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A farmer-centric analysis of an agri-food transition in the face of potential disruption from cultured meat

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The emergence of cultured meat has been presented as a potentially transformative innovation capable of reducing the environmental impacts of food production and reshaping global protein systems. However, little empirical research has examined how farmers—key actors within agri-food transitions—might respond to this potential disruption. This study explores how UK farmers approach an agri-food transition in the face of disruption from cultured meat and considers the implications for a just agri-food transition. Using a qualitative case-study approach, representatives from nine diverse farms across the four devolved nations of the United Kingdom participated in semi-structured interviews about their farm businesses and how they might respond if cultured meat were on the market. Reflexive thematic analysis identified three overarching themes: (1) connectedness, (2) farmers' positionality within the food system, and (3) the practical knock-on effects of disruption. Although farmers in the study perceived cultured meat as a distant but potentially significant threat, they were optimistically resilient, a perspective borne of the connected nature of the farming community. However, their concerns about knock-on effects extended beyond livestock production to include impacts on rural employment, landscape stewardship, regenerative agriculture and the viability of interconnected agricultural sectors. Participants described being disempowered within existing supply chains, but some expressed a willingness to engage in potential opportunities through supplying inputs, energy, waste-derived products or materials. We argue that achieving a just transition requires meaningfully including farmers in the sustainable development and governance of cultured meat. Therefore, addressing farmers' positionality in the food system is vital if the cultured meat sector is to establish a sustainable relationship with primary production, despite some advocates aiming to replace animal agriculture, and with it many farmers and their livelihoods. The study contributes novel empirical evidence to debates on cultured meat and agri-food transitions.

KEYWORDS
agri-food, cellular agriculture, cultured meat, farmers, just transition, livelihoods, rural community, sustainability

1 Introduction

Transitions within agri-food systems are widely recognised to be complex, hard to stimulate and multifactorial to control (Conti et al., 2021), with wide-ranging consequences (Morais-da-Silva et al., 2022), but wholly necessary to reduce the negative environmental and social impacts of what we eat and how it is produced (Klerkx and Rose, 2020; Morais-da-Silva et al., 2022; Guthman et al., 2022). Extensive research on defining and classifying transitions emerged from the sustainability literature (see Stark et al., 2023 for a systematic review). The literature on agri-food transitions makes clear that change is needed at all levels of human activity, aligning with the aims of the United Nations Sustainable Development Goals and United Kingdom (UK) Government targets to reduce and mitigate the negative impacts of agriculture (Climate Change Committee (CCC), 2026). It is often innovation at the production level (i.e., farm level) that is posited as the critical driver of change, for example, advances in the mechanisation and automation of agriculture (Satyasai and Balanarayana, 2018); breeding more efficient animals (Brito et al., 2021; Menchaca, 2021); improving crop yields and controlling pests and diseases through sustainable intensification (Jain et al., 2020; Silva et al., 2021); and more recently regenerative agriculture, all of which have both intended and unintended consequences (Richardson et al., 2023). In recent years, several advances in food technology, such as cellular agriculture, have been proposed as a panacea for agri-food system transformation. We use the term 'agri-food transition', which can include transformation as a potential pathway in a transition (Hölscher et al., 2018).

Cultured meat (sometimes referred to as cultivated or lab-grown meat) is a form of cellular agriculture. Cultured meat production has developed from stem cell technology used in the medical sector. The emergence of cultured meat began in 1999 when the first patent was registered, the first proof of concept was produced in 2000, and then development proceeded in earnest in 2013 with the creation of the first cultured meat burger by researchers at Maastricht University, who subsequently co-founded Mosa Meat (Stephens et al., 2018). It works by growing animal cells, usually taken from live animal tissue but increasingly from immortal cell lines, in bioreactors using a growth medium consisting of glucose, amino acids, foetal bovine serum, growth factors and other critical ingredients for cellular growth and expansion (Gottipamula et al., 2013; Handral et al., 2022). The cultured cells are then processed into products using innovations such as cell scaffolds and 3D printing to produce a wide range of meat analogues and other novel products (Jones et al., 2021; Ianovici et al., 2022; Koranne et al., 2022). The development and acceleration of this industry has been pronounced, with $3.4 billion of investment since 2016 and growth from one company to 142 in the space of 12 years (Good Food Institute, 2026).

There has been substantial attention to cultured meat in the media (Painter et al., 2020; Specht et al., 2020; Chriki et al., 2020; Treich, 2021; Goodman et al., 2024). The current promissory narrative surrounding cultured meat paints this relatively new food technology as transformative for the food system, with a reduced environmental footprint compared with conventional agricultural production (Tuomisto et al., 2011; Mylan et al., 2023), capable of meeting a growing global demand for protein in an ethical manner that reduces human reliance on animals for food (Broad and Chiles, 2022). Cultured meat proponents claim that it uses less land, which could be restored to nature as it replaces animal agriculture. Intensive animal agriculture may cease to exist (Treich, 2021; Burton, 2019) and, as a result, the sector claims it will reduce the risk of public health threats, such as antimicrobial resistance and food-borne disease (Chriki and Hocquette, 2020). However, some public health aspects of cultured meat production still need to be appropriately addressed (Manning, 2024). Some scholars argue that cultured meat may reconfigure human relationship with animals by enabling more localised, caring food chains and reconnecting consumers to farmed animal species (Helliwell and Burton, 2021).

Yet, there are many uncertainties as to how and to what extent certain aspects of complex agri-food systems will be impacted (Helliwell and Burton, 2021; Sexton and Goodman, 2022). More specifically, there are many unanswered questions about what happens when a whole industry is removed (Moritz et al., 2024)? What happens to the farmers and growers and the myriad services, co-products and supply chains built around farming? There is also growing interest in developing different routes and policies for sustainable transitions and to consider cultured meat as one innovation alongside other alternatives (Bulah et al., 2024). These are important questions to consider in a just transition (Moritz et al., 2024), inviting us to consider the distributional effects of cultured meats, as well as how society is included in setting trajectories, drawing on principles of procedural and recognitional justice (De Boon et al., 2023).

The need to address these questions is also supported by de Boon et al.'s (2022a) conceptual framework on the governance of innovation processes in agriculture. In recent literature examining innovation processes and transitions, de Boon et al. (2022b) identified the need for and importance of both normative and sociological framings of legitimacy within a transition, especially regarding the English agricultural transition post-Brexit and the policies designed to shift farming practices towards greater sustainability, identifying three key factors to achieve this: clarity around processes and outputs, diversity of problem framing and solutions, and meaningful inclusion of actors and stakeholders. When applied to the innovation process of cultured meat, many of these factors appear to be missing. There has been little meaningful inclusion of the farming sector in cultured meat innovation to date, and the diversity of problem framing and solutions has been largely one-sided, i.e., an end to animal agriculture, although this varies among different companies across the world.

When the transition that cultured meat proponents advocate is interrogated against Boon et al.'s framework, there are some notable points of divergence. The macro-context within the various actors, the actual innovation process, and the governance process all sit is hugely variable across the globe. Some countries are focused on the need for food security (e.g., Singapore) whilst others have acted in a protective manner to preserve their traditional and culturally embedded farming sectors (i.e., Italy) (Lanzoni et al., 2024). There are limited and variable governance processes for cultured meat itself, with some companies being relatively open and working with regulatory bodies (e.g., in the UK, the Food Standards Agency has published guidance to help businesses bring cell-cultivated products safely to market; Food Standards Agency (FSA), 2026), while others work behind commercial secrecy. In the framework of de Boon et al. (2022a), the immediate context around the various actors shapes the actors' own capacities and psychosocial characteristics. Key contextual factors that have influenced the trajectory of the cultured meat sector to date include links to animal rights activism, concerns about environmental sustainability and the type of investment—i.e., technocentric venture capital—that built the sector in its formative years (Sexton, 2020; Treich, 2021). Interestingly, these two immediate contexts are sometimes juxtaposed,

as discussed by Helliwell and Burton (2021, p. 183) whereby a "technocentric and reductive utilitarian perspective" is combined with concerns regarding animal welfare and the human-animal bond. This immediate context gives rise to very different drivers for transition. Furthermore, there is a direct relationship between the actors' capacities to innovate and adapt, and their learning from the innovation process itself. Currently, there is very little collaboration between those who may need to adapt (i.e., farmers) and those driving and learning from the innovation (i.e., the cultured meat sector), thus providing the backdrop and rationale for this study.

