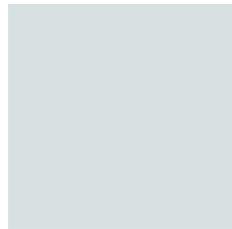
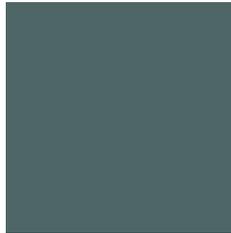




Public dialogue on genome editing in farmed animals

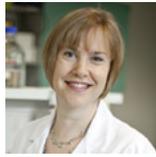
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Foreword



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The Nuffield Council on Bioethics is a leading independent policy and research centre, and the foremost bioethics body in the UK. It identifies, analyses, and advises on ethical issues in biomedicine and health so that decisions in these areas benefit people and society. The Biotechnology and Biological Sciences Research Council (BBSRC), part of UK Research and Innovation, is the main public funder of agri-food research in the UK. One of the ambitions of BBSRC is to ensure the UK's strengths in bioscience have a positive impact on global food and nutrition security, and drive innovation and policy to a deliver sustainable, productive, diverse, resilient, and healthy agri-food system.

From our different perspectives, both of us – the Nuffield Council and the BBSRC – recognise that we face a potential crisis in our food and farming system. This system is beset by multiple challenges: to produce sufficient, affordable, nutritious food for a growing population, in a way that is economically viable, while significantly reducing the impact on the environment, raising standards of animal welfare and warding off the ever-present threat of devastating disease. Maintaining the status quo is not a viable option, but any intervention in the system has the potential to have significant consequences for the lives and interests of those who depend on it.

Significant expectations have been placed by industry and governments on innovation in agricultural biotechnologies. Among these, genome editing – the precise, targeted alteration of a sequence of DNA in a living cell – promises meaningful advances in the breeding of crops and farmed animals, allowing breeders to overcome some of the limitations of conventional selective breeding strategies.

The UK's departure from the European Union may allow it to move faster to implement new technologies. However, concerns have been expressed about the pace and direction of innovation, and its wider consequences for the food system and for those who depend on it. In particular, the use of genomic technologies in animal breeding raises distinctive ethical issues, as the UK Government recognised when it responded to the findings of its own consultation on genetic technologies in 2021.

This is why we have come together to commission this public dialogue, along with UK Research and Innovation's Sciencewise programme, which supports policymakers and research councils to undertake public dialogue on important issues involving science and technology.

In a 2021 report, *Genome Editing and Farmed Animal Breeding*, the Nuffield Council recommended that innovation in agricultural biotechnology should be guided by a coherent vision of the future food and farming system, informed by the views and values of the public. This dialogue serves to illuminate some these views and values. It also takes forward BBSRC's strategic aims to embed bioscience in society, guided by social values and responsive to societal priorities. The intention is to create an opening for the public voice into discussions about policy and governance for research and innovation in this area.

The participants in this dialogue have expressed some clear views about what they see as the most appropriate aims for genome editing. They have also raised tough questions that they believe regulators and innovators need to answer as pathways to implementation are considered. And they have indicated what steps they hope the Government will now take in their interest. As the participants themselves acknowledged, this is not the last word in the discussions that are needed about new agricultural biotechnologies but a demonstration of their complexity, their public significance, and of how important following them through will be.

Executive summary

This public dialogue was commissioned by the Nuffield Council on Bioethics and the Biotechnology and Biological Sciences Research Council, part of UK Research and Innovation, with the support of Sciencewise. The aim of the dialogue was to explore with participants their views on the role of genome editing in farmed animals (GEFA) in the future food and farming system in the UK. The dialogue centred around a series of four online workshops, held between 28th May and 9th July 2022. Eighty members of the public took part in the dialogue, and they were joined at different points by specialists who were able to provide additional information on the areas under discussion.

Starting points

Although the dialogue included participants who did not eat meat, fish or dairy products, many participants regarded these as an important source of sustenance and enjoyment. From the outset, however, participants recognised that they were protecting a *'wilful ignorance'* and felt disconnected from the way in which much of the food they ate was produced, and the circumstances of the animals involved.

Although participants recognised that slaughter was an inevitable part of farming animals for meat, they separated this from the question of the quality of the life the animals lived up to that point. They wanted animals to have a *'good life'* and thought that farming animals involves a duty to provide the conditions of such a life.

In the dialogue, participants adopted several ways of expressing and relating to complex clusters of ideas and attitudes. Food that was *'locally'* sourced and processed, that came with a trustworthy narrative was associated with higher animal welfare and higher quality produce. Conversely, *'industrialised'* food production, associated with larger producers, technologically intensive husbandry systems and high stocking densities, was thought to lack transparency. There was a common feeling that this was less healthy for the animals and for consumers.

Developing perspectives

As the dialogue progressed, two dominant perspectives emerged that ordered participants' priorities in different ways.

- One centred on concerns about the impacts of livestock farming and aquaculture on animals and the environment. This perspective foregrounded individual responsibilities to care for animals and limit their own impacts, for example, by changing their diets or buying responsibly sourced products.
- The other focussed on justice, affordability and fair access to animal products as a basic dietary entitlement, at both a local and global level. This perspective tended to see biotechnology innovation as inevitable, but it was linked with scepticism about the prospects of benefits reaching consumers, or farmed animals themselves.

These were not the only perspectives that emerged and were not the perspectives of distinct groups of participants; during the dialogue many participants combined or moved between them.

A role for GEFA in the food and farming system

Genome editing was seen by many participants initially as complex and difficult, though on reflection, sometimes offering a solution to certain challenges which could be preferable to alternatives that required constant intervention. Participants saw GEFA as less risky when it resulted in a distinct, observable change in one characteristic of the animal rather than affecting the functioning of the whole animal.

When thinking about the role of GEFA, participants saw greater potential where it led to benefits for farmed animals themselves, with benefits to humans often seen as derivative from these – for example potential applications that improved animal health, followed by those that protected human health.

Views on GEFA applications to address environmental challenges of farming were mixed. A common view was that these were human-made problems, which should be addressed by changes in human behaviour rather than laid on animals. However, there was also a view that applications that supported farmers to respond to the distinctive challenges facing agriculture in low- and middle-income countries had greater potential than those that increased production in high-income countries.

Participants saw GEFA applications carried out solely to increase agricultural productivity or to provide additional consumer benefits, such as making foods cheaper to produce or altering them to improve their nutritional value, as having less potential. Rather than changing the composition of foods, they would prefer nutrition to be improved through voluntary changes in diet.

In many cases, participants saw that GEFA could be used to produce traits that were indistinguishable from those that could be produced through conventional breeding. Nonetheless, there was a sense in which participants saw a genetically altered animal as a *'new entity'*. Participants, therefore, found the description of certain uses of GEFA as being like conventional farming to be instrumental, serving to obscure or *'undermine lots of valid questions and concerns'* that they believed should be debated.

