Some insights from the farmer interviews

4.4.1.1 Contemplation: Complex and multi-faceted decision-making

At the contemplation stage, farmers are aware of the issue but are yet uncertain in term of taking action. In this context, some interviewed farmers described how complex and multi-faceted adaptation decisions could be, while acknowledging challenges associated with the changing weather. In turn, this made it difficult for farmers to move through the next stages of change (i.e., planning, action, and maintenance). For example, the pig-tillage farmer (F6) emphasised the importance of time efficiency gains in his tillage enterprise as he believed that time windows to perform field operations were becoming ever shorter due to climate change. Over the years, he had invested in his own machinery and equipment to avoid reliance on contractors. Nonetheless, he was now wondering if he needed to do additional, expensive capital investments to double the amount of work achievable in the same period of time:

> "*we already have… we do all the contract work ourselves so there's nowhere else to… do you… we have one combine, do we need two combines just to cut the corners when the weather is good? But then to justify the cost of another combine and it doing half the work. Do we need an extra plough to plough quicker? Do we need an extra sower to sow quicker? But that's… it's hard to justify the expense of modern machinery now and have it doing half the work. So that's quite difficult.*" (F6)

The non-derogation dairy farmer (F5) presents an interesting case when considering the option of reducing dairy cow numbers as an adaptation measure. This farmer identified as key issues the volatility in weather and, as a result, in grass growth rates. Along with other factors (e.g., disease on farm), this triggered a process of thinking about whether he should "*not [...] be carrying as much cows and not be as dependent on trying to get what [he] should be getting out of [his] farm, what [he] think[s] [he] can get out of [his] farm*". According to his estimations, grass growth might be affected severely three years out of ten years. Consequently, he wondered if he should "*just stock [him]self lighter and plan for the three years out of the ten instead of the seven years out of the ten*". For this farmer, fundamental barriers to move to the next stage of change were psycho-social factors such as pride and perceived peer pressure:

> "*You still like to have the number of cows. You still like to be carrying more cows. It might be false economics but it's nice to have a bigger number of cows, I think. [...] Maybe it's pride, maybe it's psychological, maybe it's... do you know, I have a number of a hundred of cows in my head, I should be able to carry a hundred cows on this farm. Like everyone would tell you a ninety-acre milking platform should be well able to carry a hundred cows.*" (F5)

4.4.1.2 Action: Experimenting with adaptation measures, what next?

On-farm experimentation with new practices involved actively modifying behaviour to move to the action stage. These experiments allowed farmers to test whether adaptation measures were suited to particular contexts, thereby reducing risk. For a number of interviewees, the experimentation demonstrated that the measure was not suited for this specific farm and farmer. For example, this was the case of the tillage farmer (F3) who ruled out cover cropping after spring crops following experimentation. In his view, this resulted in "*a waste of money*" as volunteer grains, available in the soil seed bank from previous cropping seasons, could lead to "*more green growth*" or even "*a better cover established*". However, it is noteworthy that this farmer's experience with cover crops was much more positive for autumn crops, thus highlighting the need to take farm and context specificities into consideration when examining farm-level behavioural change.

The derogation dairy farmer (F2) was experimenting with various mixes of multi-species swards and acknowledged that "*some things will work; some won't work*". He identified weed management as the main difficulty associated with the use of multi-species swards after the initial establishment phase. Despite clear benefits for soil health, the farmer explained that one of his fields had "*turned into a field now of mostly old grasses and docks after three years",* which was having a negative effect on cow performance, and thus farm profitability and income. He described this trend as being both "*worrying*" and "*disappointing*" and questioned the possibility of "*going forward*" with certain species within the multi-species mixes. Overall, the farmer highlighted that "*as much as we want to improve soil health, and the need to protect the environment [...], we still have to be able to make a living*".

As well as being a learning opportunity, the dairy farmer pointed out that a key motivation to continue experimenting with mixes of multi-species swards was to learn more about this practice in order to prepare for the future climate:

> "*we're trying to learn a little bit before, rather than being thrown in the deep end really like, so. When it actually, it does come to it, when we do start getting these really two or three years of really bad extreme weather, that we'll be kind of prepared for it.*" (F2)

In this sense, the farmer identified multi-species swards as an anticipatory adaptation measure, with the "*hop[e]*" that it would help to maximise grass growth and utilisation in the future. In the farmer's view, this justified these on-farm experiments even if "*at the moment, [he was] no better off than any other farm*" from an economic perspective when using this practice.

Another case of on-farm experimentation that did not prove to be suitable was experienced by the milk sheep farmer (F7). He delayed the lambing season in 2021 to "*reduce [his] cost exposure*" and "*skip the January, February, March period*". This experiment was considered as a potential path towards climate adaptation and was specifically motivated by the experience of a series of poor winters and springs. In the years preceding this decision, the challenging weather had had adverse effects on costs and animal welfare, among other issues, at a time when the farmer's production system was reliant on an outwintering strategy. However, this experimentation did not work as the farmer had hoped and actually added significant cost pressure to the system because of a non-typical month of May, highlighting the difficulty of making adaptation decisions in an unpredictable environment:

"we lambed in April. And on that year, it's well documented now, May was a very severe month. And so we actually experienced a significantly higher level of cost, because May didn't materialise to be the, a typical May. And we had delayed all our lambing and you know we were prepared to skip the winter and sacrifice early cash flow to get rid of, you know, to bypass the January, February, March tricky months. [...] But May was a very, very cold and wet month and basically it wasn't a whole lot better than a typical March. [...] And we were planning for it to be just a typical May. And that would've been a stressor as well do you know. So it affected performance and it affected… you know, it just made everything... and the cost, cost went up again" (F7)

Inversely, one farmer described a case where the experimentation was very successful, and promising to move from action to maintenance in the stages of change. The suckler farmer (F1) trialled the dairy calf-to-beef system as a new, on-farm adaptation measure. This experiment was motivated, among other reasons, by the lighter weight of dairy-beef cattle compared to suckler cows. These animals could be kept at grass for longer while minimising soil damage, an important consideration for this farmer who operated on heavy soil. The experiment revealed to the farmer that dairy-beef cattle were "*definitely easier to manage than the suckler cow*", notably in terms of safety when handling stock. As this farmer was helped by other, younger and older family members in the farm work, safety was paramount to him. Additionally, the farmer evaluated that "*the dairy beef [had] left more money than the suckler beef […] because [of] the cost of keeping the cow, the length of the winter to keep that cow in*". From his perspective, this was "*a big eye opener*". The farmer concluded that he needed to seek confirmation of this positive result but would consider substituting his suckler cows for more dairy-beef cattle in the future, as illustrated by the following quote:

"*So I might even concentrate on getting rid of more suckler cows and going down that route. So I'll see in time, [...] I like my suckler cows but if it's becoming... like it's nearly, it's uneconomical to keep a cow in for eight months of the year. […] it's just with the way the weather is coming, the suckler cow is... she's getting very inefficient on this type of land.*" (F1)

4.4.2 Triggers and factors delaying of farm-level behavioural change

4.4.2.1 Triggers

As previously mentioned, the analysis of the farmer interviews showed that the experience of climate events triggered the adoption of adaptation measures through reactive and proactive changes (see Section 4.3). Moreover, for some practices, other factors such as compliance with policy, speculation around future policy updates, and successful on-farm experimentation played a significant role in activating and sustaining significant behavioural change.

Nonetheless, the farmer interviews also reveal that 'crossing thresholds', i.e. increased frequency of particular events over time beyond what a farmer might consider 'acceptable', could lead to the adoption of certain practices. In such cases, reaching the threshold was key to unlocking the new behaviour. For example, the derogation dairy farmer (F2) described how his farm was "*normally self-sufficient*" in terms of feed. He acknowledged that in exceptional weather years (such as 2018 and 2024), he "*had no choice but to buy in the feed, because it was either that or cut back the [dairy cow] numbers*". In his view, reduced feed self-sufficiency was an acceptable and viable practice because it did not occur too frequently, i.e., once every five years. He highlighted that if the occurrence of extreme weather was to intensify to once every three years, then he would have to decrease his stocking rate. In this instance, increased occurrence of extreme weather is a threshold that is yet to be crossed:

> "*but at the same time [purchasing feed is] not something that we want to do every year, you see that's the difference. If you're doing that every year or two or three even it's, it doesn't make sense. It obviously means you've too many cows. Whereas if you're only doing it maybe once every five years and exception in the years, it's, do you know, it's different. […] if it did become a situation where you were doing it every, once every say three years like again, then you're going to have to look at cutting back numbers. Because you're obviously too highly stocked.*" (F2)

In line with this, the beef farmer (F1) expressed a similar idea related to the intensification of weather events, and decisions relating to capital investments and animal numbers:

> "*if we have another couple of years like the year just gone, you'd be seriously questioning yourself what you're doing you know. That's like investing in more sheds: maybe not, do you know. It mightn't be the wise thing to do. Less might be more do you know. As in less cattle*" (F1)

The Shannon Callows farmer (F8) also described how increased occurrence of summer flooding could lead to the crossing of a threshold that would have a major impact on his farming operations. In his case, he viewed summer floods as a major difficulty that could impact his ability to continue farming this land:

> "*where I feed the suckler cows that would be mostly subject to flooding you know […] but like going forward […] it's going to be very difficult to know where we'll be going because if the Callows stay getting flooded to the extent that they are, I can see the suckler cows will just have to go. And that's the harsh reality you know.*" (F8)

This farmer was particularly concerned about generational renewal for farmers in the Shannon Callows as a result of extreme weather events, and its consequential impact on biodiversity in the region. He described summer floods as being "*disastrous for farmers […] for everybody and every species*". He highlighted that the socio-economic and wildlife losses incurred by summer floods would result in frustration in young farmers and thereby caused risk of land abandonment if they were to intensify. Such an outcome, in turn, would accelerate the loss of wildlife, including threatened ground-nesting birds:

> "*certainly the young farmers, you know they're not going to farm it and it's as simple as that. Because the losses as I said are far too great. […] the young people will just get frustrated and they'll just walk away and leave it there. And that to me*

> *would be a great, great pity you know. Because in order for the wildlife to survive in the Callows, the Callows need to be farmed. And do you know you won't have the Callows, or you won't have the wildlife in the Callows if it's not farmed in a certain manner.*" (F8)

Finally, the milk sheep farmer (F7) experienced the crossing of a threshold, which led him to redesign his production system (see Section 4.3.1.5). In the previous regime, this farmer "*found [himself] needing plan A, plan B, plan C, […] plan D due to weather events*". He sometimes "*moved through A, B and C plans in a week*" when he thought these plans would carry him through the whole winter. His threshold materialised because of a combination of cumulative factors such as weather volatility, loss of "*confidence*" and "*faith*" in the grass-based production system, poor return on the rented land, animal health and welfare concerns, stress and worry, difficulties in retaining staff, and added costs. This ultimately resulted in a "*change in [his] mindset*" and triggered change:

> "*it was just the reality, the realisation for me was just like "Jesus", do you know, "I'm now worried about". You know "I'm starting…", you know I was always optimistic that "ah no, this spring was hard, the next spring will be better". Where and like we did get, you know, several springs in a row now and I'm just like. "Now I'm, you know I just can't take that chance anymore do you know".*" (F7)

4.4.2.2 Factors delaying farm-level behavioural change

Few interviewed farmers experienced lock-ins, whereby behavioural change was severely constrained because the costs (e.g., financial, human, social) involved in making the change. In some cases, lock-ins were experienced before reaching a threshold that could trigger change. Following on from the previous section, the derogation dairy farmer (F2) explained that unless extreme weather was to intensify, he did not wish to reduce the stocking rate. This was because of path dependency related to dairy expansion and recent investment in the farm business, i.e. they had sunk costs:

> "*we didn't want to cut [the numbers] back anymore because obviously we have so much facilities and investment made already. We can hold that number of cows anyway in a normal year.*" (F2)

Indeed, this farmer had significantly expanded his operations since EU milk quota removal in 2015. The dairy herd had grown from 100 to 200 cows in five years after he had become the main holder of the farm. Moreover, three full-time family members were employed on the farm, hence emphasising the need for the farm to operate at a certain production level.