The potential impact of cultured meat on the agricultural sector has until recently been based largely on theory, speculation, and historical analogues. Studies by Morais-da-Silva et al. (2022) and Proi et al. (2025) surveyed stakeholders within and outside agriculture and found widespread distrust of the cultured meat sector, with concerns raised about long-term health effects, job losses and negative impacts on rural communities. However, the opposite has also been documented, with citizens describing possible benefits for jobs and the economy (Morais-da-Silva et al., 2022) and studies also reporting consumers' willingness to pay more for cultured meat products than for traditional meat (Kantor and Kantor, 2021). Joshi et al. (2026) conducted a qualitative investigation with beef producers and related stakeholders in the US and France to develop inclusive and sustainable cultivated beef production models, which appears to be a first attempt at involving farmers in the development and governance of cultured meat. To date, few studies have explored in depth what UK farmers think and feel about cultured meat, and even fewer still discussed the potential impacts it could have on their livelihoods and what this indicates about a just transition. Farmers have concerns about the role of cultured meat in the food system and the impacts this could have on rural livelihoods (Manning et al., 2023), which mirrors many of the wider citizen concerns about health, the concentration of power, and the impact on rural communities.

In this article, we present empirical findings from the 'Cultured Meat and Farmers' project funded by the UKRI Transforming UK Food Systems strategic fund, in which we aimed to understand the threats and opportunities posed by cultured meat for UK farmers and their businesses. We formulated two fundamental research questions to address the current knowledge gap. (1) How do farmers perceive and approach an agri-food transition in the face of disruption from cultured meat? (2) What do farmers' perspectives reveal about the conditions under which a disruptive transition could become more economically, socially and environmentally just? By addressing this knowledge gap, we intend to generate empirical insights with implications for how the cultured meat sector develops and critically interacts with the UK farming sector. Furthermore, this study provides valuable empirical data that support the application of sustainable transition frameworks within broader food systems research.

2 Materials and methods

The findings presented in this paper form part of a wider UK research project (2022–2024) on the perceived impacts of cultured meat on UK farmers (MacMillan et al., 2024).

The research followed a pragmatic qualitative case-study approach and is reported here in accordance with the COREQ qualitative research checklist and Big Q Qualitative Research Guidelines (Braun and Clarke, 2025). The study was situated in the concepts of participation borne of early work by Chambers (1994), Kumar et al. (2024), and Neef and Neubert (2011), informed by the theoretical framework of responsible innovation (Rose et al., 2021), specifically anticipation and inclusivity, and more recently Just Transitions (de Boon et al., 2022a, 2024), which served as the primary analytical framework. Just Transitions was used to guide the recruitment of farmers, interview design, data analysis and interpretation. Transition is understood here to mean a non-linear and complex process of change, with the analysis focusing on the "processes and dynamics producing patterns of change to explain 'how' the non-linear shift from one state to another is supported or hindered" (Hölscher et al., 2018). The 'Just' dimension is borne of the early literature on workers' rights in a transition towards a low-carbon, climate-resilient future (Stark et al., 2023), and here captures the 'rights' and lives of farmers who work the land.

We therefore engaged with 13 farmers from nine diverse case study farms across the UK to explore in depth the perceived threats and opportunities posed by cultured meat for farmers, and the perceived realities of these impacts on UK farming businesses. Table 1 describes the types of farmers involved and their relationship to their farm business (i.e., owner or tenant) and one another in the case of farming families being interviewed. The lead author (LCM) followed a constructivist–relativist epistemology, which was not only aligned with the principles of participation, but sought to understand the realities and expressed meanings of an agri-food transition for UK farmers from their perspectives and lived experiences. This study followed on from the initial work of Manning et al. (2023), where seven exploratory focus groups were conducted with UK farmers between October 2022 and April 2023 to capture their attitudes, understandings and framings of cultured meat and its potential impact on UK farming.

2.1 Sampling

The nine case study farms were chosen purposively for this study to reflect specific but distinct agricultural sectors and systems that could be impacted by cultured meat (see Table 1). They were recruited through existing researcher networks and chains of referral (Penrod et al., 2003), such as the networks of the authors and project partners. In addition, an open advertisement was disseminated via social media, inviting farmers to register their interest in participating. It was advertised that farmers would be reimbursed for their time. All farmers were contacted by telephone to discuss the project, what it entailed, and the requirements for participation, and were then emailed the project information pack and consent form. Once all participants had agreed verbally and via email to participate, they all remained in the project until its completion. Payment for their participation was disbursed at the end of the study. The approach was similar to that of Manning and Kowalska (2021), i.e., 'casing' rather than utilising case studies.

Purposive sampling ensured that variable levels of knowledge of cultured meat were represented among the participating farmers. Some participants were well-known to the lead researchers (case farms 1, 8, 9), whereas others were unfamiliar to them (case farms 2, 3, 4, 5, 6, 7); this had methodological implications for the study. Those who were familiar with the researchers may have felt more comfortable sharing their experiences and discussing their business plans than those who were less familiar. Two case study farms (case farms 1 and 5) also took part in the focus group work described by Manning et al.

TABLE 1 Number, type and characteristics of the case farms and semi-structured interviews.

Interview sequence	Case farm	Number of interviewees (type) *	Sector	Farm system details	Approx. location
1st	1	2 (Farm owners–husband and wife)	Dairy	Family farm, block calving, extensive grazing dairy production with beef sales	Wales
2nd	2	1 (Farm owner)	Arable and beef	Family farm, circular and regenerative, beef reared on contract	England
3rd	9^	1 (Farm manager)	Organic beef and sheep, Vegetables	Tenant farm, Organic and Pasture for Life certified, native breed livestock, market garden, diversified business	England
4th	6^	2 (Supply chain manager and farm manager)	Poultry	Integrated broiler production	Northern Ireland/UK
5th	4	1 (Farm owner)	Soft fruit	Family farm, large-scale polytunnel production, on-site energy generation and farm shop	Scotland
6th	3	1 (Farm owner)	Arable and pigs	First generation, circular arable enterprise supports intensive indoor pig production (farrowing -weaning - finishing)	Scotland
7th	7	2 (Farm owners: partners)	Beef and sheep	First generation, extensive beef and sheep, regenerative	Scotland
8th	8	2 (Farm owners: ather and son)	Arable (cereals)	Family farm, conventional cereal crops, ~60% feed for livestock	England
9th	5^	1 (Farm owner)	Beef and sheep	Family farm, extensive grazing, historically sheep moving to cattle	Northern Ireland

^ = Online interview; *excluding the researchers.

(2023), which may have influenced the farmers' relative knowledge of cultured meat and how their business might respond to it in the future. Nevertheless, the selection of case farms aimed to be illustrative of a wide range of farming sectors and systems from across UK geographies (Piekkari et al., 2009), as well as including farming sectors that could be substantially impacted by cultured meat (e.g., livestock farming). This sampling strategy was designed to facilitate meaningful inclusion as discussed by Rose et al. (2021); however, this resulted in a small, skewed sample of farms that were interested in either the topic and/or general research participation. Although this sample size limits were considered during the analysis process, and whilst a limitation of the study compared to a more representative and generalisable quantitative survey approach, it did allow for the collation of richer data (Schultze and Avital, 2011) and the generation of rich accounts of people's social realities, which more appropriately answered the research questions and were a strength of this approach, with its focus in particular on the nuances of just transition. Ethical approval was secured from the Royal Agricultural University in Sept 2022; the approval number is 20220626-Dooley.