Participants were often undecided (collectively and individually) about when it was justifiable to *'change the animal'* with GEFA and when it was more appropriate to focus on *'changing the system'*, which tended to be seen as morally preferable. In many cases, though, there was a belief that this was unrealistic, and so decisions had to be taken pragmatically.

There was a wariness among participants that introducing GEFA to address one challenge could lead to further challenges arising and set society on a path of *'continual tinkering'* with animal genomes. Participants saw greater potential in what they regarded as *'one-shot'* applications of GEFA to address closely defined challenges rather than interventions for traits that could be changed incrementally. But they raised concerns that potential long-term implications – including those on animals, farming and wider society – would not be taken into account when making short-term, pragmatic decisions.

When they considered alternative responses to societal challenges, participants saw potential in lower input approaches, such as agroecology and waste reduction, which they saw as more sustainable. However, they were concerned that lower input approaches may not be able to scale to meet the current or anticipated demand for animal products.

Responsibilities of consumers and public authorities

Participation in the dialogue led to a personal awakening of interest for many participants. Many wanted to deepen their understanding of the research, food and farming system, and resolved to make more thoughtful choices about their diets and lifestyles, or engage actively with questions of policy. To support this, they wanted products from genome edited animals to be labelled as such.

However, many believed it should not be their responsibility, as individuals and consumers, to shape the industry through their behaviours; it was reasonable for them to have been ignorant of the circumstances of animal husbandry because, as citizens, they were entitled to expect that public authorities would regulate these matters in accordance with their values. All participants thought that regulation should be used to promote the public good and not just to protect them from harm.

While participants viewed current measures governing animal research in the UK as robust, they wanted information to be more readily available. This should explain the procedures used in research and the outcomes of the research, with timely publication of all research findings. As with farming policy, participants wanted public aspirations and societal objectives to influence research on GEFA.

What should happen now?

Participants want policy makers to set out a clear vision for the future of food and farming system, and to encourage and support public debate on this.

To be responsible citizens, participants want policymakers to explain the purposes for which GEFA might be used, so they can understand its impacts and wider consequences, as well as what the range of options are, in order to be able to assess its value and potential impacts.

Participants want policy makers to consider promoting alternatives without privileging novel technological solutions. Although genome editing was perceived by participants as an innovative technology, they worried that it would be used in the service of policy objectives that were unlikely to address long-term problems in the food system.

Participants want positive policy interventions in the food and farming system, not simply minimal protections beyond which it would be left to be shaped by market forces. The food system affects all people in fundamental ways. Both research and development, and the implementation and diffusion of new breeding technologies, should be treated in this light.



1

SECTION

Introduction to the dialogue

In this section, the policy context for the dialogue is summarised, before the aims, objectives and approach for the dialogue is presented.

1.1 Challenges facing the food system

Farmed animals are a fundamental part of the food system, and meat, fish, eggs and dairy can play an important role in diet, health and culture. Farming also plays a vital role in the economy of rural areas, and there are numerous 'ecosystem services' arising from different livestock management systems, including weed and pest control, the reduction of soil erosion and seed dispersal.¹ However, the effects of producing food from farmed animals on the planet, on people and on animal welfare is an area of debate and concern. Additionally, the role of farmed animals in helping to meet a growing demand for nutritious, sustainable food is complicated by the long-term challenges facing the food system.

By 2050, the global population is predicted to reach 10 billion, with approximately 3.5 billion more people to feed than there are now.² Some 77% of the world's farmland is devoted to growing crops from which feed is produced for farmed animals, yet farmed animals account for only 37% of dietary protein and around 18% of the calories consumed by humans.³ However, livestock farming is also an effective way of producing human-edible food from human-inedible grasses, crops and waste from grazing lands. The Food and Agriculture Organization estimates that 86% of livestock feed is inedible for humans.⁴

The greenhouse gas emissions (GHG) from agriculture account for around 17% of the global total.⁵ The emissions from the farming of animals for food, taking into account feed production, is responsible for 57% of all food emissions, with 29% coming from the cultivation of plant-based foods.⁶ In the EU, GHG emissions associated with the agricultural sector are lower, at 10% of total emissions. Moreover, agriculture sector emissions decreased by 24% between 1990 and 2013 through scientifically guided breeding, management and reduction in numbers of livestock.⁷

Zoonotic diseases – those passed from animals to humans – have a wide variety of causes. A 2016 United Nations Environment Programme report said that reductions in the habitat of wild animals had increased the opportunities for disease emergence through contact with livestock. Animals from highly concentrated indoor systems are especially vulnerable to disease spread because of the 'monoculture effect' of keeping high numbers of animals that lack genetic diversity in close proximity. As a result, intensively farmed livestock were especially likely to act as an '*epidemiological bridge between wildlife and human infections*'.⁸

Dietary health is also a major concern. In the UK, almost one in three people aged over 45 is obese, with the condition disproportionately affecting those on lower incomes.⁹ Diet-related health conditions, such as colorectal cancer, have been linked to the consumption of highly processed foods, red meat and processed meat,¹⁰ though the public health impacts from unprocessed red meat are debated.¹¹

There are various possible approaches to help address these issues, from social, economic and ecological changes and innovations to the use of technologies. These approaches are not mutually exclusive.

Animal breeding has long been used in farming to develop traits linked to production, quality and fertility, and breeding technologies have been used to improve the efficiency of this process. Genome editing is described as a precision breeding technology¹² that could be used to address a range of issues associated with farming animals, from improving animal health and productivity to lessening the adverse impact on human health from farming and consuming animals.

1.2 The possibilities and implications of genome editing

Genome editing offers the potential to alter the function of a gene by making targeted changes to DNA molecules that make up the genome. Recent innovations, notably the CRISPR–Cas9 technology, have made editing of the genome relatively more precise, efficient, flexible and less expensive than other genetic engineering technologies. Genome editing enables researchers to activate or deactivate genes, insert DNA and remove parts of DNA. In turn, this can influence the development of physical traits and disease risk.

Genome editing in livestock farming and aquaculture offers some of the most near-term potential applications, alongside those in crops¹³ and human medicines.¹⁴ Genome editing could be used to produce farmed animals with specific traits that might be difficult to achieve or could not be achieved so quickly using conventional selective breeding approaches. Despite potential ethical, societal and animal welfare concerns, public debate on the use of the technology in farmed animals has been limited.