Before discussing the potential reduction in stocking rate associated with crossing a threshold, the beef farmer (F1) expressed constraints on change as a result of uncertainty of future weather. According to him, plans for the farm were on hold because "*the way the weather is, it [was] stopping [him] from maybe doing anything else*". This farmer adopted a "*wait and see*" approach to "*let things play along*" and "*see how things progressed*". This included time to confirm the success of his dairy calf-to-beef experiment (see Section 4.4.1.2) and to observe the weather in future years.

The non-derogation dairy farmer (F5) also faced a barrier to change due to the uncertainty of future weather. The farmer discussed the occurrence of climate change and emphasised his lower control over the phenomenon. This led him to take a cautious approach to change, i.e. choosing not to make large adaptation changes to the farm, but to reassess his plans on a yearly basis:

> "*I can't do much about it. Just take one year as it comes. I am certainly not going to change the farm to plan for something that might happen in ten years' time. […] it's going to be year on year. Just take it as it comes is my current attitude.*" (F5)

4.4.3 Environmental, economic, social, and institutional stressors affecting decision-making

In the qualitative research stages, farmers and advisors described a series of stressors, which were outside of the farmers' control and added pressure on farm-level decision-making. These were categorised into four groups, i.e., environmental, economic, social, and institutional stressors (Table 7) by adapting a framework proposed by Meuwissen et al. (2019). Overall, these stressors highlight the need for continued support for farmers and advisors to enable climate adaptation and support resilience. Due to space constraints, the stressors that are already reported in other sections of this report are not further detailed in this section. They are marked with stars in Table 7.

Table 7: Environmental, economic, social, and institutional stressors affecting farming systems, as reported by farmers and advisors in the qualitative research.

Environmental	- Extreme weather and non-typical seasons* - Weather unpredictability*, ** - Pest or disease outbreaks** - Yield volatility** - Feed availability** - Loss of and risk to habitats and wildlife**
Economic	- Price and income volatility** - Low profitability and viability - Competition for resources (mainly staff, land, bedding material, and feed) - Uncertainty in accessing bank loans for derogation farmers
Social	- Stress caused by inspections from DAFM - Negative portrayal of farming in the media
Institutional	- Evolution of and uncertainty about the Nitrates Directive - Pressure of the closed period for slurry spreading - Perceived lack of institutional will and action to support family farms - Contradictions in the evolution of agri-environmental policy - Pace and scope of policy change - Mixed messages from advisory services - Delays in policy and lack of practicality of policy and proposed solutions

Note: * and ** content already covered in Sections 4.1 and 4.2, respectively.

4.4.3.1 Economic stressors

Low profitability and viability were a recurring stressor among most interviewed farmers (except in dairy and pig production). As mentioned in Section 4.3.1.2, this stressor could be a barrier to investing in capital infrastructure and equipment that could enhance climate resilience. The need to work off farm as a result of factors such as small farm size can exacerbate the farm management impact of climate change. The beef farmer (F1) spoke about the need to work off farm because "*a thirty-four-hectare farm in the west of Ireland [wasn't] going to make you a living*". For this farmer, combining on- and off-farm work was not always an easy task, especially around calving time. The beef-sheep farmer (F4) also mentioned the need to have an off-farm income. This farmer was a full-time farmer whose husband worked off farm. She described this as "*good*" even if on her side, she had to "*just try and keep things so that [she was] not just farming for a loss, that [she was] making a little bit of money*".

The organic tillage advisor (A7) pointed out that low margins in the tillage sector encouraged farmers to take on all the workload themselves, even at busy times (e.g., harvest). The advisor believed that tillage farmers could not afford to pay for labour, notably in the current state of the wider economy:

> *"And there isn't lots of available labour out there. And you know farmers are not too inclined, they try to do it themselves, because there's very little margin really in it. You can't really afford to pay. I'm sure most young chaps or girls now they'd*

want twenty Euros an hour to drive a tractor and a trailer. Because they're able to get money elsewhere you know" (A7)

The issue of labour availability and competition with other sectors of the economy was also raised by the milk sheep farmer (F7), specifically in the context of staff retention in a stressful farm environment. According to him, "*the help on farm [was] getting harder to source*" as "*Ireland [has] full employment*".

Competition for other resources such as land, bedding material, and feed was mentioned in multiple interviews. For example, the cost of renting land was becoming prohibitively high for non-dairy farmers. They were effectively being priced out by dairy farmers in search of additional land to comply with changes in the Nitrates Directive (institutional stressor). As for bedding material and feed, availability could become an issue in poor-yield years, as explained in Section 4.2. However, it is worthwhile to mention that some regional differences in accessing surplus bales were emphasised by the non-derogation dairy farmer (F5). Indeed, this farmer explained that "*there [was] plenty of surplus around*" because in his area (West of Ireland), "*there isn't a lot of dairy farms […] compared to Cork and Limerick*". He viewed his situation as "*lucky*" as he did not have to compete with many other dairy farmers to buy additional fodder.

Finally, the derogation dairy farmer (F2) mentioned uncertainty around his future access to a bank loan to build a new milking parlour and slurry storage. He explained that due to uncertainty around the evolution of the Nitrates Directive (institutional stressor), "*the banks [were] becoming more cautious of lending to farmers […] obviously with derogation being the biggest concern*". According to the farmer, this meant that banks were stress testing derogation farmer incomes against a scenario without a derogation. In this scenario, the interviewed farmer predicted that he would need to significantly reduce dairy cow numbers, thereby resulting in a decrease in income, and ability to borrow and invest:

> "*they could be basing our funding off a repayment request you know say a hundred and fifty or a hundred and sixty cows. Whereas like we're milking two hundred cows and that's a big difference for us like fifty cows. If they're going to base our projected income on a hundred and fifty cows, we're not going to be able to build what we need with that.*" (F2)

4.4.3.2 Social stressors

A couple of interviewed farmers described the stress associated with DAFM inspections. For instance, the beef-sheep farmer (F4) explained how she "*fel[t] that it [was] a pressure that [was] on [her]*" despite trying her best to do the work well. In her view, the department "*[did]n't realise the pressure that the weather [was] causing on people*" and added to it by "*inspect[ing] […] for anything […] on the land*". For the pig-tillage farmer (F6), farmers were "*fearful*" of DAFM inspections. He explained that with recent changes in the Nitrates Directive, he had to "*record where [his] pig manure goes within four days […] to allow for the department to do inspections*". Consequently, he was finding it harder "*to get farmers to use pig manure*" despite its benefits.

Advisors within the focus group recognised that climate change was only one of the multiple factors impacting farmers' wellbeing. Specifically, they described reported that they believed that how media and the policy landscape (institutional stressor) were also contributing to these impacts:

> "*They're bearing the brunt of the weather changes. And then they're also kind of getting hit then from a media point of view and stuff like that as well. That they're kind of, they feel like they're kind of getting hit from both sides. Because they're getting hit with all the poor weather and stuff like that. And then they're getting blamed for it then in the media. And I do think it's a big issue with, like they kind of feel like they're being closed in on. And then obviously more extreme weather is also not helping with water quality issues. And then there's more regulation coming from that. So, it kind of becomes a bit of vicious circle then as well. So, I think definitely, like, the mental health side of things there is a huge, it was always a huge issue in rural areas. And it just, it doesn't seem to be improving."* (A6)

4.4.3.3 Institutional stressors

Issues associated with the evolution of and uncertainty about the Nitrates Directive were described in the last two sections (Section 4.4.3.1 and 4.4.3.2). In addition to this, a few interviewed farmers expressed concerns associated with a specific aspect of the policy, i.e., the closed period for slurry spreading. Specifically, the beef-sheep farmer (F4) argued that on the one hand, "*the weather from October to January could be like the weather you'd get for the month of March or April*", with perceived suitable conditions for spreading. On the other hand, "*the weather from January to April could be a washout which it was this year [2024], a complete washout*", with risks of having slurry "*seep[ing] off into rivers*". Specifically, she identified a mismatch between slurry spreading dates and weather:

> "*you can go out and spread slurry in that [bad] weather and just because it's a date say "oh it's fine", but that in the weather… that doesn't make sense. I don't know, I can't fathom out the reasoning behind it. Is it what… the dates… maybe there's some scientific thing that I don't know but I can't see any, I don't understand it."* (F4)

In turn, difficulties in spreading slurry in perceived suitable conditions were "*put[ting] a lot of pressure on people*". In her view, institutional action was needed to readjust the policy in line with real-time weather monitoring.

Perceived no institutional will and action to support family farms was raised in other instances. When referring again to issues associated with slurry management, the beef-sheep farmer (F4) explained that it did not make financial sense for her to invest in additional storage space. The alternative option for her was to decrease animal numbers. She suspected that this option was what the government wanted:

> *"Part of me thinks they kind of want people to… they don't want people to stay at it, that they want to get out of it. I don't know."* (F4)

The pig-tillage farmer highlighted how in his view, it was not normal that tillage farmers would sometimes have to sell their crop products below the cost of production. In his opinion, crop sale prices needed to be regulated to protect the sector:

"It's just the way tillage is going. And then it's a shame that we're losing tillage farmers and we're importing grain instead like. It doesn't add up sometimes and like that, it's a shame that, you'd be hoping that the food regulator will make changes that the likes of a tillage farmer should never be allowed to sell his crop below cost of production. It just shouldn't happen really." (F6)

The Shannon Callows farmer also perceived a need for institutional action on the river's maintenance. He attributed summer flooding of the Shannon Callows to both climate change and this indicates the need for institutional action in rural areas:

"we have done nothing to cater for climate change and the effects of climate change particularly in this area. And I know what the government will tell you: they've spent so much money and they have. They've spent a lot of money. But they have spent it in the towns [...] But when you come into the rural areas, [...] nothing whatsoever has been done." (F8)

The farmer reported that without action from the government, the Shannon Callows farming community was unable to effectively respond to the crisis, augmenting the risks of further economic, social, and biodiversity impacts:

"So the losses are becoming massive and if there's something not, you know, if there's not a radical approach taken to this whole issue at government level. And an urgency applied to it, as I said we're going to lose a lot." (F8)

According to this farmer, this perceived inaction was putting the future of farming in that region at risk[15].

Another important stressor relates to contradictions in the evolution of agri-environmental policy; this was mentioned by both interviewed farmers and advisors. For example, the derogation dairy farmer expressed that policy had "*gone full cycle*" as his father "*was getting grants to remove hedgerows when he was [his] age*" and now he "*[was] getting grants to put them back in again*". This farmer explained that for his father who was "*always a really good farmer*", "*it [was] so hard to change that mind-set from a lifetime of farming a certain way*". In the advisor focus group, one of the advisors (A1) also raised the issue of changing policy focus. He considered that "*an awful lot of what we were telling farmers maybe only five, maybe ten years ago has been completely turned upside down*". Using drainage as an example, this advisor explained that the advice that he was giving to farmers in few years ago "*was a completely, completely different message*" compared to the present recommendations. In this context, multiple advisors pointed out that the current agri-environmental policy focus is quite different from the past emphasis on production growth:

"probably the biggest challenge […] is the fact that I suppose the message for farmers over the last twenty years has been to drive on production, drive on production. Produce more, spread more fertilizer. Now suddenly in the last couple of years the whole thing has just turned on its head, […] even though it's probably

[15] It is important to mention that the government did implement a recovery scheme following the 2023 Summer Flooding to mitigate flood impacts and ensure that farmers had the financial means to source fodder outside of the Shannon Callows (DAFM 2023).

not being said in the media or by the government […] I think that change is very frustrating for farmers as well. Because obviously they've been doing this and they've plans in place. […] And suddenly that's all up in the air, which is from a mental health point of view […] is very difficult." (A5)

According to advisors, changes in extension messages were aligned with policy changes and could confuse both advisors and farmers. In some instances, these changes in messages could be quite significant and occur rapidly. In addition to the drainage example, the advisor (A1) described how in the timeframe of a month, he had to completely re-adjust and adapt the advice around the amount of phosphorus that could be spread. This was because a large share of his clients' land was suddenly designated as peat ground. In order to provide accurate advice, the advisor needed to put nutrient management plans (NMPs) in place for his clients, which had not been the case so far. Hence, in the absence of the necessary NMP information to match soil phosphorus demand with fertiliser supply, he "*was nearly telling them not to spread 18-6-12 [fertiliser]*" anymore. In this context, multiple advisors identified advisor workload and limited time due to the increase in scheme work in recent years as major barriers for advisors to respond in a timely and informed manner to this type of challenges. One of them (A3) also highlighted that a lot of the scheme work was concentrated between January and May, which are "*the months where [...] the really important decisions are made at farm level*", thereby limiting the advisors' capacity to support these decisions.