2.2 Data collection

There were two visits to each case farm between October 2023 and April 2024: visit one was an introductory meeting during which a farm business survey was completed and notes were made regarding the structure and operation of the case farms, including cataloguing farm infrastructural assets (photographically). These first visits then informed the second visit, where in-depth semi-structured interviews were conducted with the 13 farmers (see Table 1). The initial survey also informed the development of the topic guide and interview-specific prompts based on the analysis of the data provided by participants (e.g., We noticed your succession plan has changed recently;

what are your thoughts about the farm's future? We noticed your farm is heavily reliant on subsidies and you are currently in significant debt, how does that affect how you perceive your future business trajectory?, and Your main market is beef cattle and sheep and you sell direct to abattoir, how would to you feel your business would fare in 10 years' time if cultured meat was on the market?). These questions were not designed to direct the interviewees, but rather to build a bridge between the first round of data collection and the second. The interviewees were able to reflect on these questions and then describe the futures they felt were most likely.

The qualitative data collection involved semi-structured interviews using a topic guide designed in accordance with (Krauss et al., 2009). The interview protocol was structured into four sections:

1 A brief discussion of current farm performance and farmers' livelihoods, based on the results of the initial farm survey;
2 Questions concerning the future of the farm's assets, income and markets, production, people, wastes/circularity, and impacts on climate and biodiversity in 10 years' time if:
   i business as usual,
   ii cultured meat was on the market, and
   iii The farmers did something completely different.
3 An assessment of the farm business in 10 years' time using a RAG (red–amber–green) status matrix (see MacMillan et al., 2024);
4 Perspectives on the future of their livelihoods and sector under four divergent socio-political scenarios. These ranged from unregulated free trade scenarios with extensive environmental degradation, unstable geopolitical contexts with decentralised and localised food production systems, extensive dependency on imports from trade agreements disadvantaging domestic production and more space for nature, to worsening public health outcomes with high costs of production on some food items pushing up prices (see MacMillan et al., 2024 for further details).

A pilot interview was conducted in October 2023, and minor edits were made to the farm business survey and topic guide to make them more accessible to agricultural participants. LCM and JD organised and conducted all 9 case farm interviews between January 2024 and April 2024, either on the farm (n = 6) or online using Microsoft Teams (n = 3). The average duration of the interviews was 2 h (see Table 1 for the number and typology of interviewees). All interviews were audio-recorded on a password-protected mobile phone, or via Microsoft Teams if conducted online. They were transcribed using automated transcription software. The lead author then reviewed all transcripts, anonymised them and familiarised herself with the data. The focus of the analysis was the qualitative data generated from the 13 case farmers' responses to the interview questions. Each of the 13 interviewed farmers was given the opportunity to review the transcripts from their interview, although none requested this.

2.3 Analysis

There were approximately 18 h of transcribed interview data, which was analysed by the lead author in accordance with the principles of reflexive thematic analysis (Braun and Clarke, 2021) between March and July 2024 using NVIVO v12. This analytic process overlapped with ongoing data collection as part of an iterative approach (Morgan and Nica, 2020), whereby the results from the exploratory focus groups (Manning et al., 2023), the initial findings from the preliminary farm survey, and the first set of interviews fed into subsequent interviews. This enabled the researchers to sense-check and further deepen the analysis with the participating farmers. Equally, findings of the wider project, such as the work on cultured meat ingredient analysis, also fed into topic-guide refinement (e.g., discussing the supply of inputs such as amino acids/source cells with the farmers). This iterative approach satisfies the 'Four Rs' of qualitative research of rigour, resonance, reflexivity, and relevance (Finlay, 2021).

A deductive and inductive approach to analysing the interview transcripts was taken following Braun and Clarke (2021) and Finlay (2021), whereby a pre-determined set of codes was created (i.e., deductive) based on the research questions (i.e., general risks and opportunities in agricultural transitions split by economic, environmental and social, types of and approach to transitions, threats and opportunities from cultured meat, etc.) and then further codes were created (i.e., inductive) as the transcripts were read and coded descriptively (e.g., within the economic risks in agricultural transitions—market access, loss of subsidy, contracts…; connectedness of relationships – between family, with supply chain, with livestock). Double coding of two transcripts was conducted between April and May 2024 to ensure the descriptive coding was consistent across different researchers in terms of code attribution and code generation (quality control) and that the codes generated were aligned with the interview content. This process was valuable because, during the double coding of transcripts, different iterative codes were created by each researcher and, as a result, through discussion, a common codebook could be generated that included all themes. Evidence saturation, as described by Braun and Clarke (2025), was met by interview 7, where minimal new codes were created, and no further minor themes were generated.

Thematic development following Braun and Clarke (2021) was then performed on the coded data with reflexive notes made by the lead author in NVIVO and on paper in relation to the research questions, similarities and differences within and between codes, and points of convergence with the wider literature. This process generated candidate themes, which were then reviewed, grouped, and analysed iteratively in July 2024 to produce the overarching themes from the data. The lead author also shared the candidate and overarching themes with the participating farmers and the co-authors, and discussed them in depth with two of the farmers to verify that the interpretations resonated with their understanding of the discussions. This member-reflection process ensured the resonance of the findings and adhered to the principles of responsible innovation (Finlay, 2021; Rose et al., 2021).

3 Results

This study aimed to investigate UK farmers' perspectives and approach to an agri-food transition in the face of potential disruption from cultured meat, and to whom and to what extent it poses a threat or an opportunity. Candidate themes were generated from the reflexive thematic analysis of the nine interviews conducted with 13 farmers, which were then synthesised into three overarching themes to

address the research questions, which were (1) connectedness and the role of relationships, (2) farmers' positionality within the food system, and (3) practicality of knock-on effects.

3.1 Connectedness and role of relationships

Relationships featured heavily in the interviewed farmers' understanding of the impacts of cultured meat on UK agriculture. These relationships revealed how connected the farmers felt with their farm, within their communities and with certain elements of the supply chain, but also how disconnected they perceived themselves to be from other actors in society. The connectedness between people, organisations and more-than-human elements such as the land was a key factor when approaching and dealing with an agri-food transition for the case study farmers. Connectedness here reflects the extent to which a person perceives that they have a "significant, shared, and meaningful personal relationship with another person, a spiritual being, nature or an aspect of one's inner self" (Haase et al., 1992, p.146). Relationships here also refer *to* "significant, shared and meaningful" relationships with organisations, which could be commercial, traditional, or community-based and were discussed frequently across all interviews and exemplified in many directions. The connected nature of some relationships (e.g., within families and rural communities) compared with the disconnected nature of others (e.g., with the public and urban communities) was stark. The perceived lack of control farmers felt within some relationships (e.g., in relation to large food companies and shareholders) compared to others (e.g., proximity to certain markets through direct sales of product or with their livestock and the land) has implications for agri-food transitions. If the cultured meat sector is aiming for a 'just transition', or rather a transformation (Moritz et al., 2024) in which the concept of food justice is followed (to include historical, representational and distributional forms of justice (Whitfield et al., 2021) as an example), proponents could learn from these findings to avoid reproducing existing hierarchies and power imbalances that limit connectedness and currently characterise the food system (Guthman et al., 2022).

The case farmers' relationships with the supply chain, and with their advisers or intermediaries, and wider networks, emerged as a prominent theme that has implications for an agri-food transition and any future engagement with the cultured meat sector. These relationships were often framed around contractual agreements, which were described in the context of losing contracts at short notice (case farm 1 and 4), having to meet demands that were perceived to be unreasonable, such as sharing detailed business data with no added return (case farm 1) or being left with no contract in which to negotiate with, in the case of soft fruit retail (case farm 4).