In December 2021, the Nuffield Council on Bioethics (NCOB) carried out a major inquiry exploring the social and ethical implications of genome editing in farmed animals.¹⁵ Their wide-ranging report addressed the question of innovation in terms of how best to secure justice for those (people and animals) whose basic interests were entangled with the multiple challenges facing food and farming systems. The report contained a number of conclusions and recommendations including:

- That animals should not be bred merely to enable them to endure conditions of poor welfare more easily or in a way that would diminish their inherent capacities to live a good life.
- That there was a need to establish clear standards for the introduction of new technologies to farmed animal breeding, improve collection and reporting of data to demonstrate these standards are being met, and put in place effective regulation to ensure compliance with those standards, in the light of those data.
- That innovations in breeding should not support or entrench damaging farming practices but be based on a coherent vision of a desirable future food and farming system that is informed by initiatives to explore and attend to public views.

As the main public funder of agri-food research in the UK, the Biotechnology and Biological Sciences Research Council (BBSRC) supports research that deepens the biological understanding of soils, crops and farmed animals, taking a system-based approach from the laboratory to the farm to have real-world impact. BBSRC drives the development of novel and disruptive ideas, technologies and approaches and builds capability and skills vital now and in the future.

BBSRC's ambition is to ensure the UK's strengths in bioscience have an impact on global food and nutrition security, and drive innovation and policy to a deliver sustainable, productive, diverse, resilient, and healthy agri-food system. The outcomes of this public dialogue will help to shape research strategy, and responsible research and innovation pathways, which may deliver impact, as genetic breeding technologies develop.



1.3 The current UK policy context

Biotechnologies to alter genomes (including genome editing) are currently regulated under a retained regulatory scheme deriving from EU legislation.¹⁶ Leaving the EU has afforded the UK an opportunity to explore a different regulatory approach and, after a period of consultation, in May 2022 a Genetic Technology (Precision Breeding) Bill was introduced to the House of Commons.¹⁷

‘Precision breeding’ refers to a range of breeding technologies, such as genome editing, that enable DNA to be edited *‘much more efficiently and precisely than current breeding techniques’*.¹⁸ The Bill aims to make the regulation of genome editing, and similar technologies, proportionate to risk and *‘introduce simpler regulatory measures to enable these products to be authorised and brought to market more easily’*.¹⁹ More generally, the Bill aims to support agricultural and scientific innovation.

In their response to the National Food Strategy,²⁰ the Government has highlighted an ambition to support UK farmers to maintain levels of domestic production (at around 75% of the food consumed) and drive productivity gains through innovation. The response commits to developing a joint vision with industry for agri-food innovation, identifying shared priority areas for investment and coordination, and it specifically highlights genome editing as a technology of interest. It also commits to maintain high standards for food consumed in the UK, wherever it is produced.

1.4 Aims and objectives of the public dialogue

NCOB, BBSRC and Sciencewise²¹ commissioned this deliberative public dialogue on GEFA. The dialogue explored the assumptions underlying public responses to new breeding technologies and the role of such technologies in the future UK food system. The dialogue was purposely wide ranging and included consideration of public aspirations for GEFA as well as alternatives to it.

Five objectives were set for the dialogue.

1

To identify and understand the values citizens use to frame their views on GEFA, to provide context for understanding wider public interest on this topic.

2

To map the values and principles that underlie dialogue participants’ views on GEFA, offering insights into how views are formed.

3

To explore, interrogate, and understand conditions of consensus and disagreement among citizens.

4

To identify areas of public aspiration, interest, and concern, including with respect to animal welfare and the marketing of animal products.

5

To inform future research strategies, regulation, and policy on GEFA.

In delivering these objectives, the dialogue aims to inform decision-making and policy in the UK’s research, regulatory, and industry sectors.

The approach to the dialogue is described next.

1.5 Approach

1.5.1 What is a public dialogue?

Public dialogue involves the participation of a broad cross-section of people in deliberation around issues of public relevance. The process brings members of the public together with specialists in the field over a series of workshops to give careful thought and discussion to a given topic – in this case GEFA – and to inform policy and decision making through understanding participants’ values and preferences.

The dialogue was conducted in line with Sciencewise Guiding Principles,²² and their quality framework and considerations for online dialogues.

1.5.2 Project governance

Two groups were convened to oversee the project:

A Project Team



Which had a management and governance function, and comprised representatives from BBSRC, NCOB, Sciencewise and the appointed evaluator, Ursus Consulting.

An Oversight Group



Which had an advisory function, and comprised 18 stakeholders drawn from academia, industry, the third sector, learned societies, non-government organisations and professional societies.



Further detail on project governance can be found in Appendix A.



1.5.3 Participants

This dialogue involved a total of 80 participants²³ recruited to reflect a variety of socio-demographic backgrounds, regional diversity from across the UK and different attitudes towards the use of genetic science to address food and agricultural challenges. Certain participants had a close relationship with food and farming and were purposely recruited to reflect those with lived experience of working on farms. All participants were recruited by an independent fieldwork agency and were remunerated for their time.

Participants were organised into 16 smaller breakout groups, each moderated to aid discussion, together with plenary sessions at the beginning and end of each workshop.

In addition to public participants, several specialist participants also took part in the dialogue to support deliberation on GEFA and provide participants with differing perspectives on the topic. These specialist participants had a wide variety of backgrounds, and included researchers working on genome editing, social scientists and ethicists, those with a background in farming and the rural economy and those representing non-governmental organisations.



For further detail on the dialogue participants, please see Appendix B.



One pre-task included a ‘*friends and family*’ dialogue to gain other thoughts on GEFA and encourage debate.²⁴

The dialogue also involved experts to help develop the information provided to participants,²⁵ several of whom were directly involved in the dialogue discussions as specialist participants. All plenary sessions and breakout group discussions were digitally recorded, enabling analysis of the video, audio and chat. The analytical process involved:

1.5.4 Dialogue structure and analysis

The dialogue process centred on four online workshops held over an eight-week period between 28th May and 9th July 2022. The workshops focused on the following areas:

Workshop 1:

Participants’ relationship to farming and food production.

Workshop 2:

Challenges facing the food system over the coming decades.

Workshop 3:

Potential applications of GEFA, in the context of alternative ways of addressing food system challenges.

Workshop 4:

Policy and governance measures applicable to animal research and animal husbandry, and proposals for regulating the products of GEFA, including farmed animals and foods derived from them.

An iterative approach to the dialogue design was adopted, responsive to participants’ concerns and interests. Before each workshop, participants were invited to complete short pre-tasks to help them to engage with the topics under discussion.



Thematic coding: sifting and structuring the transcript data into a code frame.



Interpretation: exploring patterns and associations, similarities and differences across the data, and how discussions evolved.



A review process: involving five participants from the dialogue, the Project Team, and the Oversight Group.



For details on the analytical approach, please see Appendix C.

This report explores a series of themes that have emerged and been shaped by participants over the course of the dialogue workshops. These have implications not only for GEFA, but more generally in considering the type of food and farming system that society may wish to develop in the future, and the role of farming technologies and alternatives within this.

Findings

SECTION 02.

Farming and food production

SECTION 03.