Both an advisor (A5) and the derogation dairy farmer (F2) outlined the need to implement a step-by-step approach with farmers to encourage incremental change. This mainly referred to having clear, actionable recommendations and ensuring consistent messaging from all sources. For the advisor (A5), it was important to give "*two or three key messages, or clear things that [farmers could] practically do on their farm*" instead of "*bombarding them with information*". Other advisors shared this view. One of them (A4) emphasised the importance of providing "*the one consistent message*", "*streamlined and simple*", notably in a context where "*there's so many different changes coming at farmers*". In her opinion, the amount of (sometimes conflicting) information that was provided to farmers could become a barrier to behavioural change:

"If they're getting mixed messages, they're just… there's fatigue out there anyway with all the changes that are coming at them. That they're not going to want to make any changes if they're getting mixed messages." (A4)

In this context, advisors also acknowledged that there can be trade-offs across different environmental issues and thereby trade-offs among practices and extension advice for farmers when different environmental priorities are being focused on. For instance, an advisor (A6) explained that water quality and climate change advice "*are kind of pulling against each other […] when it comes to phosphorus use*". The use of 18-6-12 fertiliser is being recommended for climate action but not for water quality. While "*neither of the messages are wrong*" (A6), this could lead to mixed messages and further confusion for farmers.

Finally, the advisor (A6) pointed out that necessary policy changes were sometimes slow in being decided. She used as example the most recent CAP reform (2023), which officially recognised landscape features such as scrubs for their contribution to biodiversity by making them eligible for payment. This advisor explained that "*a couple of years [ago], […] we were talking about of the environment and this, that and the other, and yet farmers were still being penalised for scrubland and stuff like that*". In her view, "*it took a while for policy to catch up and stop penalising farmers for having this kind of biodiverse area on their farm*". Similarly, policy and proposed solutions were not always deemed practical. The advisor (A6) mentioned the new forestry schemes, which allow farmers to plant up to a hectare of ground without needing a forestry license. She highlighted that while some farmers were interested in availing of the scheme, "*the foresters [would not] do it*" because areas to be planted were too small. In her view, "*sometimes there [was] just like a link missing maybe between what's put into policy and what happens on the ground*". Regarding proposed solutions, advisors also emphasised that research/demonstration farms tend to explore practices that are applicable only to "*the more highly stocked guys*" (A5), who represent a small share of the farming population. This could also be a barrier to adoption by "*your 70, 80% farmers that are lowly, more lowly stocked*" (A5).

4.5 Support structures and farmers' trusted agents

Key messages:

- Farmers reported their most important influence to be other farmers.
- Extension services were reported to be an important source of information, support, practical advice and inspiration.
- Grant schemes such as the Targeted Agriculture Modernisation Schemes (TAMS), the fodder support scheme and the Agri-Climate Rural Environment Scheme (ACRES) provided support to farmers and were facilitators of climate adaptation.
- Farmers suggested a wide range of additional supports: financial support, help with planning and sourcing finance, more information, and further research.
- Advisors pointed out a need for information on a wider suite of adaptation measures to support farmers' climate adaptation.

4.5.1 Current support structures and trusted agents reported by farmers

Other farmers, farm advisors, and family members were the three primary sources of social reference from which farmers communicate and obtain information regarding weather-related issues (Figure 4). In contrast, farmers reported that farming media served as one of the least significant sources of information, with lower social influences noted from accountants and contractors in relation to challenging weather events. However, veterinarians were identified as the fourth most important source of information and social influence (Figure 4).

As with the survey findings, the farmer interviews found that other farmers and extension services were regarded as the most important sources of information and support. The interviews also identified that many farmer-to-farmer interactions took place within a farmer discussion group context. Agents such as vets, contractors and accountants did not emerge as sources of influence from the farmer interviews. Likewise, there was little evidence about the influence of the farm family. In addition to extension services and peer networks, support for this cohort also encompassed education, media, and public policy.

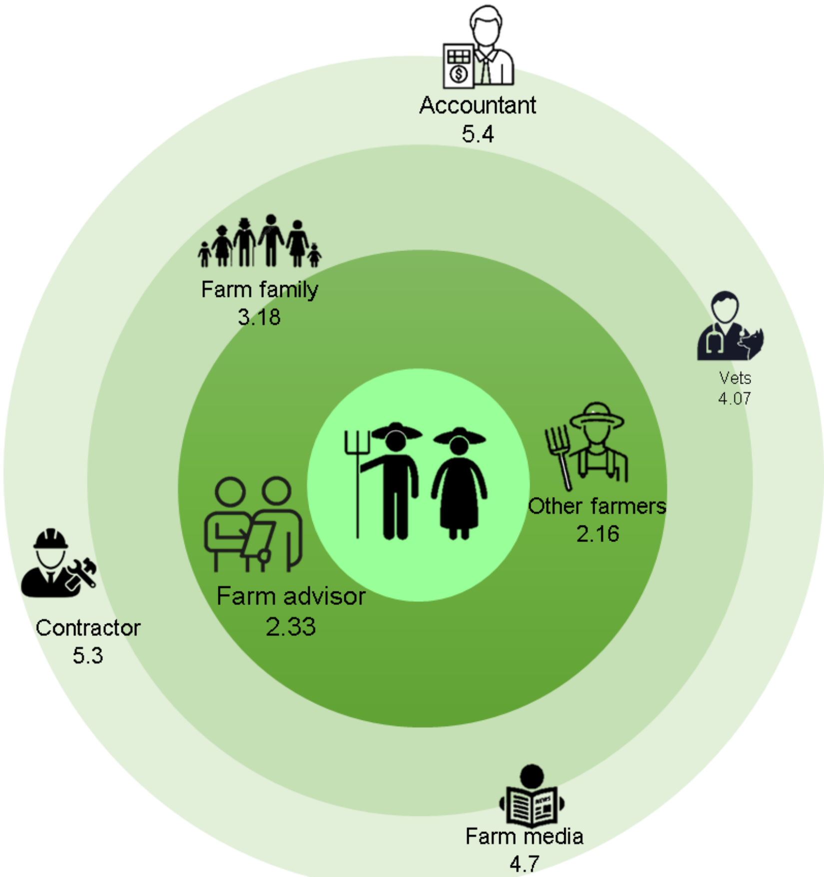

Figure 4: Key influences affecting the decisions and actions of surveyed farmers in response to challenging weather events, ranging from 1 (most important) to 7 (least important) (n = 195).

4.5.1.1 Extension services and peer support

Famers consistently identified extension services and peer learning as their most influential sources of information and support in the context of weather-related issues. Discussion groups, farm visits, and open days were highly valued for providing technical knowledge and were seen as a valuable source of support especially during challenging times:

> *"I find the discussion groups are absolutely brilliant. Just you'll always learn something at them, you know always pick up something, psychologically just if you are having a bad couple of days or weeks, your cows have dropped back in milk or something for some reason. And you can't put your hand on it, and you go to a discussion group and there's fifteen other farmers just saying the exact same*

thing. [...] So the discussion groups are brilliant. They are a bit of consolation when things are going wrong. And the kick in the arse you need sometimes when you are relaxed, and you are taking things for granted. I enjoy going to them. A lot to learn from them." (F5)

Farmers appreciated the opportunities given by extension services to witness practical adaptation solutions applied in different farm contexts. The sheep farmer (F9) reported that even one valuable takeaway could justify attending these meetings. "*If you only take away one message*", he reflected "*it's a message worth learning*". Moreover, seeing other farmer practices could be a source of inspiration:

"you know could be something very simple that you can see somewhere else that's so simple you overlooked it yourself." (F9)

The pig tillage farmer (F6) recounted seeing an umbilical system for slurry management being demonstrated at an open day. After visiting other farms with an established umbilical system, he implemented it in his own farming operation because "*It showed us that it could be done*". However, this farmer also highlighted challenges in accessing such events due to time and labour constraints. He regarded podcasts as a practical alternative, allowing farmers to stay informed while managing daily tasks:

"You have a farmer sitting in a combine, maybe he can have a little pod… like I find the pig podcasts are brilliant. I could be working in a field and I have the pig podcast on the radio. So, I'm still working but I can still pick up information, you know. Or like this now, my father would be running the grain dryer for twelve hours a day and if something was on a radio podcast he can listen to it or be doing it. But for a farmer to leave his farm and go to an event is incredibly hard anymore because labour is not there to help him." (F6)

Location specific, one-to-one expert advice was mentioned by the dairy farmer (F2), for environmental advice. During the focus group, farm specific guidance was seen as essential for developing appropriate risk management plans. "*It's going to need to be farm specific*", one advisor noted so that farmers "*identify what's the highest risk to their farm going forward" [...] [to] help them put some bit of a plan in place for how they can adjust or protect themselves from that risk."* (A6)

Within the dairy sector additional supports were reported in the form of Joint Programmes, e.g., programmes involving Teagasc and a dairy processor. This source of support was raised by advisors in the focus group. The main focus of these programmes was climate mitigation. However, it was recognised that there were some cross overs that were helpful to adaptation. Financial incentives were usually built into such programme to support change:

"I suppose from a dairy point of view then as well you have the co-ops all kind of have their own sustainability bonuses that help promote them to make adaptations." (A4)

Outside of extension services, the importance of other farmers remained evident. The beef farmer reported how practical advice from experienced peers informed his own decision-making:

"Just people like that that you would, that are at it every day fulltime, trying to make a living out of it, you'd be following them to see what way they're doing it you know." (F1)

4.5.1.2 Education

Additional educational resources were provided for farmers in the dairy sector, with some processors funding environmental education through Irish universities. The dairy farmer (F2) noted his appreciation of the processors' role in advancing environmental knowledge within their supply chains:

> *"So the processor is actually very good too as well to educate the farmers as well"* (F2)

Conversely, the milk sheep farmer (F7) noted limitations to his education; he noted that his educational background was predominantly focused on low-cost, grass-based production systems, a model that was no longer the right approach for his farming system:

> *"Just you know not be as low, low cost focused is an all round better system for the animal and the operator. [...] And that's moving away from the research do you know and like I would've been trained in Moorepark."* (F7)

4.5.1.3 Media

Traditional and digital media also featured as valuable sources of information and inspiration regarding climate change. Farmers reported consulting publications such as the "Farming Independent" and "The Farmers Journal", as well as online platforms. "*There's no shortage of information there*" according to the derogation dairy farmer (F2). Social media provided additional peer learning, with some farmers actively engaging with digital communities:

> *"And I'd keep an eye on you know your social media things. And I'd always be watching out to see what other people are doing. So to try and constantly improve, or try to improve anyway."* (F1)

4.5.1.4 Policy

Government schemes and grants, such as the Fodder Support Scheme and the Targeted Agricultural Modernisation Scheme (TAMS) were essential in supporting farm infrastructure, economic resilience and potential adaptation measures according to the research. The non-derogation dairy farmer (F5) described taking advantage of TAMS funding to expand slurry storage in the belief that future regulation may force this investment:

> *"I'd sooner have more slurry storage now while there's an option there to get a grant on it than be forced into doing it in a few years' time."* (F5)

However, for others, the cost of infrastructural improvements remained prohibitive despite available grants, as indicated by the beef-sheep farmer (F4):

> *"Still, it's still, it's expensive and it wouldn't pay for me, on the size of my farm it wouldn't."* (F4)

As mentioned in Section 4.3.1.2, the beef-sheep farmer was also unsure about her succession plans. This suggests that farmers who were more socio-economically vulnerable were less likely to avail of capital grants and invest in infrastructure.