> *I know that was one of the reasons we have left MILK PROCESSOR. [They] issued that statement saying that by 2030, we have to be 15 thousand Litres average per cow for it to be sustainable. And if we do not get to it, they'll send an advisor, so we. So that was one of the reasons we left them.* […]. *You're not controlling your own farm then, are you? I know… our contract with them is our milk, is not it? It's the product, is not it? It's not. Should have nothing to do [with how we manage the farm]. They're taking what's in the tank. What happens on here, they really should not have a say, should they? It's not theirs, is it? They're [not] paying the mortgage, are they?* Case farm 1 (husband and wife).

These more formalised and commercial relationships revealed issues around the agency of farmers; they revealed limited negotiating power with the organisations they were in commercial relationships with (i.e., if they disagreed, they had to exit the contract), and this has an impact on the business decisions of the farm. Relationships with the cultured meat sector may replicate the same issue, but they could also acknowledge this imbalance of power and forge new models. Nevertheless, similar issues could also be seen with informal family relationships where, due to the limited income to support family labour on the farm and the uncertainty of whether family members would stay, future business planning was challenging.

> *I am hoping that the next gen[eration], one of the next generation will be farming and I will be helping. It's getting an income out of it is the problem for… [] each generation comes along…the next generation comes along, you've then got two… two houses to keep. You really need 2 incomes and… and farms need to get bigger to sustain those two incomes.* Case farm 5

Both dynamics have implications for farms undergoing an agri-food transition. The ongoing challenge of securing and retaining labour is often intertwined with family relationships, which makes planning for future disruptions difficult. Accessing markets is often realised through contractual working relationships with supply chain actors. These are examples of typologies of connectedness, one with a workforce and one with a market respectively, which influences decision-making on the interviewed farms. Indeed, case farm 3 explained how their close connection with their buyer is beneficial for their future business trajectory, albeit forming an uneasy relationship borne out of necessity rather than choice.

> *We're sitting having a chat like this with the Managing Director of that big company a month ago. So we're quite lucky and they've… [OK]… It's tripled the size of that factory.…[]. They're opening it in a month's time and… [] we, myself and [Wife], we're slightly different to some of the other farms, but we've been invited to the opening…[yeah]… Ceremony, which is quite nice. Yeah, so that's quite nice that. We don't have full trust in them and we're aware that there's not many other options, but we've got a dialogue with them. There's not many other people that can say that.* Case farm 3

There was evidence of dependency between farms and other commercial entities in the supply chain, which was a characteristic of the connected nature of the sector and will have implications for how the cultured meat sector may want to work with farmers. Do the two sectors want to be dependent on one another for supply and demand of co-products, or have a healthy independent relationship where each mutually benefits? In many cases, the type and quality of the relationship was what strengthened and supported farm businesses, even in the context of professional contractual relationships with supply chain companies.

Another element within this theme is connection with the banks. Some case farms had substantial debt, and therefore had close relationships with their bank managers (i.e., they saw them every few months and shared their accounts with them). Contrary to what was expected, the existence of debt and ongoing dialogue with banks were seen positively, with some case farms not worried about it and describing themselves as "I'm always a glass half full" (case farm 3). They described how their assets were increasing in value and would more

than pay the debt off if needs be. It was not their problem but the banks. Others stated at least they were in dialogue with the banks, which was better than many others in the industry. This demonstrates an optimistic resilience amongst the case farms in how they approached transition. Regardless of this seemingly rosy relationship and close connection, debt was still a threat to transition as it ultimately restricted cash flow, as demonstrated below.

> *We're gonna have to get a fair price for stuff, to do it. I think there will be a fair price. Uh, I just do not know from our own personal position. I do not know how anybody could get into farming and have that outlay of buying a farm and actually trying to make enough money to do it. And that's once in our accounts hav[n't] been that particularly good this last number of years because we have had to spend a lot of money on things you would not be spending on going forward. Yeah, but if we did not have a loan, it probably would be comfortable. It would not be extravagant, but it would be comfortable if we did not have to pay back so much money to the bank.* Case farm 7.

The role of banks and capital investment has been substantial in the development of cultured meat (Good Food Institute (GFI), 2026). The role and influence of financial institutions in supporting collaborative relationships between agriculture and the cultured meat sector constitute a potential area to explore further.

The farmers also talked about the connectedness with their animals, the land and being a food producer.

> *Yes, you've got an emotional attachment to your animals. You've worked hard to breed certain animals. You invest in that, you've got rare breed and genetics in there, you know, and love your animals. So there's that connection. But then there's also the day-to-day routine. […]. Your routine as you go and check your animals. Check your water pipes. You take the dog for a walk. You check the sheep. It changes your day-to-day.* Case farm 9

These wide-ranging but critical relationships demonstrate the embedded social nature of farming. Many of the case farmers saw farming as more than a job and were wrestling with the perceived shift from a food producer to a nature or land manager, or in light of this work, a "*protein producer.*"

> *As farmers who loving looking after livestock, it would pain me a little bit to do this one* [a future scenario where land is returned to nature] *because we've just… brought up with cattle, sheep, creating good products, creating meat that people love and all that stuff. I would hate the day that we have to let our land out to… to… for carbon credits or whatever, and go out and cut it with a mower twice a year or whatever. Just to… I think… with the starving [in the] world, it doesn't sit right with me. It's alright looking at the UK as we are, but as people [are] out there starving and I think we have the… we have the land and we have the climate [to grow food]. We're willing to grow meat in… in a sustainable way.* Case farm 7.

Farming is more than a business; it is a way of life within an intricate web of people and more-than-human dependencies, or as Darnhofer (2020) articulates it, "dynamic and relational". Displacing a sector, such as livestock farming, is not as simple as substituting one protein product for another but could have wide-ranging ramifications (Helliwell and Burton, 2021). Human–nature connectedness more generally, and in the agricultural context, has been explored in several studies (Gosling and Williams, 2010; Riechers et al., 2021). Relationships and connectedness were the foundations on which the farmers in this study based their future decisions and built their livelihoods (e.g., fair contracts, local rural labour). The farm was a central employer for many people in the rural community, with some participants describing a long list of dependencies, including contractors, fencers, mole catchers, shop assistants, and veterinary surgeons. The farmers' connectedness to local people and embeddedness in the community were keenly felt.

> *Everybody around here is from our neck of the woods, sort of thing, which this whole thing is connected to farming in some way. So, you know, I said [to] you the last time, we got our single farm cheque through for 40 grand and we…we sent it off to 21 different people and that was the farm cheque all gone. And that was the guy that fixes this…That does the silage and… [] …You know, it's …it's even down to the mole man who comes and gets a £6 per mole. You know it's …it's… it's all those types of people that are all getting something out of here and pretty much everything we spend goes. Everybody [you] talk to in the village, works on a farm, they work in a shop, they're a fencer, or … So they work at the market. They work here, they work… and just around, around the whole place, just that's, that's just what everybody does.* Case farm 7

All case farmers commented on the disconnect between consumers and producers in the context of potential disruption from cultured meat. This divide was felt most keenly by the livestock farmers as they felt most attacked for what they produced.

> *Just over the course of the last number of years, they've been brainwashed into thinking the cows were killing the planet and … which we don't believe to be true at all, in respect of what's, what's going on, and… like you know… Everybody that lives in London has heard about how cows are ruining the country, but they… don't think of Heathrow airport and all those types of things that flying above their heads…* Case farm 7.

This revealed a keenly felt disconnect between producers of food and consumers of food, which the narrative around cultured meat is at risk of perpetuating (Sexton et al., 2019). The farmers often spoke about those who were disconnected from where their food came from being 'townies' and living in cities, which perpetuates a rural–urban divide (Smithers et al., 2005). Interestingly, the case farmers from Northern Ireland and Scotland indicated there was a better connection between farming and non-farming people, compared with those in England or near to urban centres (case farms 1 and 2), which supports the idea that disruption from cultured meat could be regionally determined even within the UK (Mylan et al., 2023)

> *But Northern Ireland, I think people have a better understand of where their food [is] coming from and how it's produced. And you know, they know somebody that's usually a farmer that grows it or whatever. So, it's a bit more… It's a bit more known here.* Case farm 5

Nevertheless, there was a strong sense that cultured meat could risk widening the disconnect between consumers and producers of

'real' meat, even by non-animal farmers (see also MacMillan et al., 2024). The public were often perceived as ignorant when it comes to sustainable farming and net zero, as indicated in the following quote, and basing their food choices overwhelmingly on price. This further widened the perceived disconnect between consumer and producer.