Animal farming and welfare

SECTION 04.

Participant views on potential applications of GEFA

SECTION 05.

Conditions under which GEFA may be developed and applied

SECTION 06.

Conclusions





In this section, participants' views on how food is produced, concerns around food production and views on different farming systems are discussed.

Key themes include:

- Participants perceived a disconnection between the food they eat, which was described as familiar and routine, and how food is produced, which was described as distant and hidden.
- Participants believed there is a lack of transparency in 'industrialised' food production. They were concerned about highly processed foods, and food being 'messed about with' – described by participants as food being altered for profit or to compensate for problems arising from the food production process.
- Participants contrasted 'industrialised' food production with buying food locally from butchers and farmers' markets, which was linked to perceptions of quality and being able to know the provenance of products.
- Participants' concern that food would be 'messed about with' was also associated with potential applications of GEFA, specifically those that focus on increased farming productivity.
- While participants associated different farming systems with various benefits and problems, using genome editing to intensify farming was seen as backward looking and more likely to address the symptoms than the causes of problems in the food system.

Participants discussed their relationship to food and farming principally in workshops 1 and 2 (though they returned to these concerns throughout the dialogue).

To aid their deliberations, participants were provided with information, which included the following.²⁶

In workshop 1

- Statistics on the amount of meat, fish and dairy consumed in the UK annually.
- The statutory codes of practice for the welfare of different species.
- Short film clips showing how animals are reared on farms and fish in aquaculture.
- Details of different farm assurance schemes.

In workshop 2

- Trends in the production and consumption of food, the ownership of food production and challenges facing the global food system – including food waste, dietary health and the GHG emissions from agriculture.²⁷
- Different ‘visions’ for future food production, including:
 - The greater intensification of animal husbandry – its objectives, benefits and limitations;
 - Farming focused on waste reduction and agroecology – its objectives, benefits and limitations;
 - Alternative ways to address demand and supply side food system challenges, including tackling food waste, the use of alternative proteins and meat taxes.



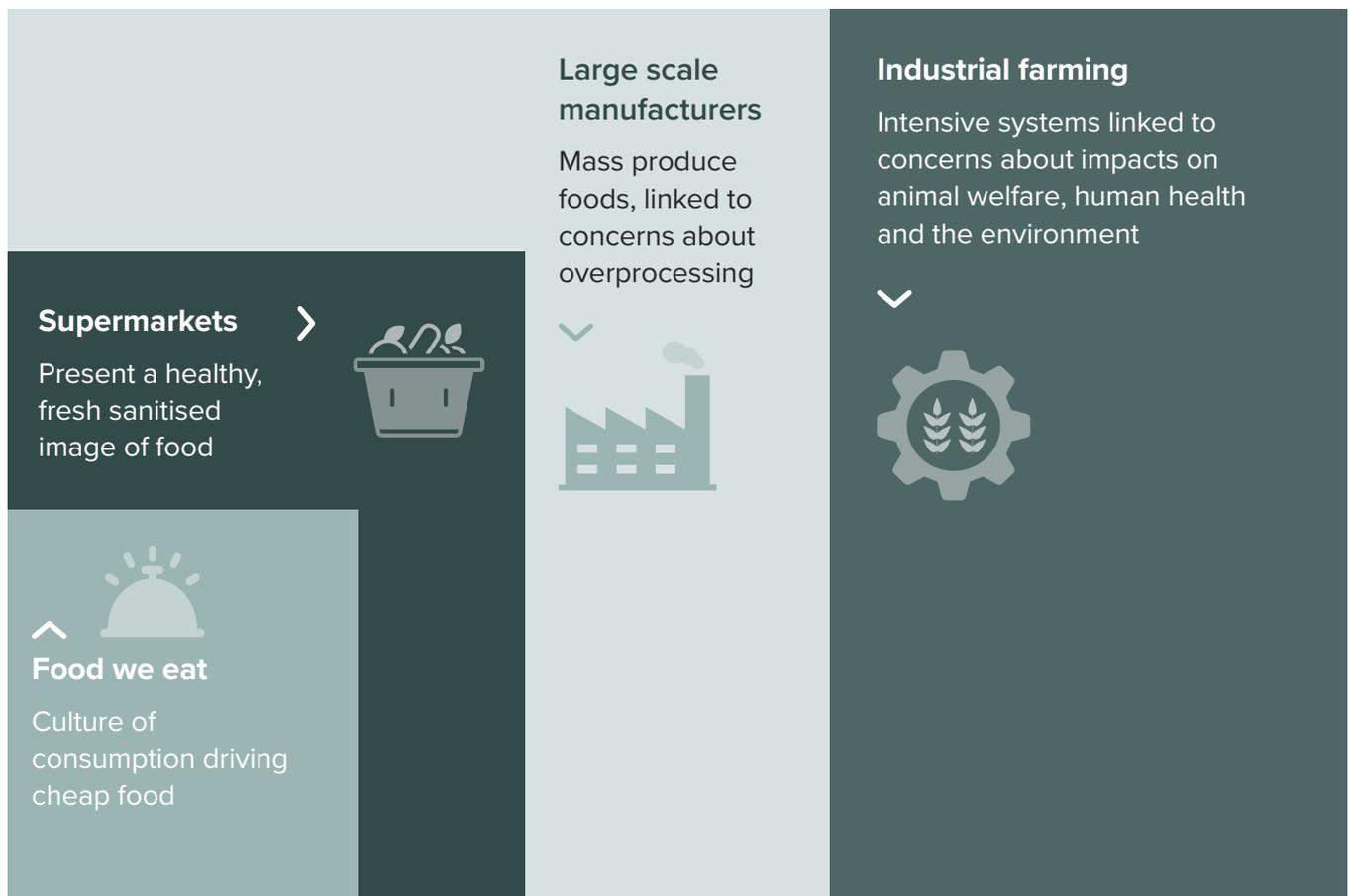
2.1 Participants felt disconnected from how food is produced and lacked trust in industrialised farming

In advance of workshop 1, participants were asked to record a video about their relationship with food and their thoughts on how meat and dairy products are produced. A short film summarising participants' views was shown in the workshop as a prompt for discussion.

While food plays a rich and varied social and cultural role for participants, and is an important and familiar part of their lives and routines, they felt disconnected from how food is produced, which was described as distant and hidden.

Participants described this disconnection in relation to the complex web of activities involved in food production, processing, transport and consumption. The disconnection was viewed as a relatively recent phenomenon (within living memory for older participants), driven by the emergence of large-scale food producers and manufacturers (variously called '*corporations*' or '*the food industry*'), the growth of '*industrialised farming*'²⁸ and a culture of consumerism. Supermarkets and other retailers were also seen to have created an environment where people are spoilt for choice and presented with an overly wholesome, sanitised view of food – with the '*reality*' of food production obscured. This view of the system is summarised in Figure 1.