Farmers also reported engaging with environmental schemes such as ACRES. The derogation dairy farmer (F2) discussed the importance of financial support for these initiatives. This was because environmental measures can be costly, indicating a potential trade-off between economic and environmental sustainability:

> *"And then like the environmental schemes obviously as well like we are going to need to be paid to do those like. Even like I loved to plant this hedgerow here this year or next year but like with the grants, we can't really afford to do it without getting funding." (F2)*

This farmer, who had implemented a range of environmental measures with and without support from these schemes, suggested that providing a comprehensive support package, including site-specific advice and specialised contractors, could maximise the schemes overall impact, support its implementation, and alleviate the time and expertise burden on farmers. He reported that expert advice that he received optimised the placement of trees for multifunctional benefits and sustainability synergies such as carbon sequestration, livestock shelter, and water protection:

> *"But you could plant a tree in the right place or the wrong place so. He said you could plant a tree in the middle of the field and that'll be great for say sequestering carbon [...] But [the expert] said what about if you went down and plant it say down here like say for example where you have a water course, so you're actually, you've multiple benefits then. So you're planting a tree which will actually be good for sequestering carbon. Also then it'll protect the water course, because it'll be like a riparian zone. And it'll be a shelter for the cows as well at the same time."* (F2)

4.5.2 Potential additional supports suggested by farmers and advisors

4.5.2.1 Farmer supports

When asked directly about additional supports for climate adaptation, farmers described various needs. Financial assistance to help offset escalating winter costs was one priority for livestock farmers. The sheep farmer (F9) described the mounting expenses associated with extended housing of animals due to longer wetter winters. "*Winter is costing a lot*" he stated, "*costing me to keep them in extra time*" (F9).

The milk sheep farmer (F7) suggested practical support in planning and sourcing accessible finance options, particularly low-cost loans to help build feedstock reserves and ensure resilience within farm business plans:

> *"Farmers should be given more support around planning and financing their business plans, to be more resilient. So you know like having feedstock, surpluses and reserves and maybe being supported to keep those reserves. You know finance available, loans and you know low-cost loans or whatever. That could be a way to help, to allow farmers to build up stocks in years when things are good. And you know have those in place for when you know challenging times hit like, weather wise and that"*. (F7)

The tillage farmer (F3) expressed the need for improvement in technology to increase the accuracy of weather predictions in the future. More accurate forecasts would allow him "*to work a bit better on working around the weather instead of trying to fight* *it on a daily basis*" (F3). He also advocated for further research on soil resilience, the development of new, climate adapted crops, and more research into sequential cropping to maximise productivity within shifting weather patterns. He acknowledged that alongside research, this may also require farmers broadening their mindsets to consider alternatives to traditionally grown crops stating that "*people need to keep an open mind on that side of it. And that's where some research needs to be [...] looked at as well*" (F3).

Soil fertility and nutrient management also emerged as key areas for research and knowledge transfer. The dairy beef farmer (F5) described the need for insights into nutrient retention across variable weather conditions, which could improve application efficiency and reduce environmental impact:

> *"But like what is the nutrient loss? [...] You know, a bit more, and both extremes the wet weather and the extreme dry weather, what affect it has on manure. And both from the short-term period when you are spreading it, and the long-term period [...] A bit more information about something like that I suppose is something I'd be curious about."* (F5)

Advisors in the focus group emphasised that any proposed solutions must undergo on farm validation to avoid straining already pressured farm operations:

> *"there's so many changes coming at farmers at the moment […] if they require massive changes that there's [...] on-farm studies of them, before they're [...] pushed onto farmers." (A4)*

4.5.2.2 Advisor capacity to support farm-level climate adaptation

Within the focus group, not all advisors shared the same understanding of climate adaptation. Nonetheless, several advisors emphasised that they had a role to play in increasing farmers' preparedness for climate change and reducing risk exposure on farms:

> "*I suppose just to help them be better prepared you know. It's going to need to be farm specific you know. So I suppose identify what's the highest risk to their farm going forward and how things can change. And trying to help them put some bit of a plan in place for how they can adjust, or protect themselves from that risk.*" (A6)

However, these advisors highlighted that apart from fodder budgets and slurry storage calculations, they lacked practical information on a wider suite of adaptation measures that could be recommended to livestock farmers:

> "*Probably a lot of messages we're getting across is more mitigation rather than adaptation. Like we're talking about things we can do to reduce emissions. But not really what farmers can do for the changes that have happened already. […] there's not too many [practices] that spring to mind that we got a lot of information on.*" (A5)

In their view, the focus in advisory services (including advisor training) had been predominantly placed on climate mitigation as opposed to adaptation:

> *"But I don't think that there has been enough focus on adaptation, whether that being, even in training and stuff like that for us. There has more so been a focus on mitigation than adaptation I would say."* (A6)

Overall, this pointed out the need to strengthen advisors' capacity to support farm-level climate adaptation. In this context, one of the advisors (A6) suggested including visits of innovative farms in advisor training to learn from farmers "*thinking outside the box*".

4.6 Pathways towards climate adaptation

Key messages:

- Farmers who have had more experience with climate change impacts have stronger perceptions of susceptibility to climate change.
- Social influences were the main drivers of behaviour change directly and indirectly through positive effects of perceived behavioural control (self-efficacy) regarding adaptation actions.
- Farmers are more likely to expect negative impacts from climate change over the next five years due to direct effects on their farms, frequent negative experiences, and seeing similar impacts on neighbouring farms.
- Farmers recognise the importance of taking adaptation actions in response to climate change.
- Although farmers acknowledge the need for adaptation, many struggle to progress beyond the contemplation stage to preparation, action, and maintenance stages of change.
- Farmers perceive low control and lack confidence in performing adaptation actions, primarily due to insufficient social support and limited opportunities for exchanging ideas, views, and experiences with their counterparts.
- There is a risk that farmers may normalise climate change incidents over time if they remain in the contemplation stage.
- A few farmers discussed the future of Irish production systems, notably identifying climate-induced market opportunities and expressing interest in crop species imported from other areas of the world.

4.6.1 The key role of social influences in stimulating behavioural change

The farmer interviews revealed many factors influencing farm-level behavioural change (Table B.5: Mapping of factors influencing farm-level behavioural change towards climate adaptation using the farmer interview data., Appendix B: Additional tables and figures). This section draws on quantitative survey data analysis to present exploratory statistical modelling results that identifies how these factors interact and shape intentions and behaviours. As shown in Table B.4, all factors influencing farm-level behaviour change, except one, are positively linked. The exception is a negative association between the perception of climate change impacts and PBC. Farmers who reported higher scores for psychosocial factors, such as positive attitudes, subjective norms, PBC, higher perceived risk of negative impacts, and belief in climate change, demonstrated greater adaptation behaviour. It is important to note that farmers perceiving greater negative impacts reported lower confidence or control in performing selected adaptation actions, although this link was, statistically, weak.

Strong positive correlations were observed between climate change impacts and risk perception (Table B.4). This suggests that farmers who reported negative impacts or consider themselves vulnerable to climate change tended to have a greater perception of the likelihood of the negative impacts of climate change in the future. Equally, those who experienced more frequent incidents (either directly or indirectly associated with climate change) reported a greater perception of the likelihood of the negative impacts of climate change in the future. Additionally, a strong positive link was found between subjective norms/social influences and PBC/self-efficacy. Therefore, farmers reporting positive social influences felt more control or confidence and perceived fewer difficulties in performing selected adaptation actions, resulting in higher behaviour change (Table B.4).

The structural equation modelling (SEM) analysis exploring the influences on 'climate risk appraisal' indicated that farmers perceive a higher likelihood of negative climate change impacts primarily due to direct experiences, the frequency of negative impacts on their farms, or observing neighbouring farmers being affected (Figure 5). This analysis shows that farmers' belief in climate change is influenced by their perception of risk (e.g., likelihood of negative impacts in the next five years). These beliefs, in turn, affect their attitudes. Farmers who are risk-averse and aware of climate change tend to value taking adaptation actions to mitigate impacts and weather-related risks they have experienced (Figure 5). However, the role of subjective norms or social influences in shaping risk perception was insignificant, due to limited social interactions, passive social influences, and slight negative social pressure (Figure 5). The SEM also enables an exploration of those factors influencing adaptation behaviours (Figure 5). The significant role of social norms in shaping behaviours is evident, as is the influence of this factor on PBC, which, in turn, shapes adaptation behaviours.

This analysis showed that while farmers are aware of climate change and acknowledge the importance of adaptation, many remain in the contemplation stage, struggling to progress to preparation, action, and maintenance stages. Their positive attitudes towards adaptation actions are primarily reactive rather than proactive. This reactive approach results in attitudes shaped more by direct climate change impacts than by beliefs in the time- and cost-effectiveness of these actions. There is a risk that farmers that are stuck at the contemplation stage increasingly normalise climate change incidents (see Figure 1 and Table B.1: Weather change beliefs reported by surveyed farmers (n = 195).) even if they have slightly positive attitudes regarding the importance of adaptation measures but are uncertain regarding their efficiency and cost-effectiveness.

The analysis also suggests that farmers perceive low control and confidence in performing adaptation actions due to insufficient social support and limited opportunities for exchanging views and experiences. External barriers such as policy and regulatory uncertainties, lack of financial support, and limited opportunities for tailored, including place-based, knowledge exchange further reduce perceived control and confidence (Figure 5).

The directionality and strength of relationships between different factors is of note. Whilst this is an exploratory analysis, the results highlight weak influences associated with beliefs and attitudes on behaviour, compared to the relative strength of the association of subjective norms on beliefs and attitudes. This suggests that greater consideration be given to actions that influence or shape subjective norms. Rather than a 'top-down' approach to increasing awareness and understanding of the implications of climate change, there is also a need for 'bottom-up' sharing of experiences through means such as the farming media, discussion groups, training courses.

In summary, the decision-making model highlights that social norms and support are the main factors influencing behaviour change. These factors positively impact PBC and foster more positive attitudes, particularly regarding beliefs in the efficiency, time, and cost-effectiveness of adaptation measures. The findings underscore the need for effective communication on weather-related issues, experience sharing, and discussions on adaptation measures. Such participatory knowledge exchange and training, combined with financial support and transparent/stable policies, can encourage farmers to move from contemplation to preparation and action stages. In conclusion, it is important to, once again, stress that further analysis is needed to explore which factors can be leveraged in policy and knowledge transfer initiatives to motivate behavioural change in selected practices.

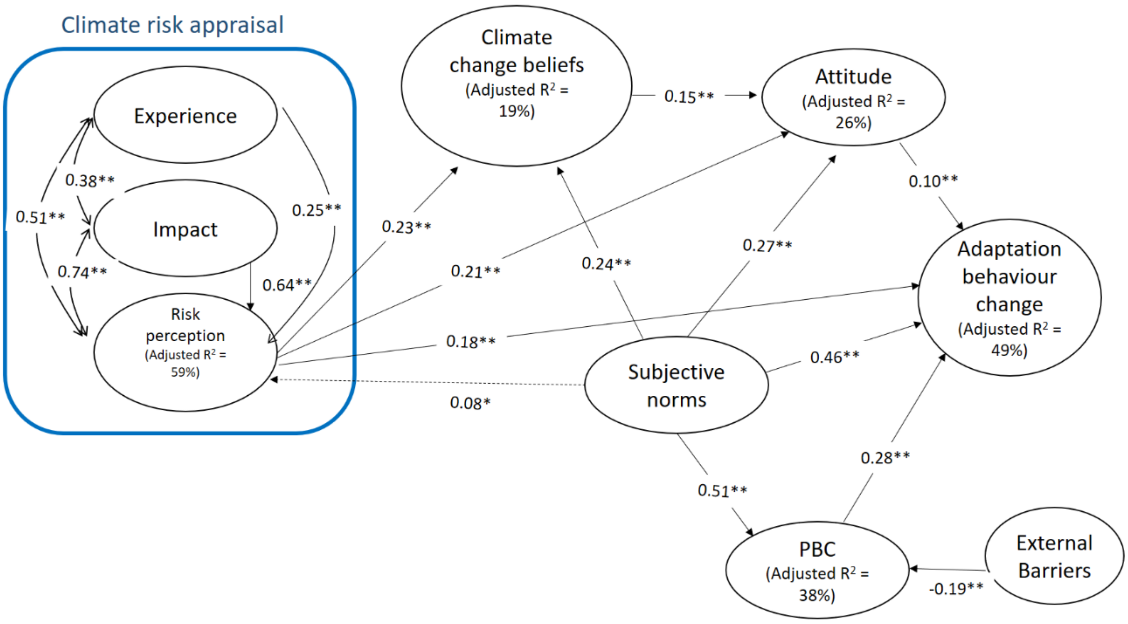

Figure 5: Key factors influencing farm adaptation behaviour change (findings of the SEM analysis (n = 195).