> *I don't reckon the public are ready for it yet. It's…it goes back to what I was saying about the public having no clue about what's involved in NetZero …The public will be ready for it, if its half… When it, you know, when food gets really expensive on the, on the shelves, something cheap, even if it's got a funny name – non-meat - that's nutritious and all the rest, they will take that.* Case farm 8

There was considerable uncertainty about cultured meat's place in our food system and questions raised by the farmers around how the technology worked and the end-product (see also Manning et al., 2023). However, more fundamental questions were around how much market share would it take and the sort of product it would be/replace.

Like how long does it last? And you know, is it a fad or whatever. Case farm 6.

In response to asking whether it would be more of a top-end product, the two farmers from case farm 1 responded:

> *I don't think so, I mean don't think the likes of that Tesla man, he wants the majority of mouths eating it. Not the little restaurants. He wants to be the leader of the world, yeah.* Case farm 1 (husband)

> *They want they want it to hit the floor like McDonald's …Not they don't want to have it on just Christmas Day, don't they?* Case farm 1 (wife)

Key questions regarding market demand and market share needed to be answered first, before the interviewed farmers could confidently or precisely predict the impacts it would have on them and their businesses. All farmers commented on not knowing much about the what or how of the technology but were willing and able to discuss the implications of losing markets and livelihoods to something that, arguably, intends to displace/replace animal-based protein.

> *It's difficult to give a full response without knowing the full opportunities of the cultured meat industry, I think that the idea around [animal] cells and breeds and things like that is a very interesting question, could potentially have a lot of natural capital opportunities, as well as commercial opportunities.* Case farm 2

> *The vertical farm is meant to be right next to the population, so you can just send that mile down the road and be consumed… [yeah]… It depends. Yeah, how many tonnes of wheat or grass do you need to produce a tonne of [cultured] meat?* Case farm 3

Nearly all farmers were sceptical of the claims made by the cultured meat sector regarding environmental credentials; the motives of the companies; and the taste, nutrition, and social acceptance of the end-product, which mirrors many non-farmer perspectives (Conversano et al., 2026).

> *But the drive behind this is the money that's behind it, isn't it? It's not the consumers yet, is it? It's the people who've got money that's driving it. You could…You could put anything on the market really, couldn't you? As long as you got money behind you … Through marketing and advertising, you could sell it wouldn't you?* Case farm 1

The analysis revealed that there was a quiet confidence amongst some of the farmers regarding the value and longevity of their own products, and in particular 'natural meat'. In fact, there was a feeling shared amongst some that they might even see consumers turning back to real meat and increased demand could work in their favour.

> *So, it is a potential protein competitor, yes, for if it takes off, it will be looking for market share. Will it impact it on us? It depends on their story, the brand, what their environmental footprint looks like, their routes to market. And consumer reaction to all of that. Is it all negative? So, I think yeah. At the end of the day, yeah, more protein, more protein substitution. Yes, it could push the price of beef and lamb down. Potential benefits…? Yes, the potential benefits are that consumers might revert to having cultured proteins or other forms of protein in their diet and seeking out niche premium local meat with the provenance, and eating less but better, of a better means, and maybe paying a little bit more for it, so it could also play into our hands. And all of that is a massive unknown.* Case farm 9

Ultimately, how cultured meat would impact their businesses depended on its eventual market share and consumer response. Despite feeling disconnected from consumer, the farmers demonstrated an optimistic resilience borne of their relationships within an (inter)connected farming sector, from which they drew both economic and social support. This analysis also revealed that disruption from cultured meat could impact farmers' connection with their animals and land, which has further implications explored later in this paper (see 3.3).

3.2 Farmers' positionality within the food system

The second theme examined farmers' positionality within the global food system, where 'positionality' borrows from feminist theory and includes the concepts of relation to others, power and it being continually shaped/reshaped in relation to space, place, scale, and time in a global economy (Sheppard, 2002). Despite the nature of connectedness demonstrated by the case farmers, the imbalance of decision-making power within supply chains, where farmers self-identified as 'price takers' and 'bottom of the pile', was prominent and follows on from themes identified by Manning et al. (2023).

> *Farmers always lose out. I think that's, you know, as primary producers as price takers, most of us. We're at the bottom of the supply chain. Effectively, we will always lose out to new products, processing new inventions, innovation, marketing, share value. So I think it's fair to say that, yeah, primary producers are always at the bottom of the pile. There's no share value in this for any of us. And all we have to try and do is find our own route to market and protect it to route to market and add a bit of value to our product. With lots of different threats around. As it's been shown a few times that when there is a spike in innovation, it's nearly always the farmers on the ground that lose out.* Case farm 9

There was evidence of farmers not being able to exercise the power that they do have (i.e., stewards of land, producers of food), especially considering the wider project found that the cultured meat sector needs primary agricultural production more than it needs the cultured meat sector (MacMillan et al., 2024). Nevertheless, there was a sense of 'why would cultured meat bother with us?', especially where size and scale of production/facilities/land were seen as the main attraction for cultured meat's collaboration with primary agricultural production.

> *We haven't got the funds to do that sort of thing and even our unions are too weak to face them as well. Our union haven't even typed started to talk about culture [meat].* Case farm 1

> *The other factor that works against that [localised food systems] is the industrialisation of agriculture in sort of the third great cultural revolution, where we've all been pushing and chasing costs and efficiencies, which has led to no dairy farms in the east and all the big milk factories being in specific parts, and the abattoirs being in specific parts. What that [localised food systems] is all relying on is the separation of all that out, to be sort of more equally dispersed, to paint that mosaic. And I just can't see these major retailers being willing to spend money, to lose money in smaller scale operations, rather than to have it scattered more efficiently around the country.* Case farm 2

The role of intermediaries or actors on behalf of farmers was important for some case farms, such as case farms 3, 4, and 6. This was largely because the relationship between rural communities and 'outsiders' from a sector such as cultured meat (similar to the role played by processors/buyers), could be what makes or breaks any sharing of resources between the agricultural and cultured meat sectors. The cultured meat sector could offer new models of protein production that forge new ground (Chiles et al., 2021) in recognition that "*our job is not only as protein producers, we're providers of public goods*" (case farm 9)". The cultured meat sector could work in partnership with farmers, but there is a risk that they operate like existing processors and buyers, reinforcing existing imbalances in power across supply chains which are arguably controlled by and benefit the few, as discussed by Jiménez Rodríguez (2023).

> *I think there's… there's a lot of… a few big players that have an awful lot of sway in what happens… They represent their shareholders.* Case farm 2

> *Tesco will never buy a farm because they've got so many fools to do the Job for them.* Case farm 1

This supports the significance of contingencies and eventualities in the development of cultured meat as discussed by Helliwell and Burton (2021). For cultured meat to succeed (i.e., bring down their cost of production and for lots of people to buy it), and at the same time for there to be a just and inclusive transition that involves collaboration between the two sectors, farmers need to not just be at the table but actually be able to influence what's on it. There needs to be a perceived legitimacy to the goals, process and outcomes, or what de Boon et al. (2022b) describe as "throughput legitimacy."

This links to the next minor theme within farmers' positionality in the global food system—market access. The current structure of the food supply chain has locked farmers into limiting contracts and relationships with powerful actors, such as processors and retailers who dominate the food supply ecosystem (Barnes et al., 2022), as the case study farmers all alluded to to varying degrees.