Figure 1
Participants' view of their relationship to food production



Participants perceived several benefits of industrialised farming and food production, notably a reliable supply of relatively cheap food and access to a wide variety of food choice at any time of the year. Lower-cost and plentiful food had become an important part of participants' expectations when grocery shopping. It was strongly valued and acknowledged as something that would be very challenging to live without.

Despite these significant benefits, a concern of participants was that, given this distance and complexity, it was very hard to know the detail of how food had been produced or the motives of those involved. Specifically, participants were not only concerned about what is done to food, but why and who benefits.

Participants wanted to believe that social, environmental and animal welfare considerations are central to how food is produced. However, this aspiration was seen by participants to be undermined by problems in modern farming – such as pollution and animal welfare – driven by consumer demand to produce ever cheaper food.



Everything is driven by cost. That's just the way it is. And so, consumers have a significant influence on this whole chain of events because, as consumers, we want things cheaper. And that puts pressure on all elements of the system right the way through from the shops to the producers. We have come to expect food cheaply, bought without too much consideration for consequences. If you want to have healthy animals and you don't want your rivers polluted from pesticides and the like, there is a cost impact, which obviously everybody is then caught up in.

Participant, workshop 1

In contrast to this view of a remote, *'industrialised'* food and farming system, participants also discussed *'local food'* production,²⁹ and buying food locally from butchers and *'farmers' markets'*. Participants linked *'locally produced'* food to perceptions of quality and being able to know the provenance of products.

In the context of meat, participants placed value on butchers being able to *'tell the story'* of an animal – where it comes from, how it was reared, what it was fed and so on. In turn, this made participants feel more connected to their food and gave them confidence that food was produced in the *'right way'*.

However, *'locally reared'* meat was also viewed by participants as very expensive, with people paying a premium for what was seen as a modest expectation: that an animal had a good life and was farmed in a *'natural way'*.



[Butchers] give you all the details of the actual beef, where it's come from, you've got the whole story of the animal that's been slaughtered. I pay a huge premium for that.

Participant, workshop 1

Section 2: Farming and food production

Participants drew a distinction between large and conceptually distant agribusinesses, and smaller '*local farms*'. Participants saw agribusinesses as producing cheap and plentiful food, but whose motives were driven by profit and the wish to extract increasing commercial value from animals.

Participants saw '*local farms*' as exhibiting greater care for animals. They were very keen to support '*local farms*', which they viewed as a fundamental part of a thriving and resilient food system, but were concerned about their ability to afford to purchase '*locally produced*' meat. These concerns were also identified in the 'friends and family' dialogue (see Appendix D).

Across groups, participants had a broadly consistent view of these characteristics of '*industrial*' and '*local*' farming. Overall, the costs of caring for animals in '*local farming*' was seen as borne by the consumer. In '*industrial farming*', companies were seen by participants to exploit animals, the costs of which were paid for by society in terms of pollution and by animals in terms of lower welfare. How these factors influenced participants' purchase and consumption of meat is explored in section 3.1.



2.2 There were concerns about food that is highly processed and ‘messed about with’, which in turn was associated with certain applications of genome editing

Arising from this disconnection between the consumption and production of food was a concern that food is highly processed and ‘messed about with’, which was common among participants. In the context of meat and fish, participants variously related this to:

- the unnecessary use of food additives, preservatives and colourings;
- meat being pumped with water;
- chlorinated or ‘bleached’ chicken;³⁰
- the use of hormones,³¹ vaccines and antibiotics in farming.

Participants felt that high levels of processing are required to compensate for problems arising from food production – for example, to make low-quality food look and taste better, or to tackle hygiene issues associated with different farming practices.



I want to know what animals are eating, in terms of hormones and what they’re pumped full of to make them appetising on the shelf... I read quite recently about colour dyes in fish. Like, you see, like a lovely big piece of yellow haddock or like pink salmon and that’s not actually its natural colour.

Participant, workshop 1

This linked to a deeper unease for participants: that, despite the look of a product, ‘*behind closed doors, anything could be going on*’ without any real knowledge or consent of people.

Participants did not frame this unease as a consumer issue. Consequently, this was not about demonstrating their concerns through purchasing decisions. Moreover, consuming cheap food did not mean that people consented to the way it was produced (as people were financially constrained over food choices).³²

Rather, participants felt that greater transparency was needed in the ‘*agricultural industry*’. Moreover, participants identified the need for public rather than consumer values – such as ‘*providing sustenance to the nation*’ – to shape the food production system.



As a society we need to be shining a light into these dark corners. I feel like the feed and agriculture industry is just not well lit... They’re providing the sustenance to the nation. And I feel like we need to rekindle that relationship that I feel like was there in the past with the providers of our needs. I don’t think it’s just there in the 21st century.

Participant, workshop 2

The greater emphasis on public rather than consumer values when thinking about food increased between the first and second workshop, and (as will be explored later) became a factor in how participants considered GEFA. In part, this was in response to discussions with other participants – for instance, the affordability of meat and the role of meat in different diets were framed more as public rather than individual issues.

Information provided in the second workshop explored the impacts of food production as a system. Thinking about addressing these challenges prompted participants to think more about the social desirability of different ways of producing food. Specifically, there was greater focus on discussing what we should do as a society to develop a better food system, rather than frame food production as responding to consumer choice.

This framing of ‘*messing about with*’ food for profit was returned to when participants discussed GEFA applications in workshop 3. Participants did not associate such motives with all uses of the technology. Rather, they centred on those applications that aimed to improve the productivity of farming and the nutritional quality of food – applications that primarily concern the production and consumption of food.

“

What are the knock-on effects if you’re changing the meat product? I don’t like the idea of bleached chicken or chemicals, hormones being pumped into food or even seafood on a shelf. So even that makes me feel unsettled, let alone the very DNA of this creature has been changed for the sake of human consumption. That does feel quite extreme on paper, but I don’t know that much about it.

Participant, workshop 3

“

I think that out of all applications we’ve talked about so far, [developing elite breeding lines through surrogate sires] is the one that’s kind of made me feel the most uncomfortable. I think I’d use the word *messing with*... I don’t know, it just feels very I don’t know... I think the thing that’s making me uncomfortable with everything is the word *productive*. That word *productive* just feeds into that whole thing with me of just feeling like it’s for [commercial] gain, and that still just doesn’t sit right with me.

Participant, workshop 3

While participants saw potential applications of GEFA as having multiple uses, the primary purpose mattered as it was seen as influential in how GEFA would be shaped. The use of genome editing for farming productivity was seen by participants as likely to be exploited by large food businesses.



2.3 The use of genome editing to further intensify farming lacked support

The principles of intensive and agroecological farming systems were shared with participants and discussed in workshop 2.³³ These were chosen not only to illustrate different food production systems, but also to show how different technologies could work in each system.