4.6.2 Design of future production systems: Opportunities and challenges for the Irish agricultural sector

A couple of interviewed farmers reflected upon the future of production systems in Ireland and the potential for opportunities as a result of climate change. The milk sheep farmer (F7) identified a market opportunity due to climate change making production conditions less favourable in Southern Europe where sheep milk is currently being produced. According to the farmer, this "*[was] helping [his] business in that sheep milk is in demand*". Despite the climate change challenges that he faced in Ireland, he considered that "*it's probably still easier to milk sheep in Ireland than it is in Italy or Spain now, because of the heat and the droughts*". In his view, climate change is having a more "*severe*" effect in those areas of the world than in Ireland. He acknowledged that while some adjustments in his system were needed, he could still continue producing:

> "*I can still do everything I dreamed I could do with sheep and farming. But I just have to do it differently. But it doesn't really… you know it's just costing more; it's harder to do it. But we can still do most of what we want*" (F7)

As described in Section 4.3.1.5, the milk sheep farmer (F7) adapted to climate change by reducing his reliance on spring grass and moving towards an indoor-outdoor system. In this way, he saw an opportunity to transition towards a higher-yielding system while "*capitalis[ing]*" on spring grass when conditions were suitable.

The tillage farmer (F3) highlighted the importance of "*keep[ing] an open mind*" and considering growing new crop species in Ireland to adapt to climate change. Due to unpredictability, he wondered if tillage growers "*should [...] be learning how to grow rice, or soya bean*". He mentioned current trials being undertaken by a seed supplier to import and adapt crop species from other, drier parts of the world:

> "*They might be looking at some of these South American crops, or North American, southern parts of North American crops, that we might actually be able to start growing [...] and see how they get on then with torrential rain when you do get that heavy rain. But maybe we will be finding things will warm up a bit and yea that those crops will actually survive and yea do well here. Yea just to keep an open mind I think going forward so.*" (F3)

5 Conclusion and areas for future research

This exploratory mixed-methods study analysed primary data collected from farmers and agricultural advisors to examine farm-level behavioural change that can foster adaptation to the current climate and enhance the resilience of the Irish agricultural sector. Even if the study is not generalisable due to sample limitations, it offers a preliminary understanding of farm and farmer resilience to climate change and has important implications for the agricultural sector and policy development. Overall, the study highlights the need to strengthen the climate adaptation strategy in Ireland at the policy level to better support farmers and coordinate the agri-food industry, including the Agricultural Knowledge and Innovation System (AKIS). In this context, the publication of the next Agriculture, Forest and Seafood Climate Change Sectoral Adaptation Plan 2025 provides an opportunity to further explore, and address key issues raised by this research.

The study findings revealed that surveyed farmers had a high level of awareness of weather changes, notably due to the experience and impacts of these changes on their business and livelihoods. They also recognised impacts on their neighbours. As a result, these farmers recognised the need to adopt adaptation measures to reduce climate impacts and vulnerability. The farmers were, however, uncertain about the type of practices that they could implement. The research established that more work is needed to identify climate adaptation solutions, and that these could be co-created among all relevant agricultural stakeholders (Eastwood, Turner, and Romera 2022) to ensure that they are inclusive and do not lead to maladaptation (Biella et al. 2024).

Alongside the adaptation measures that were selected through a literature review and consultations with farm advisors for the study survey, the farmer interviews revealed a range of innovative adaptation actions that highlight the social and human capital, including experiential learning, among farmers. While interviewed farmers were already developing creative adaptation solutions, these need to be systematically studied, validated, and shared through formal research, extension, and education networks. Hence, these actions could be a starting point for future research to better understand their contribution to climate resilience and sustainable development, before incorporating them in widespread extension advice. Moreover, farmers' role in interrogating and experimenting with research-led innovations and practices that they have identified is paramount to test their suitability to local conditions and ensure sustained behavioural change, as indicated by the farmer interviews. They could thus be supported further in this role. Additionally, agricultural advisors support and empower farmers to make informed decisions in individual and group settings in relation to climate change. As such, their potential role in facilitating the co-creation process could be acknowledged and further investigated. Overall, more efforts could be made to better integrate the co-creation process among key stakeholders of the industry in the context of climate adaptation.

As pointed out by the EEA (2019), where possible, solutions promoted and implemented at the farm level should have multiple aligned objectives and benefits to leverage sustainability synergies. The farmer interviews showed that farmers adopted multi-objective practices that can contribute to climate resilience. Nonetheless, trade-offs among and within sustainability dimensions were identified in the qualitative data. It is important to highlight that due to interconnectedness and 'knock-on effects', any action targeted at one area can lead to positive or negative/unintended consequences for the farm and farmer. This indicates the need to further explore farm-level sustainability synergies and trade-offs associated with co-created adaptation measures through a systems perspective. In turn, this will allow for a better integration of farm-level strategies to build climate resilience while achieving wider sustainability objectives.

The study confirmed the intersectionality of sustainability issues in the context of climate adaptation in Ireland. The qualitative data provided examples of how farming is intertwined with flood management, water quality management, and habitat preservation. In such instances, farm-level climate adaptation measures may not be applicable. A wider landscape or regional approach may be needed to coordinate efforts among farmers and with other members of the rural community through collective action. In environmentally sensitive areas, the multi-actor approach could be used to find solutions to complex, intersectional problems.

The study findings indicated that farmers considered, planned, and implemented measures that could foster resilience building. Reactive practices that mitigated environmental, social, and economic impacts during or immediately after disruptive weather events were undertaken, while proactive, anticipatory practices reduced vulnerability to future weather events. The farmer interviews suggested that farmers may need additional financial support to recover from the impacts of weather events. In the future, proposed solutions to build climate resilience could be conceptualised around three key areas, adapted from the field of disaster risk management; protection to reduce climate impacts, prevention and preparedness to reduce climate vulnerability, and recovery to mitigate socio-economic impacts and vulnerability after an extreme weather event (Karrasch et al. 2021). This framework could contribute to the integration of risk management, climate adaptation, and sustainable development for the Irish agricultural sector and at the national level, as recommended by Medway et al. (2022) and UNDDR (2023).

The survey findings established that farmers perceived a need for technical skills, lower control over the negative impacts of climate change, and confidence in performing climate adaptation actions. The low social influences was a key factor in explaining these findings. In the context of climate adaptation, farmers seemed to have limited opportunities to share their thoughts, experiences, and needs with other farmers and advisors. This indicates the need for greater incorporation of climate adaptation within knowledge exchange and extension programmes to build capacity and empower farmers. Specifically, testimonial or storytelling approaches (e.g., adaptation champions, resilience builders) could be implemented to encourage peer-to-peer learning amongst farmers through programmes such as the Teagasc Signpost demonstration farms. Community-based knowledge exchange around climate adaptation could be promoted by leveraging existing farmer support structures such as farmer discussion groups, with the benefit of enhancing social support and validation among farmers. Community-based approaches can also be effective in implementing the co-creation process for developing innovative adaptation practices and proactively engaging farmers in co-creating solutions. Additionally, more one-to-one farm-specific advice could be provided to farmers to support the adoption of multi-functional practices that require spatially explicit advice (e.g., trees, hedgerows). Nevertheless, greater incorporation of climate adaptation in extension programmes would also require more advisor training to increase their knowledge and capacity in supporting farm-level climate adaptation. It is also noteworthy that the increase in scheme work reported in the advisor focus group is a general trend in the EU due to the number and complexity of current CAP schemes (EC 2024). This tends to take advisors' time away from on-farm and group-based advice on issues such as climate adaptation. Overall, future research is needed to understand constraints to farm advisors' engagement in climate adaptation discussions with their clients, with the aim of building advisor capacity and improving farmer support.

Additionally, the study findings showed that farm-level behavioural change could be hindered by uncertainty in relation to future policy development (notably the Nitrates Directive), and insufficient financial resources and support. The qualitative data indicated that both farmers and advisors had difficulties in adjusting to rapid policy change, which could result in mixed messages and change fatigue.

The need to urgently respond to climate change is recognised by the farmers and advisors, but a step-by-step approach is required to ensure consistent messaging that improves understanding of the need for and engagement with change. Moreover, interviewed farmers emphasised the usefulness and need for continued financial support such as the TAMS grant aid to build climate resilience. For farms that were more socio-economically vulnerable, such measures were not always sufficient to promote climate adaptation measures that required large investments. More research is needed to explore how these farms can be supported further to adapt to climate change and build resilience.

The importance of cooperation among farmers was underlined by the qualitative data analysis. The results suggested that farms competed for access to resources such as land, labour, feed, and bedding material, with some specific sector and location dynamics. However, cooperation was key when feed supplies were low to allow for a transfer of fodder from farms with surplus feed to farms in need. A deeper understanding of the cooperation among farms and farming sectors, and its role in enhancing resilience, is needed to develop specific supports around these issues. This could include an examination of the differences in the environmental, economic, and social vulnerabilities to climate change across farms types and farming sectors.

Due to uncertainty about future climate, most farmers in this study were uncertain about the opportunities associated with climate change, with a few exceptions: climate change might lead to less favourable production conditions in some areas of the world, which could provide a market opportunity for the Irish agricultural sector. Moreover, climate change might make it possible to grow new crop species in Ireland. In this sense, it is important to emphasise that this report focused on adaptation to the current climate, as opposed to the future climate. However, whilst new opportunities may present themselves as climate change unfolds in Ireland and around the world, so too will challenges to existing farming systems. To prepare for future climate, more research is needed to improve climate projections in Ireland and use this information to conduct regional analyses depicting farming conditions on different farm types and sizes under various climate scenarios. This will inform farmers, and the industry, of the extent and scale of adaptation measures required. Moreover, a deeper understanding of the effects of global climate change on Irish agriculture, including Irish input and output prices and trade of agricultural commodities, is also required to identify opportunities and disadvantages for the sector. This will allow assessing whether potential benefits offset the costs of adaptation to climate change.

Beyond the research areas already outlined, additional avenues for investigation were identified. Although the qualitative interviews aimed to represent diverse farm types, sample and time constraints limited geographic diversity. This may have excluded location or sector specific impacts, such as those faced by coastal and organic farms, and the horticulture sector, potentially narrowing the applicability of these findings for these contexts. Likewise, the limited sample size in the quantitative survey may limit generalisability. There is a need to scale up this study to improve understanding of the adaptation perspectives and barriers to change of farmers in different sectors and regions. Future studies could also benefit from employing additional socio-cognitive frameworks rooted in insights from qualitative studies such as the one presented in this report. This could be complemented by a broader examination of the psychological and risk perception dimensions. Moreover, while the study offers an initial view of behavioural change, more comprehensive research would allow for the development of a farmer typology that incorporates background, economic, business, and structural factors reported by some interviewed farmers.