> *Well, if you look at the last 10 years, there was probably 20 different processing factories and now there's eight in the UK for pork.* Case farm 3

> *I'm not going to sit here and slag off retail because I wouldn't have a business without them. But they're, you know, absolutely ruthless. And especially when it comes to UK products, they've got no affiliation to it.* Case farm 4

> *…You know, Lidl can do it. You know, I'll sell stuff into Lidl and they will pay me the same price as another mainstream retailer, for example. But they are happy to do it 15% margin, 20% probably. Whereas the other retailers looking for 40%, so that's where you're getting this different price point at retail level. And so you know I can take nothing away from them. They've got that model. So why shouldn't the consumer benefit from that?* Case farm 4

The price paid by consumers for most food products was the main explanation given for these often "ruthless" practices within the supply chain, and farmers perceiving they had little choice or negotiating power for a better return. This was also supported by the preliminary survey data conducted at the first farm visits, which often showed low margins, significant debt and reliance on diversification of income (i.e., non-food production businesses such as weddings).

Historically, when the UK was in the European Union and governed by the Common Agricultural Policy (CAP), many UK farm businesses became reliant on subsidies, with ~50% of EU farms receiving only 10% of the subsidy (Bateman and Balmford, 2018). It is argued that the subsidy system has contributed to this 'price taker' situation (Bateman and Balmford, 2018) and despite being out of the CAP at the time of the study, funding from the Government was still the main incentive-based system for UK farms to shift practices and adapt businesses to the requirements of new environmental policies.

To further highlight the perceived disadvantaged position of farmers within the food system, what they do, how they farm and whether it aligned with their own value system, one farmer reflected:

> *I've never been particularly enthusiastic about growing large amounts of grain to go into cattle to go into burgers. I don't feel hugely proud, I mean, Dad has, I can't speak for Dad, but he's always struck me as… Dad is very proud to produce food that contributes to… to produce grain that contributes to people's plate.* Case farm 8

There was variation across the case farms and between generations about how they perceived their own role in any transition, from food producer to "*protein producer*." The farmers from case farms 5, 6, 7, and 8 positioned themselves as food producers first and foremost, whereas case farmers 1, 2 and 9 included their role looking after the land in their answers. The case farmers in soft fruit and pigs saw their role as varied, but all the interviewed farmers aligned with describing themselves as "*price takers*" with minimal influence on the market and wider food system. These case farmers highlight a sense of powerlessness when reflecting upon approaching a transition due to the arrival

of cultured meat, or what others describe as complacency (Burton, 2019), or low adaptive capacity (de Boon et al., 2024). Their positionality within the food system is a contributing psychosocial factor influencing not only innovation processes but their future trajectories. A wealth of literature examines farmer identity and the role this plays in transitions (Burton and Wilson, 2005; Kump et al., 2026) and behaviour change (Gütschow and Bartkowski, 2025). This study not only supports this literature on the need to meaningfully include farmers within a just transition (Blattner, 2020; de Boon et al., 2022a) but argues that we need to address the inherent injustice within the food system before launching into supporting a promissory narrative around cultured meat and other meat analogues, as put forward by Sexton et al. (2019).

Furthermore, when evaluating an agri-food transition from a farmer-centric perspective, there is a moral argument for farmers to exercise their power in the food system, not only as material providers of food, ingredients, resources and land, but as knowledge holders with wisdom that can serve to enhance the pace of transition and mitigate unintended consequences. We see this most clearly when the case farmers shared the potential knock-on effects from the arrival of a disrupter such as cultured meat.

3.3 Practicality of knock-on effects

There was a divergence in views between the interviewed farmers as to whether cultured meat would replace cheap cuts (the dairy farmers) or expensive cuts of meat (the Scottish beef farmers), and the wide-ranging ramifications of this were pointed out in detail by all farmers. Would cultured meat be food for the wealthy or food for the masses (or perhaps both)? The interrelated nature of carcass balance (making multiple products from one animal carcass and selling to diverse markets) and the multitude of products gained beyond just meat (e.g., leather, soap, etc.) is something that could be severely disrupted by a product such as cultured meat (MacMillan et al., 2024).

> *They're not wanting to compete with us in, in the meatball, burger, mince roll, you know, they are. they wanna be at the high end if they are going to make money. And that's what those export markets going to be like. So from a carcase balance point of view if. if all of the more expensive cuts are no longer as valuable, and we have to drop prices to get those. Then obviously it. it has a big impact. On a beast [cow], there's 5 kilos of fillets for example, but they are worth £30 / kg.* Case farm 7.

Interviewees described potential knock-on effects on farm income and business viability if they were to get less for premium cuts, especially in the sheep and cattle sectors. Alternatively, the risk of losing markets to sell lower-value animals into, such as dairy-bred calves/cull cows, which may affect the dairy sector disproportionately, was also discussed if cultured meat competed with the lower-value cuts of meat. However, this was caveated with the impact being contingent on the scale of displacement or replacement in these markets. It was also recognised that these were volatile markets anyway; many farms in the UK sell their animals to an agent or to the abattoir, and there is little to no awareness of where they end up. There were also indications that farmers were reliant on the market finding places for their products

> *"…somebody out there looking for… [] …they'll take on your barren cows, won't they?" (case farm 1),*

which suggests some degree of undue optimism, if you consider what happened when previous industries were substituted (Burton, 2019).

Furthermore, non-livestock enterprises like arable farms could also face severe disruption from the arrival of cultured meat. The arable farmers interviewed (case farm 8) noted that a substantial proportion of their income came from grain grown for the livestock market.

> *I think it could break us. And that my understanding from Dad is 80% plus of our produce goes to feed animals, so if there are 40, 40% less animals, I think the bottom falls out of the feed market. So until somebody proves me otherwise…* Case farm 8.

If livestock farms were to be displaced or even reduced by cultured meat, this would have ramifications for the arable farmers' livelihood and what and how they farmed. They described that it would be a challenge to simply switch the types of crops grown due to the long-term nature of arable farming and the suitability of the land they were on. Nevertheless, they recognised some of the potential opportunities posed by cultured meat, such as supplying inputs or on-site production, however, they shared the same uncertainty as other farmers interviewed across all nine farms when it came to the size and viability of the market for cultured meat.

All farmers interviewed agreed they were price takers and held little negotiating power when it came to price paid (dairy, fruit) or even the markets they sold into (beef, sheep and arable). Cultured meat was just another threat that could worsen this position. However, from a fresh-produce perspective (case farm 4), there were potential benefits to the creation of another food/protein production system, into which their business could supply inputs such as energy, or that could add value to waste products such as cellulose or glucose. When discussing the potential business scenarios that could arise from cultured meat, whether supplying inputs or on-site production, the interviewed farmers were clear that it would depend on market share and demand, ability to supply, contractual agreements and the terms of these.

> *I mean, if I was looking for a new enterprise…[]… So your first things your market, right, what's the market opportunity, what's the [] again your scale, what's your you know pricing structure contracts we spoke about earlier, what is the long term opportunity within that? How does that sit and look? Is it a long term? Is a short term? Is it… you know something that you sort of get behind and you know…. You've gotta do a business plan, business model to it and appraise how it complements or might have a conflict with our current portfolio as well. So it would all have to be sort of assessed on that basis.* Case farm 4

The severity of the threat to livelihoods varied across case farms. The livestock farmers were not unanimous in their perception of threat either. The Northern Irish beef/sheep farmer (case farm 5) and the tenant, Organic-certified beef/sheep farmer (case farm 9) viewed cultured meat as far off, unlikely and potentially a fad. Although both participants identified serious concerns about consolidation of power in the supply chain, they viewed their business models as resilient to the arrival of cultured meat. This was either from the low cost of production of grass-fed meat from grass, which cultured meat could not compete with, or from stacking diversified enterprises. Interestingly,

the arable case farm saw it as a very significant threat, which was not imminent but not that far-fetched either. This was largely down to a substantial part of their income coming from grain grown for livestock feed, which would be severely negatively impacted if that market shrank, but this was balanced with the desire and perceived ability to look to different production systems due to ongoing crop pest and price challenges (partly exacerbated since the removal of CAP subsidy in the UK). This demonstrates a level of control in their willingness to adapt, as well as supporting the case for adaptive capacity around access to resources and state of mind (de Boon et al., 2024).