In the information provided to participants:

- Intensive animal farming systems were described as focused on maximising the amount of food produced, with the minimal amounts of resources, and doing this in a way that keeps animals physically healthy and provides an affordable supply of meat.
- Agroecological animal farming systems were described as involving small-scale food production, with lower stocking densities. The focus was to improve biodiversity, soil and plant quality and keep farmed animals healthy. It included the use of less soya for animal feed and more grass and insects for animal feed.

Participants' views on different systems evolved as they discussed with each other the benefits and shortcomings of each system.

'Control' (of humans, over nature) was a key concept used by participants in discussions, particularly by those participants who questioned the use of technical fixes for complex problems, such the environmental and social impacts arising from animal farming. Control was discussed in two ways: controlling an animal (which was contrasted with the freedom to be an animal) and the belief we can fully control nature (which was seen as misguided and can lead to unintended consequences). These issues were central to participants' concerns about the impacts of GEFA and are discussed in more depth later (see section 5.1).

When reviewing and discussing intensive farming systems, participants saw certain benefits, especially regarding the monitoring and management of animal health. For example, in the context of pig breeding, swine flu was discussed as a major problem, and participants thought that housing animals in indoor facilities could potentially help manage biohazards, such as infectious disease.

However, for those participants less supportive of intensive systems, housing animals in large numbers and in '*artificial conditions*' was perceived as unnatural and very much against the grain of animals being able to lead '*a good life*' (a good life for animals was a key ethical concern – see section 3.1).

For participants more supportive of intensive farming, the reality of feeding a growing population with affordable food was paramount. Through this lens, these participants had a greater propensity to see intensive systems as safe and affording a secure environment to protect an animal's basic needs. While the system was still seen as '*unnatural*', *fundamentally 'people needed to eat'*.



It's a really hard one to think with me because as I said, we need more food. And as I was thinking earlier, with chickens, if our population grows and if those people are going to be meat eaters we would run out of chicken. If we let our pigs roam free, we would run out of pork. It's just a really hard thing to get around. It's either the population's or the animal's welfare.

Participant, workshop 2



I think it's difficult because obviously we've got a growing population that needs feeding, but should we be mass-producing these animals in such an unnatural way? If there's not enough animals to feed us, there's other foods we can eat. Do we sacrifice animals living in a natural way just to feed humans? I don't know, it's just really difficult. People need to eat.

Participant, workshop 2

Agroecological farming systems were generally viewed more positively by participants than intensive systems, with benefits perceived in terms of lower environmental impacts, higher animal welfare, better-quality meat and promoting human health. Overall, agroecological systems were described by participants as more natural, enabling animals to live a *'good life'* with freedom. Participants also used words like *'harmony'* and *'balance'* with nature when discussing agroecology and were supportive of the idea of *'using nature to support itself'*. Participants also associated this system with a traditional, *'farmed landscape'* view of the UK countryside.



Even though it's going to produce less meat, it's going to be of higher quality, from what I gathered. Also, it's going to create a bit more harmony with the husbandry industry and the farming industry and the environment.

Participant, workshop 2

Notwithstanding the above, participants had practical concerns about adopting an agroecological model as the main system of farming in the UK.

Participants' concerns centred on two questions:



— Can it produce enough meat to sustain a growing population?



— What are the implications for the affordability of meat for those less well off?

Participants felt that a greater focus on agroecological farming would likely need to be coupled with dietary change (eating less meat) to be achievable. There were mixed views on how likely this was to happen, and on how desirable or necessary changes to meat consumption are.



One of the challenges of this model is it's more expensive, and it will mean lower yields. And whether we'll threaten our ability to keep up with demand is another issue. But you could argue that if we need to reduce our meat consumption by 30%, maybe by 2030, then that's not such a problem. So, I think it's how we balance the food production with the environmental benefit this system will provide. I think it probably needs a wider diet change to enable this kind of vision to be practical.

Participant, workshop 2

Overall, participants believed the required diet change was unlikely to be brought about by individual consumers, and *'we need government action on diet to incentivise this'* (see section 4.3.2).

While less common, certain participants (including those who worked on farms), were more dismissive of agroecological systems, describing them as *'fairy-tale farming'*, divorced from the realities of food production, which presented risks to outdoor animals from infectious disease.

“

My initial thought was that the consumer has gone so far away from knowing what the animals do and what is best for the animals that this seems to be a fluffy utopia. We used to house our pigs outdoors. They used to roam freely, within reason. But we found that the biggest disease risk was birds coming. Why would we want to increase the amount of birds?

Participant, workshop 2



When participants reflected on different farming systems, the issues appeared more complex and less like a binary trade-off between animal welfare and productivity.

Two issues were particularly influential on participants' views: whether or not we should eat less meat as a society and the alternatives to greater food productivity.

Information was provided to participants on both issues. Alternative proteins (such as synthetic meat, insects, proteins from pea and soya) were discussed as a way to eat less meat, and reducing food waste and the potential use of meat taxes as alternatives to increasing production.

Participants had varying views on these alternatives, which are discussed in the next section. But, importantly, this information encouraged discussion within groups about choices we could make as a society to address problems in the food system.

This consideration of alternatives to GEFA became more prominent as the dialogue progressed.

Participants did not just react to the information provided. Rather, it sparked broader discussion in the groups. For example, while addressing problems of food waste was a very significant concern for participants, it also led them to question how food was distributed and wider issues of demand and supply within the global food system.

While taxes to encourage reduced meat consumption had little support and views on alternative proteins were mixed (discussed in 4.3.2), the consideration of alternatives opened up the discussion and helped people imagine different futures than farming greater numbers of animals.

In this context, and despite different views on the policy levers to pull, there was a broad consensus among participants that creating an increasingly intensive farming system, and producing more meat, was a very limited view of the future of food. Participants viewed such production as driving rather than just responding to consumer demand, described as '*an Amazon culture consumerism, leaking into food*'.

As one participant noted, '*you can't solve a problem by continuing to do the same thing over and over again*', and while intensification was thought to have a possible positive short-term impact, it was felt that this does not address the long-term problems in the food system, or deal with a pattern of production and consumption that participants viewed as '*out of balance*'.

While participants acknowledged there will always be a mix of farming systems, GEFA was perceived by participants as less desirable when supporting intensive farming practices.³⁴ If used in intensive systems, improving animal health and welfare was seen as paramount, and it was felt that GEFA should not be used to lower such standards.



I thought that's what we were trying to get away from, for example, the chickens and battery farming, that's something that we as a country, I believe we're trying to get away from. And I don't believe [using GEFA] would be in our interest to go the same way with larger animals.