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Appendices

Appendix A: Details about the methodological approach

Table A.1: Research hypotheses examined in the survey (quantitative research).

Hypothesis	Factor/variable affecting behaviour change	Statement
H1	Triggering behaviour change: person and place-based experiences	Experience of climate change (extreme events and climate variability) (a) and negative impacts of the climate change (b) will positively and directly influence risk perceptions, and indirectly attitude, PBC/self-efficacy, and behaviour change. Attitude (c) and PBC (d) will then directly influence the behaviour change.
H2	Risk perception[1]	Risk perception regarding the negative impacts of the climate change will directly influence adaptation behaviour (a), and indirectly influence behaviour via positive and direct influences on climate change beliefs (b), attitude (c), and PBC/self-efficacy (d).
H3	Subjective norms/social influences	Subjective norms will influence the behaviour change directly (a) and indirectly via direct effects on climate change beliefs (b), risk perceptions (c), attitudes (d), perception of self-efficacy/PBC (e).
H4	PBC and self-efficacy	External barriers will negatively influence (a) self-efficacy or PBC. PBC will positively influence behaviour change directly (b)

1. Perceived probability of negative impacts of the climate change.

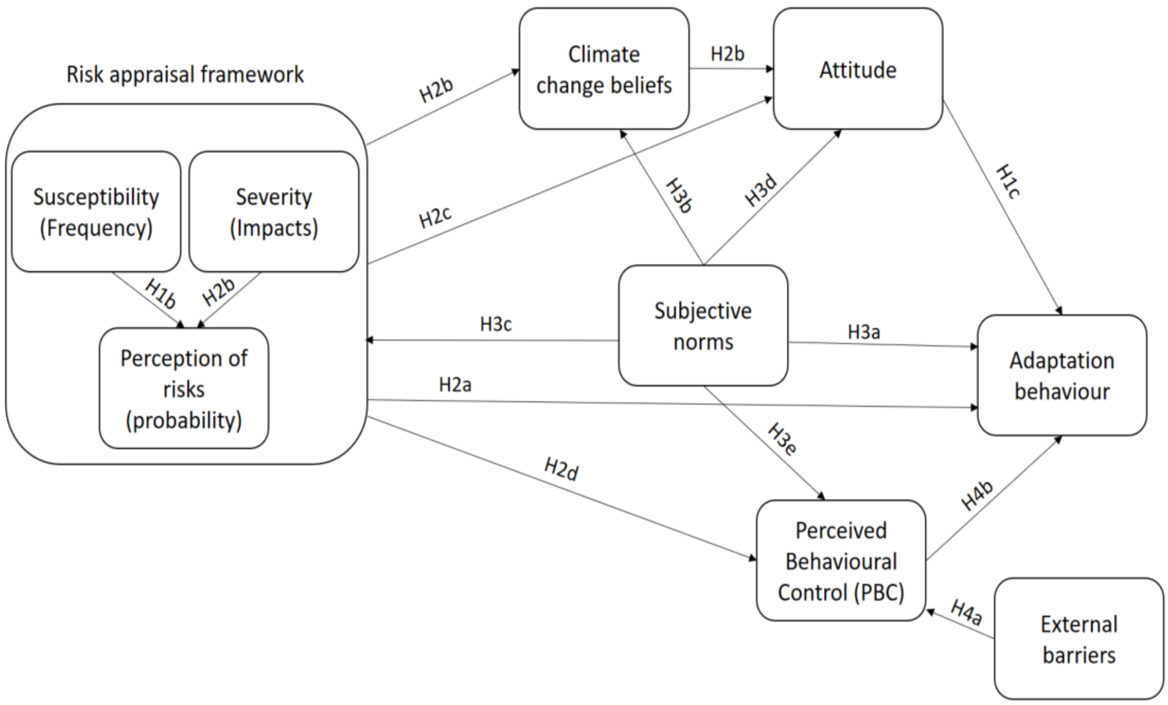

Figure A.1: Theoretical and hypothetical frameworks for the quantitative research (application of Theory of Planned Behaviour (Ajzen 2006, 2020) and PMT (Rogers 1975)).

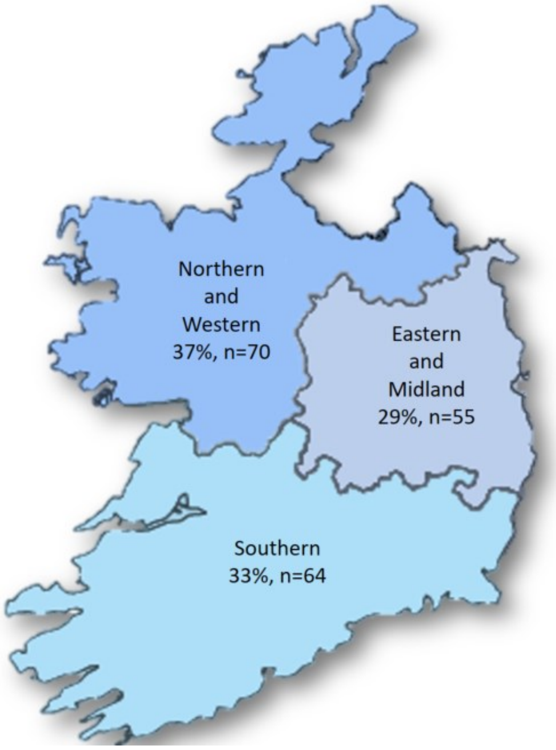

Figure A.2: Distribution of surveyed farmers across NUTS2 Regions (n = 189).

Figure A. 3: Online survey flyer.

Table A.2: Profile of farmers who responded to the survey (n=195).

Variable	Mean ± SD	n	%
A. Demographic and background			
A1. Age	55.21 ± 12.46	NA	NA
A2. Farm experience: How long are you the main holder (being involved in decision-making) of the farm (in years)?	29.28 ± 12.46	NA	NA
A3. Gender			
• Male	NA	174	89.2
• Female	NA	19	9.7
• Prefer not to say	NA	1	0.5
• Missing value(s)	NA	1	0.5
A4. Education			
• No formal education	NA	12	6.2
• Completed primary education	NA	34	17.4
• Completed secondary education	NA	88	45.1
• Third level	NA	61	31.3
A5. Agricultural training			
• No formal agricultural education/training	NA	43	22.1
• Certificate in Farming	NA	27	13.8
• Short Course (s) – less than 180 hours (c 6 weeks)	NA	36	18.5
• Diploma/ Farm Apprenticeship Scheme	NA	17	8.7
• Short Course (s) - more than 180 hours	NA	13	6.7
• Cert in Agriculture/ Agricultural College	NA	21	10.8
• Full time 3rd level agri course	NA	17	8.7
• Missing value(s)	NA	21	10.8
A6. Location			
• Northern and Western	NA	70	35.9
• Southern	NA	64	32.8
• Eastern and Midland	NA	55	28.2
• Missing value(s)	NA	6	3.1
B. Business and structural			
B1. Farm enterprise			
• Cattle/beef	NA	83	42.6
• Dairy	NA	43	22.1
• Sheep	NA	15	7.7
• Tillage	NA	16	8.2
• Mixed livestock	NA	38	19.5

Variable	Mean ± SD	n	%
B2. Do you have an off-farm employment?			
• Full-time	NA	47	24.1
• Part-time	NA	65	33.3
• No	NA	83	42.6
B3. Do you operate under a Nitrates Derogation?			
• Yes	NA	16	8.2
• No	NA	174	89.2
• Missing value(s)	NA	5	2.6
B4. Do you take part in the ACRES scheme?			
• Yes	NA	86	44.1
• No	NA	97	49.7
• Missing value(s)	NA	12	6.2
B5. Do Have you done any environmental training as part of a local programme or an advisory scheme?			
• Yes			
• No	NA	100	51.3
• Missing value(s)	NA	84	43.1
	NA	11	5.6
B6. Do you operate an organic farm?			
• Yes	NA	8	4.3
• No	NA	177	90.8
• Missing value(s)	NA	185	5.1
B7. Are you a Teagasc client?			
• Yes	NA	131	67.2
• No	NA	54	27.7
• Missing value(s)	NA	10	5.1
B8. Do you use a private farm advisory service?			
• Yes	NA	43	22.1
• No	NA	144	73.8
• Missing value(s)	NA	8	95.9
B9. Are you a member of Farm Discussion Group (FDG)?			
• Teagasc FDG	NA	64	32.8
• Private FDG	NA	39	20
• No	NA	81	41.5
• Missing value(s)	NA	5.6	5.6
B10. How would you best describe the soil type on your farm?			
• Heavy soil predominantly	NA	83	42.6

Variable	Mean ± SD	n	%
• Free-draining soil predominantly	NA	34	17.4
• A 50/50 mix between heavy and free-draining soil	NA	76	39
• Other (please specify)	NA	2	1

Table A.3: Profile of qualitative study participants.

Code	Region	Gender	*Age category	Farm enterprises and relevant characteristics
Farmers				
F1	West	Male	Middle	Suckler-to-finisher beef
F2	South-East	Male	Young	Dairy with Nitrates derogation
F3	South-West	Male	Young	Tillage/Poultry/Dairy heifer contract rearing
F4	West	Female	Middle	Beef/Sheep
F5	West	Male	Middle	Dairy without Nitrates derogation
F6	-	Male	Middle	Integrated pig-tillage
F7	-	Male	-	Sheep (milk)
F8	West	Male	Older	Includes suckler enterprise farmed on the Shannon Callows
F9	Border	Male	Middle	Sheep (lowland and hill)
Advisors				
A1	West	Male	-	-
A2	Border	Male	-	-
A3	West	Male	-	-
A4	South-West	Female	-	-
A5	Midland	Male	-	-
A6	Mid-East	Female	-	-
A7**	South-East	Male	-	-

Note: (-) not reported to protect participant confidentiality. *Young: <40; Middle: 40-65; Older: >65. **Supplementary interview.

Table A.4: Items measuring psychosocial factors in the survey.

Factors	Questions	Scale
Weather Change Beliefs (WBC)	**WBC1.** In general, I do not believe that the weather has changed noticeably in my region over the last 10 years. **WBC2.** I think that extreme weather-related events (such as floods, droughts or storms) are not Occurring more frequently than they did 10 years ago.	5-point Likert 1 (Completely disagree) to 5 (Completely agree)

Factors	Questions	Scale
	WBC3. I believe that there have been changes in the weather; that is, the four seasons are less typical than they used to be in 20-30 years ago (for instance, wetter / drier, colder / warmer).	
Climate change normalisation belief	**N1.** I think the recent occurrence of floods, droughts, and storms is normal and nothing new.	5-point Likert 1 (Completely disagree) to 5 (Completely agree)
Climate change advantages/opportunities belief	**A1.** I think that changes in the climate will bring opportunities for my farm in the future.	5-point Likert 1 (Completely disagree) to 5 (Completely agree)
Experience of weather events	**EXP1.** Which of the following weather event(s) have you (experienced in the past five years on your farm? Please tick all that applies.	Nominal/categorical Flood □ Drought □ Storm □ Non-typical seasons (for instance, wetter / drier, colder / warmer) □
Person and placed-based experience of climate change negative impacts	**PE1.** Over the last 5 years, how often have you heard and/or observed a neighbouring farm negatively impacted by extreme weather (flood, drought or storms)? **PE2.** Over the last 5 years, how often has your farm and activity on your farm been negatively impacted by extreme weather? **PE3.** Over the last 5 years, how often has your farm and activity in your farm been negatively impacted by changes in weather patterns (non-typical seasons)?	5-point Likert 1 (Completely disagree) to 5 (Completely agree)
Negative impacts of the climate change	Have changes in the weather negatively impacted the following, Over the past five years:	Binary (Yes/No)
	If yes, how likely is it that this will occur in the next five years?	5-point Likert 1 (Never) to 5 (Always)