Nevertheless, all participants, irrespective of their production system, described the negative impact cultured meat could have on the highly connected nature of the rural community, which they were not only part of but relied upon for labour, services and social support.

> *It's affecting the bigger picture. You know, if farmers are farming, they're, you know, if they're making money, they're spending money. They're keeping the different economies going. But if this is a factory built then it's, that's it. Who else you support? And I think you look at the bigger picture, but the amount of jobs has been … and I always think you know, farmers, if there's no farmers, you know, there's massive amount of people there out of work. I mean, you've already drivers, you've building supplies, you've bigger drivers, you've you know you've so much stuff there that supply farms. So, if you're going to this sort of factory farm that you don't need deliveries, you don't need to build anything. You're doing more than a farmer and more, you know, and other good people out of work too, so… Case farm 6*

If they or other farms went out of business, so could the myriad services they used and supplied, which they perceived as having wide-reaching impacts on the rural community. This could not only impact jobs and the local economy but also the management of the countryside and how the land was farmed. If they were not there, who would be instead?

> *I understand there are farmers out there who, you know, take everything out of it and what have you. But there are good farmers out there as well who look after the land. And I'm just thinking, if we go and take the sheep off the mountains and the dairy out the… and the what's left? Well, not what's left is it, but I can't see how that is going to be better because it looks pretty because you know, most farmers look after it.* Case farm 1

The interviewed farmers generally supported the industry-wide direction of travel with respect to sustainability and farming in harmony with nature. Many were already implementing regenerative, nature-friendly or traditional farming practices, with two farmers identifying as regenerative, one as organic, two as traditional and extensive graziers, and one circular (see Table 1), which is illustrative of the diverse make-up of UK agriculture. Notably, 71% of UK agricultural land was utilised as grassland as of 2024 (United Kingdom Government, 2025), and 3.2% of the UK agricultural land area is farmed organically (United Kingdom Government, 2026).

The diversity of the case farms revealed an important issue regarding sustainability that cultured meat could potentially threaten, despite good intentions. The utilisation of farming resources some would term as 'wastes', such as animal manure, is central to a regenerative, circular, or organic farming approach. By removing animals from the farming system, there could be a decrease in organic manures, and this could precipitate an increase in artificial fertiliser use and subsequently impact soil health and biodiversity. It could also impact crop rotations and the planting of legumes such as beans, which are promoted as beneficial for soil health (Carlisle, 2022).

> *No beef, no lamb, no feeds. There's going to be less crops that I can sell. I'm not going to grow beans because there's nothing to eat the beans.* Case farm 3

Another unintended consequence that the arrival of a disrupter such as cultured meat could precipitate is the further intensification of production, as cultured meat companies potentially tending towards integrated supply chain models as seen in the poultry sector. Despite this, the poultry participants did not perceive cultured meat to be a major risk and they were quietly confident they would be competitive with it.

> *Again, it can go either way. Intensive meat production sector being more efficient might be better placed to rival cultured meat on carbon footprint. Input and output to efficiency measures. And driving the price down of that and getting bigger and more intensive. So it might actually intensify intensive meat production….* []*… I think that they* [cultured meat companies] *own their own livestock, wouldn't they? [] But also investment and private equity and, yeah, I think that power dynamic, who owns the land? Yeah, pension companies. The race for net zero. Yeah. I think those… those top-down power dynamics, I think will ultimately govern the size of landscape scale change into like the Cotswolds.* Case farm 9

> *I think the…the bigger implication to me is that our food would then, it's bad enough our food, our protein food being controlled by half a dozen organisations or people…[Hmm]…it's the fact that if it was being, if, God forbid we… we went to the scenario where, you know, cultured meat, lab grown meat was the norm, well then one or two people would control the food supply… That, to me, is more scary you know, it's who controls the food controls the… controls the country I suppose.* Case farm 5

The existing and potential continuation of the intensification of the food system was spoken about in the context of efficiency and control of the food system, rather than any impact on planetary/people's health and animal welfare. However, some case farms, as illustrated in the next quote, outlined the implications of intensification from using more harmful inputs such as artificial fertiliser, despite this being in contrast to the long-term downward trend in cattle and sheep numbers nationally.

> *So like in the last few years, we've worked on the fact subsidies are getting less and less and less. So we increase, we're increasing the cattle, increasing the stock. So that's going to take the place of subsidies….[]… I'm not sure if it's doing any good for the environment because we're putting more livestock on the land, so which will mean more artificial fertilisers. But it's replacing subsidies. So are we going to take that same attitude when we have nothing for our barren [cows] and we're just going to increase our milk?* Case farm 1

This calls into the question some of our understanding of the way an agri-food transition could play out. As described in Blythe et al.'s,

work (2018) on the dark side of transformation, despite the best intentions in a process of change, there are latent risks. No transformation is apolitical and there are many vested interests to consider (Chiles et al., 2021). Other (forgotten) actors, market forces and political agendas may become more prominent, as explained by Mylan et al.'s (2023), where differences in regions, regulations and politics mean technologies like cultured meat develop very differently and impact people and communities in varied and unpredictable ways. As the final quote illustrates, there are many ways in which to look at the real and perceived impacts of cultured meat on UK farming depending on your positionality, and there are multiple knock-on effects to consider contingent on how cultured meat develops, many of which are still 'silent' in the wider discussion.

> *I suppose it's not out of the question, but….I mean a different generation thinks differently. It depends what where they're taught and brought up. But I mean, my wee fella, he's coming up to 8 now like and he just wants to do what I'm doing…he doesn't even want to go to school anymore. So, it's just, I don't know. It's hard to explain. It's just the way you're brought up on a farm. It's just the way you think. If anything's different or it's hard to adapt… Especially something like that [cultured meat]… But I'm not saying that it couldn't be supplied [in]to it, but… I think there's a lot of factors that need considered with it as well.* Case farm 6

4 Discussion

We are at a critical point in the development of cultured meat with various possible pathways forward in an uncertain agri-food transition. One pathway could be 'business-as-usual' where exploitation of people and planet continues (Crippa et al., 2021; Jiménez Rodríguez, 2023), or alternatively, we seek to develop new models of production and cooperation (Chiles et al., 2021), which some farms are prepared to engage with (Joshi et al., 2026), in contrast to past food system shocks (Burton, 2019). Acknowledging this uncertainty, this paper has explored two research questions—first, how do UK farmers perceive and approach an agri-food transition in the face of disruption from cultured meat, and second, what do the farmers' perspectives reveal about the conditions under which a disruptive transition could become more economically, socially and environmentally just?.

The case farmers perceived cultured meat to be a distant threat with unpredictable impacts on market share and therefore on their businesses. They recognized the uncertainty of an agri-food transition, as well as raising questions around consumer acceptance and development of the sector, as well as its competitiveness with existing meat supply chains. They largely approached the potential of a transition towards this technology with optimistic realism regarding the continuation of their own businesses, but with scepticism towards the wider food system. Their optimistic resilience was rooted in *connectedness* with their local community and built on being key actors in the rural economy.

The analysis demonstrated the importance of *connectedness* and relationships, particularly among farmers, organisations and the more-than-human (with their animals, their land and nature, as well as with institutions such as processors and banks). In this context, the case farmers raised specific concerns about the negative consequences cultured meat could have for future sustainable regenerative land management. Previous studies have demonstrated the role of connectedness to nature as a driver of conservation behaviours and environmental stewardship (Gosling and Williams, 2010; Valizadeh et al., 2025). Furthermore, the farmers in this study perceived a *lack of* connectedness within broader society's contemporary relationship with food; it was unclear, in their opinions, whether cultured meat would redress or perpetuate this disconnection.