Participant, workshop 2



Animal farming and welfare

3

Participants' views on farming animals, animal welfare and breeding animals for specific traits are discussed in this section. This includes how participants reconciled eating animals with their respect for them, and the tension between duties to protect animal welfare and duties towards supporting people to have what they perceive to be an affordable, healthy diet.

Key themes include:

- Eating meat is a source of sustenance and pleasure for many participants.
- Participants acknowledged they have a romanticised view of animal farming, and some engaged in '*wilful ignorance*' concerning how animals are housed, reared and slaughtered.³⁵
- It is less the act of slaughter but the ability of animals to have a good life that mattered to many participants.
- There were different values associated with the need to provide a good life for animals (associated with freedom to express itself, care and compassion) and the need to provide society with affordable, healthy food (associated with security, fairness and wellbeing). What people eat and how it is produced were key considerations in this.
- Creating an animal with specific characteristics through breeding technologies (including GEFA) presents distinct challenges and responsibilities when considering animal welfare.

The information reviewed by participants as part of these discussions is summarised in section 2, (2.1). The specific information on which participants drew is given in the text overleaf.

3.1 Participants felt we have a duty to provide farmed animals with a good life

Participants liked to believe and took in good faith that the UK generally has good standards of animal welfare and animals are generally well looked after. This was often framed in relation to perceptions of welfare standards in other countries. While participants were aware of various food or farm assurance labelling schemes, they did not have any real sense of what these mean in practice. Indeed, when greater detail was shown to participants of different farm assurance schemes, the space that animals were provided with less than assumed and the industrial size and scale of sheds housing indoor-reared chickens was seen as *'unnatural'*.³⁶

Participants acknowledged they have a romanticised view of how animals are farmed and the reality is likely to be different. Even participants living in rural areas suspected that the livestock they see in local fields is not typical of how much of the food on their plate is produced (suspecting that this comes from more intensive, indoor conditions). Overall, certain participants said they adopted a *'wilful ignorance'* around where meat comes from, due to feelings of guilt, animal welfare considerations and ethical concerns around killing animals.



People know what's good and what's bad. We choose to ignore it because we like the taste and it's easy to do.

Participant, workshop 1



I need to think about where my food comes from and how it was produced, and maybe there's a slight guilt sometimes when you haven't thought about it enough.

Participant, workshop 1

Most participants in the dialogue ate meat,³⁷ and for many it was a source of pleasure, as well as a key part of their diet. But they also cared about animals and their treatment. Participants negotiated their respect for farmed animals and their welfare, and their ultimate use as food, by reflecting on a distinction between the animals and the product. For participants, this process of reflection on eating meat was not something they considered routinely – having previously described themselves as feeling disconnected from food production.

Rather it emerged through the time and space given in the dialogue to discuss this issue.



I was always sort of disconnected between like, I buy meats in supermarkets or the butchers and stuff like that, and I don't necessarily associate it with an animal. I just associated it with something I can eat.

Participant, workshop 1

For certain participants, this was a powerful, reflective moment leading them to question the meat they ate and why, the animals involved in the production process and the consequences of their choices. This was challenging for participants and resulted in four main responses.

First was a stated desire to cut down on the amount of meat consumed. While several participants noted they had eaten less meat in recent years, this was predominantly due to the cost and for health reasons. The dialogue brought issues of animal welfare and the impacts from animal farming more central to their consideration, and in some instances led people to consider becoming vegetarian.



I am not a vegetarian and I do eat meat. I don't eat meat very often, but actually from doing this, I am starting to question whether I really would want to eat meat.

Participant, workshop 4

Second was a fatalistic view that the food system is hard to change. For these participants, the scale of animal farming needed to meet the demand inevitably would have consequences for animal welfare. There was a sense that people had limited power to change the system, and that an individual's choice whether to eat meat, fish or dairy was a drop in the ocean given the scale of consumption.

Third were participants who wished to find out more about the food system and the impacts of farming animals and a consequence of engaging in the dialogue.

Fourth, and more common, was an active choice for participants to try not to think about the lives of animals they ate, described as a '*wilful ignorance*' or '*ignorant bliss*' of not having to deeply think about the consequences of eating meat or the pressure on the food system.



As others have said, it's something that sort of you're aware of, but you try and ignore it. If you went around day to day thinking about the increase of the population, the climate change, animal welfare, you can't deal with it – it would seem like a hopeless case... But I need to try to, and find a better balance, buying smaller quantities of meat raised in an ethically good way.

Participant, workshop 2

Given that '*wilful ignorance*' was a common response, participants felt that it was difficult to ensure animal welfare was safeguarded through consumer choice (as people did not routinely consider such issues when purchasing the weekly shop) and there was a legitimate role for public policy to provide better constraints and standards.



We're making informed decisions' on biased information. We need to promote animal welfare more and things that ultimately reduce our consumption...

The welfare of animals is never on the agenda [of government] it is all about meat eating and profit. It needs to be oriented towards that.

Participant, workshop 4

The idea of providing ‘*a good life*’ for farmed animals was central to this – a term initially formulated by participants and subsequently presented back as a concept in later workshops.



I’m very much on the side of animal welfare, making sure that animals, if they’re going to be slaughtered for food purposes, then they must have a good life, the best life possible, free of stress with natural behaviour.

Participant, workshop 3

A good life for an animal was considered to go beyond its health and welfare, though both aspects were important to participants. It linked to an ability of an animal to behave and live naturally, and, importantly to act out its true nature – for instance, a sow being able to root, forage and nest build and so on.

Participants identified several factors that influenced an animal’s good life:

- to have sufficient space;
- to have access to food, water and shelter;
- to be healthy;
- to live in a natural environment;
- to have an ability to roam and behave ‘naturally’;
- to be happy;
- to be slaughtered without undue stress.

While these factors broadly map onto the Five Freedoms for animal welfare³⁸ – shown as part of the information participants looked at in workshop 1 – they had already emerged spontaneously in initial discussions and were articulated in different contexts throughout the dialogue process.

There was a clear and positive correlation in participants’ minds between an animal’s wellbeing, the quality of meat in terms of its taste and nutrition and the environment in which an animal is reared. The factors above were often associated with different farming systems – and were less associated with intensive farming.

Breeding technologies were seen by participants as presenting different challenges and responsibilities when considering animal welfare, and raised distinctive welfare uncertainties.

Notably this concerned developing traits that enable an animal to adapt to the farming system (such as a harsh environment, or being tolerant of being kept in crowded conditions).

Specifically, participants felt that those involved in the development and application of breeding technologies should protect the animal’s interest and wellbeing and not just employ them to serve human interests. Participants wanted benefits for animals to be a central consideration in GEFA’s potential use.



3.2 **Different principles and values were associated with animal welfare, compared with supporting people to have an affordable, healthy diet**

While animal welfare was considered important, the affordability of food was also a very significant issue for participants, made more acute by the cost-of-living crisis being experienced by many households in 2022.