Factors	Questions	Scale
	A. Environmental **A1.** Soil condition (soil temperature, moisture and compaction) **A2.** Grass or crop establishment and growth **B. Work Organisation & Management** **B1.** Unable to fertilise or spread slurry as planned **B2.** Needed to house animals for longer during the housing season (over the late autumn, winter, and early spring period) **B3.** Unable to harvest crops (including fodder) on time **B4.** Unable to plough or till when planned **B5.** Unable to sow crops on time **B6.** Fodder reserve **B7.** Needed to rehouse animals during other times of the year when they would normally be outside **B8.** Farm infrastructure (barns, farm sheds, tree falling, etc.) **C. Wellbeing and Quality of Life** **C1.** Work related stress or depression or anxiety due to the impacts of weather events on your farm **C2.** Compromised personal activities or hobbies due to the need to undertake more work in response to recent weather events	
Attitude	**ATT1.** I believe it is always my priority to take actions (above actions) to mitigate the risk and impact of weather changes on my farm. **ATT2.** It is not important for me to take actions (above actions) as they are costly.	5-point Likert 1 (Completely disagree) to 5 (Completely agree)

Factors	Questions	Scale
	ATT3. It is not important for me to actions (above actions) as they are time consuming. **ATT4.** I think it is not necessary to take actions (above actions) as who knows how the weather might be next year.	
Subjective norms	**SN1.** People who are important to me think that I should not implement these actions (above actions) as who knows how the weather will be next year. **SN2.** People who are important to me always implement actions (above actions) if they are not sure how the weather will be next year. **SN3.** People who are important to me think that I should not implement actions, as they are costly and/or time consuming. **SN4.** People who are important to me always implement actions (above actions) to manage the risk of changes in the weather.	5-point Likert 1 (Completely disagree) to 5 (Completely agree)
PBC	**PBC1.** It is not always possible to take actions, as they are costly. **PBC2.** It is difficult to take actions (above actions) as they are time consuming. **PBC3.** I feel confident that I can take actions (above actions) as I have the necessary skills or knowledge. **PBC4.** It is difficult to take actions (above actions) as changes in weather are out of my control.	5-point Likert 1 (Completely disagree) to 5 (Completely agree)

Appendix B: Additional tables and figures

Table B.1: Weather change beliefs reported by surveyed farmers (n = 195).

Variable name	Mean[1]	SD
Weather change Beliefs (WCB) (three items) (α = 0.84)	3.41	1.32
WCB1. In general, I do not believe that the weather has changed noticeably in my region over the last 10 years (reversed scale).	3.25	1.35
WCB2. I think that extreme weather-related events (such as floods, droughts or storms) are not occurring more frequently than they did 10 years ago (reversed scale).	3.76	1.24
WCB3. I believe that there have been changes in the weather; that is, the four seasons are less typical than they used to be 10 years ago (for instance, wetter / drier, colder / warmer).	3.24	1.37
Normalisation belief. I think the recent occurrence of floods, droughts, and storms is normal and nothing new.	3.15	1.32
Climate change opportunity belief. I think the recent occurrence of floods, droughts, and storms is normal and nothing new.	2.87	1.15

Note: 1. ranging from 1 (completely disagree) to 5 (completely agree); It is important to note that WCB1 and WCB2 report reversed scales, i.e. 5 (completely disagree) to 1 (completely agree).

Table B.2: Farmers' reported likelihood of negative weather-related environmental, farm operations and management, and psychological and well-being impacts in the next five years (n = 195).

Variable name	**Mean[1]**	**SD**
Likelihood (L) (twelve items) How likely is that following will occur in next five years?		
L1. Disruption to grass or crop establishment and growth	3.96	0.98
L2. Disruption to soil condition (soil temperature, moisture and compaction)	3.67	1.22
L3. Unable to fertilise or spread slurry as planned	4.04	1.06
L4. Needed to house animals for longer during the housing season (over the late autumn, winter, and early spring period)	3.77	1.24
L5. Unable to harvest crops (including fodder) on time	3.65	1.12
L6. Unable to plough or till when planned	3.45	1.30
L7. Unable to sow crops on time	3.44	1.26
L8. Disruption to fodder reserves	3.52	1.13
L9. Need to rehouse animals during other times of the year when they would normally be outside	3.47	1.27
L10. Impact on farm infrastructure (barns, farm sheds, tree falling, etc.)	3.11	1.28
L11. Work related stress or depression or anxiety due to the impacts of weather events on your farm	3.76	1.26
L12. Compromised personal activities or hobbies due to the need to undertake more work in response to recent weather events	3.63	1.25

1. Ranging from one (Very unlikely) to five (Very likely).

Table B.3: Farm-level adaptation measures implemented, or actively planned, by interviewed farmers.

Types of measure	Measures
Grassland and pasture management	• Shortening of the grazing season • Rehousing of livestock when necessary to limit poaching • Adjustments in grazing rotations • Adjustments in pasture stocking rates to match grass availability and quality • Grass measuring • Timely closing of grazing paddocks to prepare for spring grass • Improved soil organic matter and phosphorus contents on cropland through the application of organic fertiliser • Reseeding • Establishment of multi-species swards • Limited use of machinery when poor soil trafficability
Cropland management and cropping choices	• Adjustments in dates of tillage field operations (sowing, spraying, fertilising and harvesting) • Implementation of a crop rotation • Incorporation of legumes in the crop rotation • Crop diversification (including mix of winter and spring crops) • Use of adapted (weather resilient) crops • Sowing of cover crops • Limited use of machinery when poor soil trafficability
Livestock management	• Change in farm enterprise (transition to a dairy calf-to-beef system or move from beef cattle to contract heifer rearing) • Reduced farm stocking rate • Adjustments in lambing/calving dates • Earlier finishing of beef cattle • Sheep shearing before lambing for better lamb survival • Ad libitum concentrate feeding to finish lambs and counteract poor grass supply and quality
High nature value farmland	• Planting of hedgerows and trees • Modification of cutting patterns to let hedgerows grow taller and wider • Implementation of field margins
Capital infrastructure and equipment	• New or upgraded housing infrastructure • Building of slurry storage or sheds for poultry litter • Investment in an umbilical dragline slurry spreading system on cropland

Types of measure	Measures
	• Investment in machinery to reduce reliance on contractors • Automatic milking system and automatic gates (remotely controlled) to access grazing paddocks
Risk management	• Use of exceptional aid measures when fodder supplies are scarce • Cropping contracts between livestock and tillage farmers (from the perspective of livestock farmers) • Production or purchase of fodder to buffer feed and/or build fodder reserve • Lowering of the animal stock before winter • Preparation of business plans that include weather and price volatility to stress test system
Engineering solutions	• Ecosystem compatible drainage
Redesign of current farming systems	• Move to an indoor-outdoor livestock production system

Note: Set of selected adaptation practices reported in Figure B.1 for tillage farmers and Figure B.2 for livestock farmers.

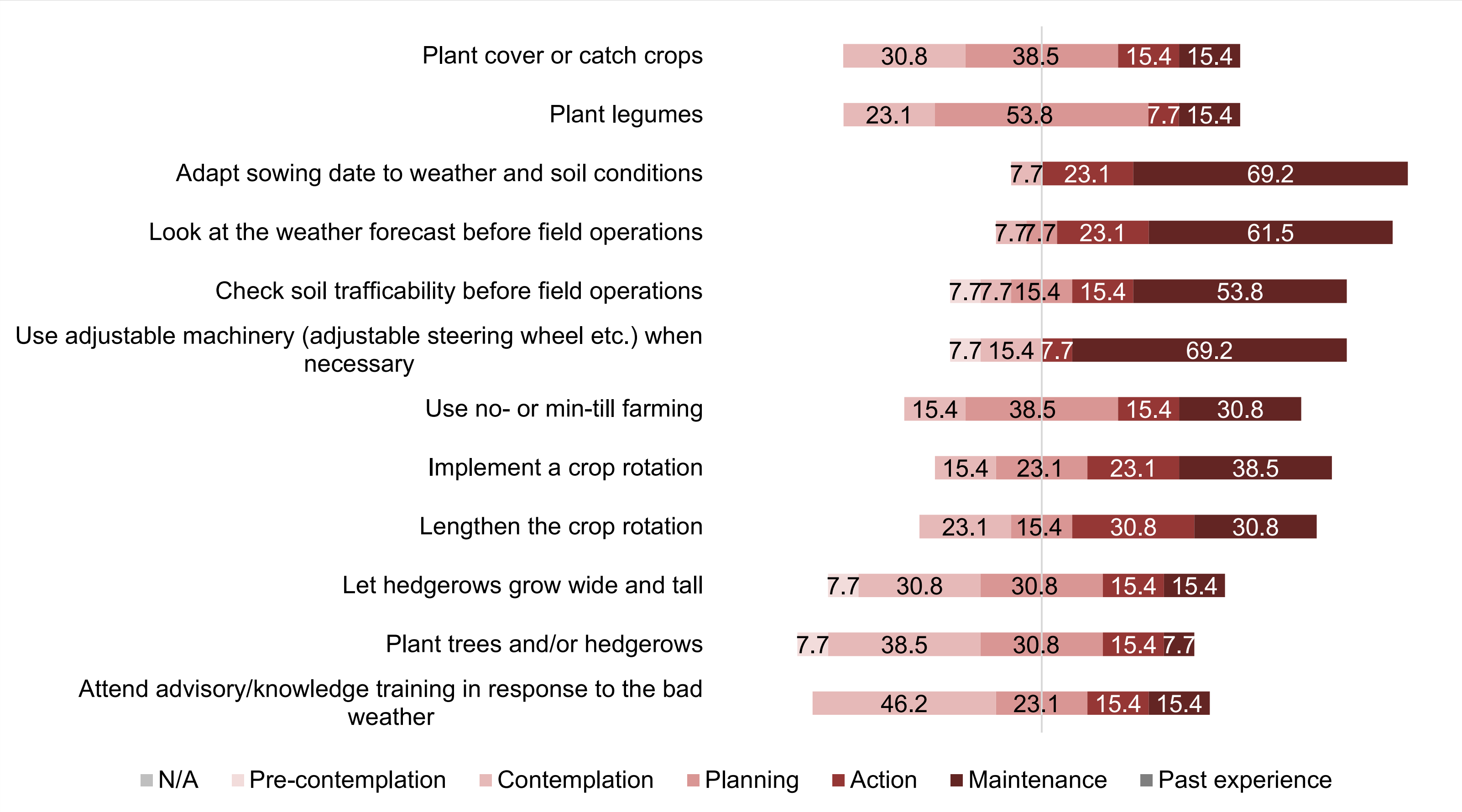

Figure B.1: Behavioural change over set of selected practices, surveyed tillage farmers, % (n = 14).

Note: N/A = not applicable; Pre-contemplation = Not at all/never; Contemplation = I am thinking about doing this; Planning = I am actively planning on doing this; Action = I have started doing this; Maintenance = I am doing this now and will keep doing this in the future; Past experience = I did this in the past, but I am no longer doing it.