Conducting a farmer-centric analysis has been valuable for spotlighting important social justice issues, both relating to current agri-food systems and the perceived potential impacts (both positive and negative) on these systems posed by cultured meat. One key impact is the potential for large-scale displacement or replacement of whole agricultural sectors rather than simple product substitution. Many agricultural sectors are interdependent on one another, such as cereal grown by arable farmers for the livestock feed market. The potential consequences of disruptive transition include: The systemic loss of jobs and roles supplying into farming businesses and the risk this poses to rural communities and the services they provide; reduction in farm incomes across interdependent sectors, not just livestock; reduction in co-products and impacts on carcass balance; reduction in ability to support sustainable farming practices such as integration of livestock and diversification of crop rotations; and finally the loss of organic fertiliser generated by livestock and the negative impact this may have on soil health and regenerative farming.

The knock-on effects or eventualities of multi-scale system-level transitions are of interest to many actors (Geels, 2011), not least policymakers who are currently grappling with this new technology and how to regulate it. There are several examples from the past that may give an indication of what could happen when a sector or whole industry is replaced, as seen with madder being replaced by artificial alizarin or vanilla and synthetic vanillin. Burton (2019) recommends that the affected industries and those within them should avoid being dismissive of emerging new technologies or taking on a position of complacency, instead aiming to adapt to inevitable transitions. As we have seen globally, some countries are supportive of getting cultured meat on the market (e.g., Singapore, the US, and the UK with pet food as the first product range), whereas others are opposed to the point of criminalising its production and sale (e.g., individual states in the US and Italy) see Lanzoni et al. (2024).

However, the uniqueness of cultured meat as a threat to animal agriculture, compared to the threat posed by replacements such as alizarin or vanillin, is the scale of the disruption. Cultured meat is not simply aiming to replace one product, species or sector (e.g., chicken), but arguably could replace all animal-derived protein from beef, poultry and pork to fish, dairy and even eggs. In addition, this disruption directly affects products up and down the supply chain. This has implications for not just production but also consumption. Therefore, there are further social, cultural and ethical elements to consider and, critically, consumer acceptance of the end-product (see Bryant and Barnett, 2020).

As demonstrated in the empirical data, key characteristics of many UK farming businesses are that they are deeply connected, community-based, and inter-generational, with relationships extending far into the supply chain and with the more-than-human. Switching the 'how and the whom' of meat production is not the same as, for example, switching our energy supply from fossil fuels to

renewables. The former comes with the additional baggage of deep cultural, social, emotional and visceral assemblages that make food as an end product unique, with distinct cultural value different to other commodities (Lingham-Tsiaparas et al., 2026). This has implications for those in the cultured meat sector seeking to work with primary producers, i.e., building sustainable commercial relationships with suppliers of feed ingredients or other resources, for example. To embody the principles of a Just Transition, this could go beyond existing models of contractual relationships, which we have shown limit farmer agency, and instead include more inclusive decision-making and shared ownership of resources and benefits.

Power, or the lack of it, was a recurring social justice issue cited by several case farmers, with many explaining that actors downstream in current agri-food supply chains (e.g., processors, banks, and retailers) have disproportionate influence over how and what they can farm; hence the theme of farmers' *positionality* in the food system (perceived and actual), where relationships with others and power dynamics were evident constructs that could both be barriers and/or enablers in this example of agri-transition. In this context, cultured meat was perceived as being potentially another mechanism for further concentrating power and agency over food production away from farmers. However, as *positionality* can be shaped and reshaped by the spaces, places, scale and timing of an innovation in a global economy (Sheppard, 2002), there is an opportunity for cultured meat and conventional agriculture to coexist and enable one another. Recent work by Joshi et al. (2026) describes four different hybrid models of production: two different forms of *decentralised production* where farmers provide inputs and can remain farming, or eventually plan to exit the industry; *co-production,* which allows existing farming to continue whilst supplying resources to the cultured meat sector and both share the benefits; and lastly, *regional bio food innovation hubs*, all of which enable culturally legitimate participation.

By considering these social justice themes together, and if the cultured meat industry is serious about being as the food system panacea that many proclaim, then there is a strong argument to start building relationships with farming communities rather than casting them as the opposition. We argue that a much more productive approach for this new sector would be to (a) understand the multi-scalar, multi-actor and political complexities of contemporary agri-food systems from which they seek to capture market share, (b) understand that food is more than just an end product that cannot be easily substituted in isolation from where, how and by whom it is made; and (c) understand that the potentially large-scale economic fallout that cultured meat represents to rural communities undermines the technology's promise of a win-win food future for all.

There are many gaps or silences around aspects of cultured meat production that warrant further exploration if cultured meat is to deliver on its promises, such as the types and extent of wastes that are inputs to and outputs from cultured meat production (Helliwell and Burton, 2021). There are also wider-ranging uncertainties, such as how the landscape will be stewarded if there are fewer farm animals and farmers in it, as pointed out by the farmers in this study, and the impacts on rural communities if people are forced to close businesses and leave. There is a gap in our understanding of the long-term impacts of exclusionary displacement (Manning and Grant, 2025), and the hollowing-out of existing rural communities, arguably a form of eco-gentrification (Gearin et al., 2023; Manning and Grant, 2025). As Helliwell and Burton (2021) put it, will the countryside resemble Chernobyl rather than a mosaic of diverse landscapes on which whole communities depend?

The literature around Just Transitions and food justice repeatedly emphasises the need to meaningfully include those who could be most affected by a disruptive technology in an agri-food transition (Blythe et al., 2018; de Boon et al., 2022a) and is now beginning to be supported with empirical data in the context of alternative protein transitions, such as from Joshi et al. (2026). However, the cultured meat sector to date has not had a track record of working collaboratively and has only recently started to look at more democratic and open models of innovation (Chiles et al., 2021). Considering the value of cooperating with primary production when it comes to the supply of feed-grade inputs for the cultured meat sector (Risner et al., 2023), this study highlights an opportunity for new ways of working where, for example, rather than completely replacing an industry and all the supply chain infrastructure and knowledge that goes along with it, there may be an interdependency between the two opposing sectors where one's success is contingent on the other.

This study was part of a wider Transforming Food Systems project which focused only on the UK and drew upon a small purposive sample of farms across the devolved nations. Therefore, the results are not statistically generalizable, but rather shed light on potential impacts of disruptive technologies and add much-needed empirical data to understand the way sustainability and agri-food transitions could occur. The unique position of farmers in the food system, but apparent lack of ability to exercise power within the supply chain, highlights not only the influential role some companies have over others, but the risk of further consolidating power in our food system from a yet uncertain disrupter such as cultured meat.

The findings in this paper were generated from qualitative data collected over a relatively short period of time (2023–2024), so there may have been developments in both sectors that impact these findings. A larger dataset over a longer period of time with case farms from across sectors, regions and operational systems would be recommended for further research.

Finally, there is scope to build on this study with further modelling and the use of larger, diverse samples to reduce uncertainty. Maintaining transdisciplinary collaborations within this research is, we argue, critical for capturing the multi-faceted opportunities and risks that a large-scale transition to cultured meat production presents to UK agriculture.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

LCM: Formal analysis, Writing – review & editing, Writing – original draft, Methodology, Data curation, Investigation. JD: Project administration, Formal analysis, Data curation, Writing – review & editing, Methodology, Investigation. ID: Methodology, Investigation, Writing – review & editing. MG: Writing – review & editing, Conceptualization. KL: Project administration, Writing – review &

editing. LoM: Methodology, Investigation, Formal analysis, Writing – review & editing, Data curation, Validation. DR: Validation, Conceptualization, Formal analysis, Writing – review & editing. WS: Investigation, Writing – review & editing, Methodology. AS: Validation, Conceptualization, Formal analysis, Methodology, Writing – review & editing. TM: Validation, Conceptualization, Project administration, Writing – review & editing, Supervision, Funding acquisition, Formal analysis.

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Conflict of interest

ID was employed by Cellular Agriculture Ltd.

The remaining author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that Generative AI was not used in the creation of this manuscript.

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