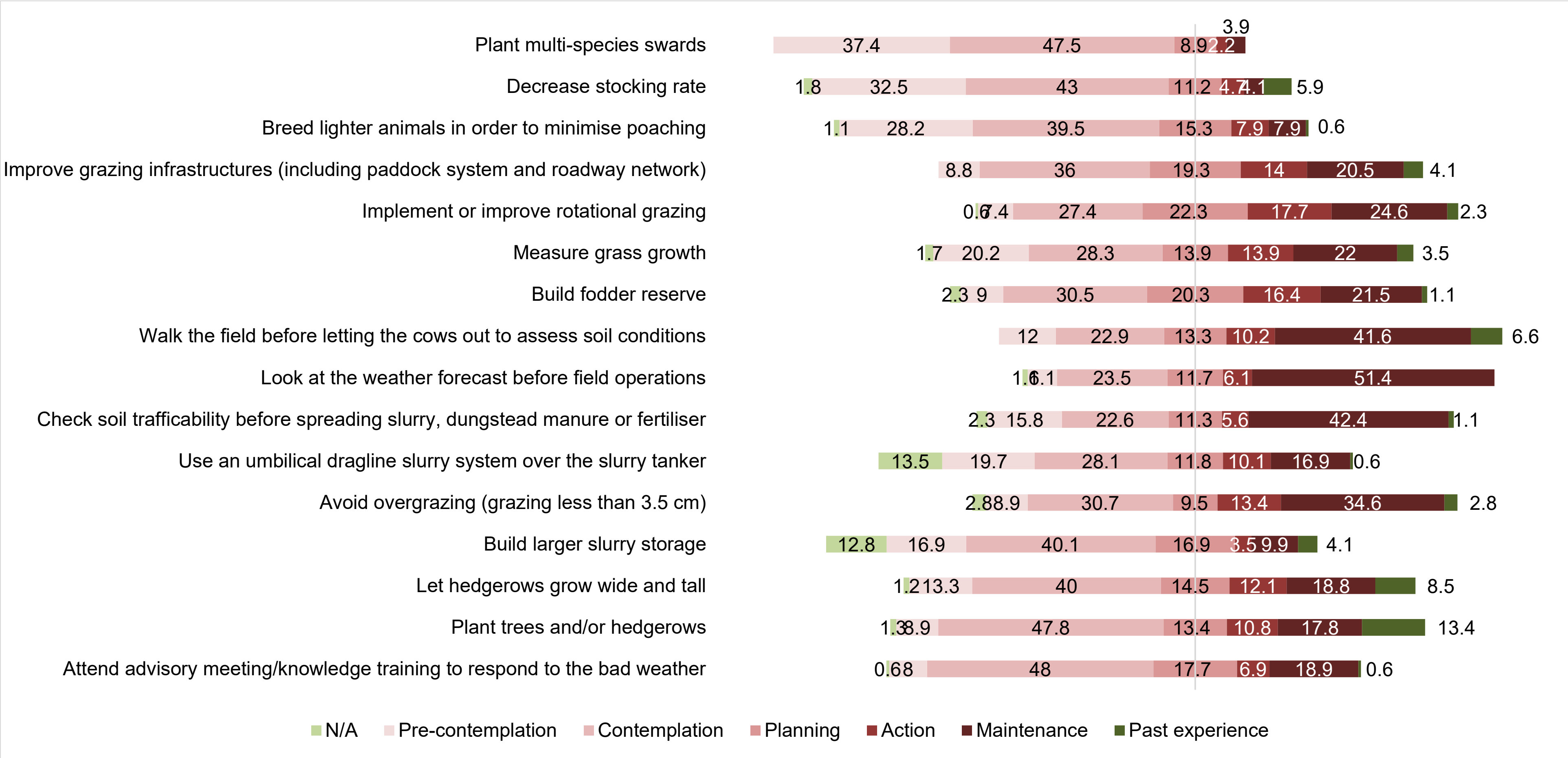

Figure B.2: Behavioural change over set of selected practices, surveyed livestock farmers, % (n = 174-179).

Note: N/A = not applicable; Pre-contemplation = Not at all/never; Contemplation = I am thinking about doing this; Planning = I am actively planning on doing this; Action = I have started doing this; Maintenance = I am doing this now and will keep doing this in the future; Past experience = I did this in the past, but I am no longer doing it.

Table B.4: Correlations between psychosocial factors and adaptation behaviour change (n=195).

	Person and place-based experience	Climate change impact	Climate change beliefs	Risk perception[1]	Attitude	Subjective norms	PBC	Adaptation behaviour change
Person and place-based experience	1	0.38**	0.36**	0.51**	0.14*	0.33**	0.17*	0.27**
Climate change impact		1	0.22**	0.74**	0.10	0.24**	-0.13*	0.21**
Climate change beliefs			1	0.28**	0.31**	0.35**	0.09	0.31**
Risk perception[1]				1	0.30**	0.25**	0.14*	0.28**
Attitude					1	0.37**	0.39**	0.35**
Subjective norms							.61**	.66**
PBC								0.53**

1. Perceived susceptibility to the negative impacts of the climate change.
** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
-1≤ r <-0.6 , -0.6≤ r <-0.3, -0.3≤ r <0.0, 0.0≤ r <0.3, 0.3≤ r <0.6, 0.6 ≤ r ≤ 1

Note: Set of selected adaptation practices reported in Figure B.1 for tillage farmers and **Error! Reference source not found.** for l ivestock farmers.

Figure B. 3: Attitudes of surveyed farmers towards selected adaptation practices, % (n = 195).

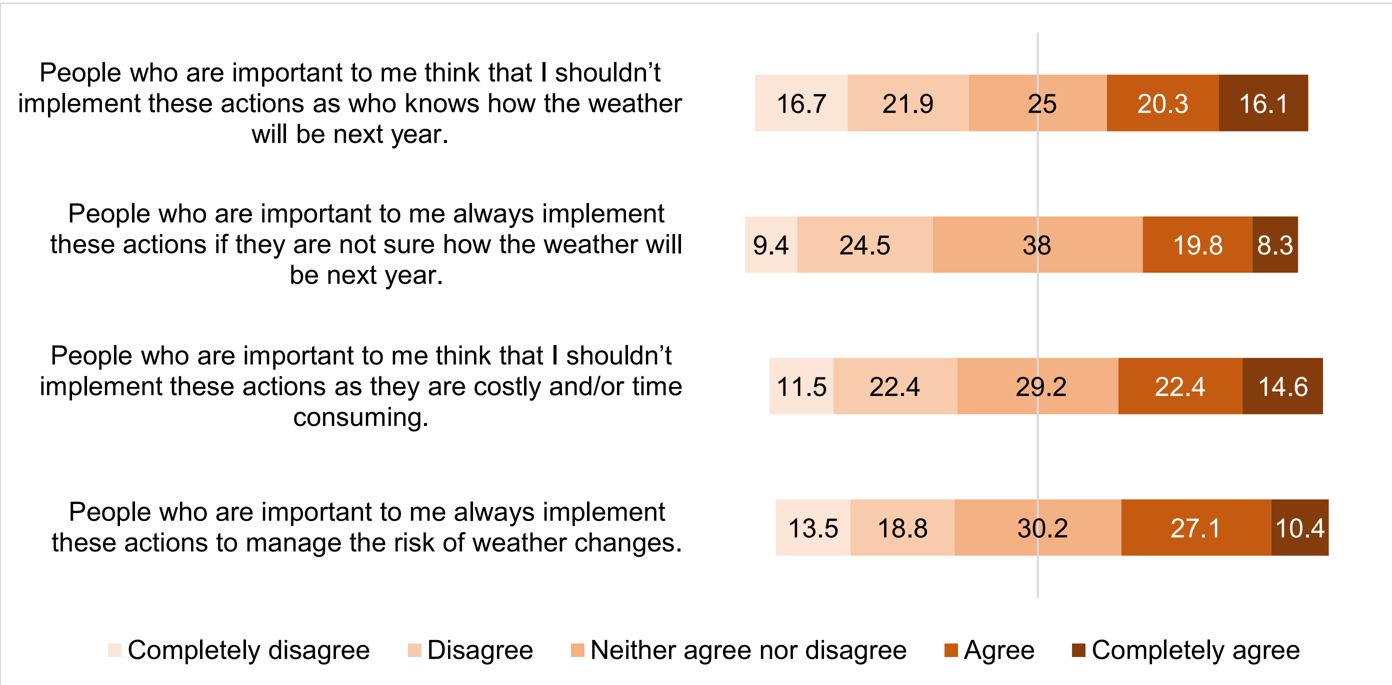

Figure B. 4: Subjective norms of surveyed farmers towards selected adaptation practices, % (n = 192).

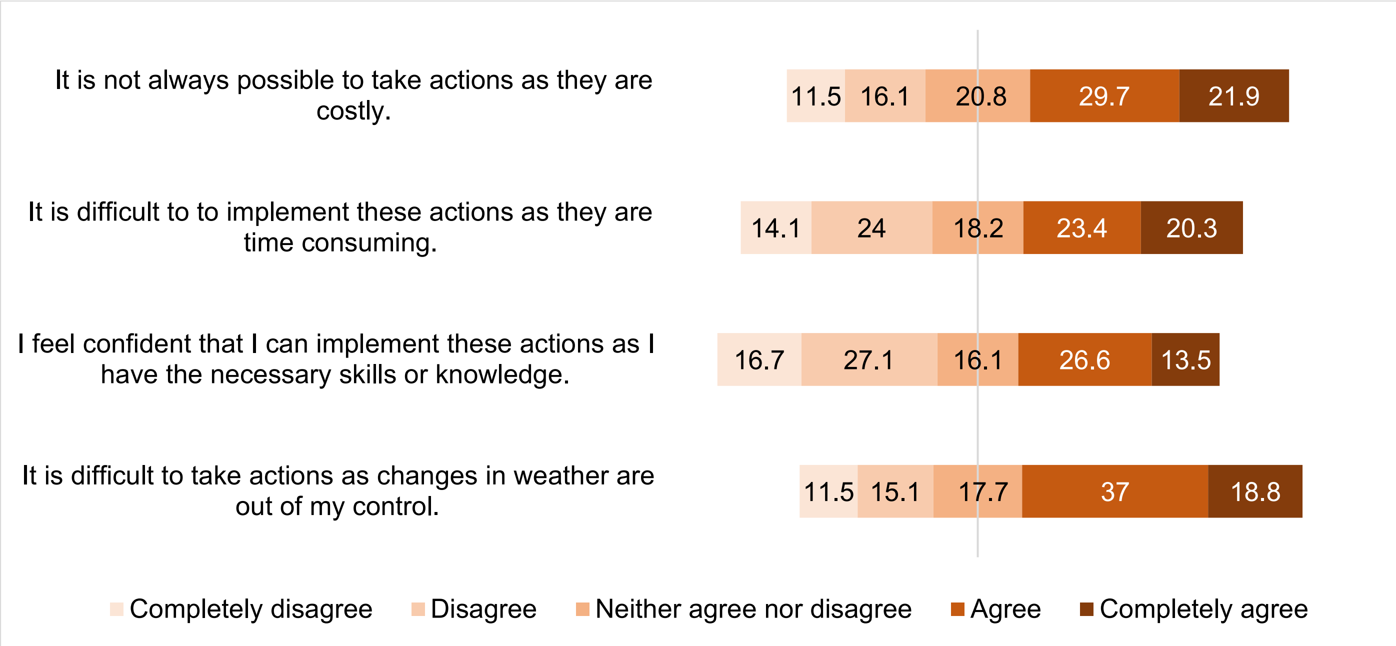

Figure B. 5: Perceived behavioural control of surveyed farmers towards selected adaptation practices, % (n = 192).

Note: Set of selected adaptation practices reported in Figure B.1 for tillage farmers and Figure B.2 for livestock farmers.

Table B.5: Mapping of factors influencing farm-level behavioural change towards climate adaptation using the farmer interview data.

Categories of factors	Behavioural change factors (direction of the effect(s))
Environmental and structural	• Experience and intensification of weather events (+) • Soil type (+, -) • Farm location (+, -) • Poor weather and ground conditions (-) • Farm infrastructure (+)
Economic	• Farm economic viability (+) • Farm scale (+) • Path dependency due to dairy expansion (-) • Difficulties in securing bank loans (-)
Social and farm organisation	• Time and labour constraints (-) • Difficulties in recruiting and retaining staff (-) • Farmer discussion groups (+) • Influence of a lead farmer (+) • Peer pressure (-) • Lack of collective action (-) • Reliance on contractors (-) • Access to one-to-one farm advice (+) • Access to media content (+)
Psychosocial	• Farmer mind-set (e.g., openness to change, future-orientation, environmental conscientiousness) (+) • Pride (-) • Hope (-) • Lack of optimism (-) • Frustration (-) • "*Good farmer*" identity (-) • Perceived benefits (+) • Perceived disadvantages (-) • Loss of confidence (-) • Farm succession (+) • Legacy (+) • Uncertainty (-)
Education and experience	• Farmer education (+, -) • Farmer age (-) • Farmer experience abroad (+)
Policy	• Compliance with regulation (+, -) • Speculation around policy changes (+) • Access to grants (+)