Specifically, while cheaper meat and fish products were associated by participants with food of lower quality, lower animal welfare standards and greater environmental impacts, being able to buy higher-welfare foods was seen as a privilege that few can afford because of rising food prices.

While certain participants adopted a *'less, but better'* approach to the amount and quality of meat they ate, it was common for participants not only to have reduced their meat and fish consumption, but also to have changed the type of meat and fish they choose, and where they purchase food from due to cost pressures.

In many participants' diets, meat was seen as a necessity. Consequently, key issues for participants were the production of affordable, good-quality meat, fish and dairy products and not to stigmatise those unable to afford higher-welfare foods.

Overall, participants associated different values with animal welfare, compared with supporting people to have an affordable, healthy diet. These are summarised in Figure 2.

“

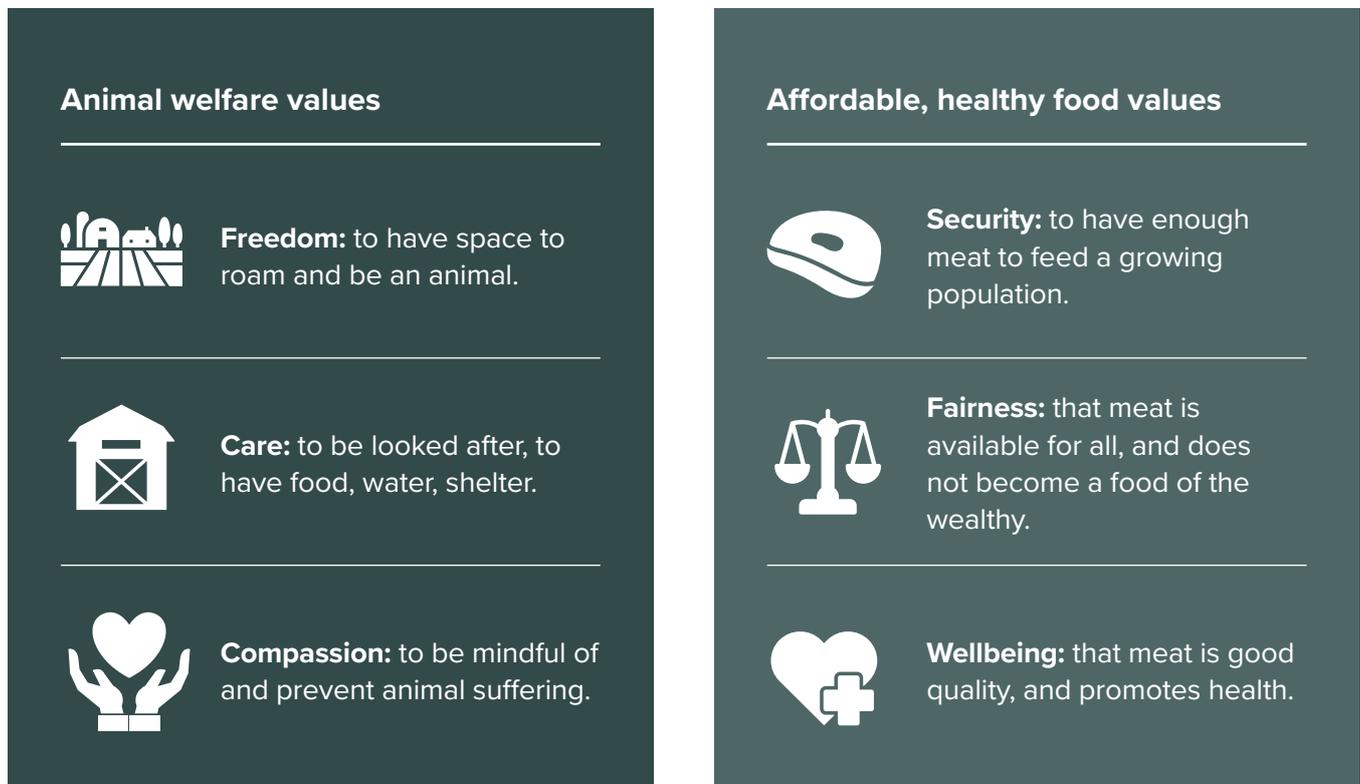
It's definitely affected where I get meat from at the moment because of the price, because of the cost-of-living crisis. I've really changed where I get it from and the amount I consume because of it.

Participant, workshop 1



Figure 2

Main values associated with animal welfare, and affordable healthy food



While these values were not seen as mutually exclusive and individual participants considered and articulated aspects of both during the dialogue, there was a tendency for participants to emphasise different dimensions. Two perspectives emerged.

First were participants for whom there was a hierarchy of needs, and the most fundamental were about an ability to feed yourself and your family. While considerations for animal welfare were important, they were secondary concerns. This was a significant though not dominant view in the dialogue.



It's sort of hierarchy of needs and you focus on what your immediate needs are. With COVID and more recently, the rising costs of food, people aren't going to be looking at packets of meat thinking, I wonder where this came from. Was this ethically sourced? They're going to wonder if they can afford it and if they can afford to feed their family.

Participant, workshop 2

Second were participants for whom framing the discussion between affordability versus welfare was felt to be narrow. This was not about preventing people being able to eat a healthy, affordable diet but rather the choices we make as a society concerning what diets should be and how animals are treated in this context. Such participants felt a duty to look after farmed animals, specifically because they are reared for food. This view became more dominant as the dialogue progressed as participants reflected on why they ate meat.

“

We share this planet with these animals and we consider ourselves superior, and in that capacity, we really should be looking after them. We should treat them in many ways as equals with regard to pain, sensation and general cruelty... The way I sort of think about it is, if I was a cow, if I was a pig, would I be happy to live that animal's life as if I was that animal? And if you wouldn't be happy enough to be that animal, then you shouldn't be supporting that system and eating that food.

Participant, workshop 2



There were two perspectives that emerged from discussions:³⁹

1

For those mindful of affordability, there is an obligation to ensure that people can afford to eat a healthy, nutritious diet, and meat is seen as a fundamental part of this. While important, for them, farmed animal welfare is secondary to feeding a family, and animals are ultimately farmed to be eaten. Raising prices is fraught with moral problems, potentially making meat unaffordable for the least well off in society.

2

For those more mindful of welfare, there is a duty of care for animals, and farming should not be at the expense of their wellbeing. People can exercise choice in their diet and eat less meat, which in turn can be of higher quality and better for them. In turn, this leads them to value the meat people eat, and see animals as having intrinsic worth.

In considering this, as a purpose, participants felt the affordability of meat was not how the current food system operated. Rather, they drew a distinction between ‘*affordable*’ meat and ‘*cheap*’ meat.

In particular, participants saw intensive production and rearing practices – which created the conditions for ‘*cheap*’ meat – as being concerned with improving company profit margins and a desire to extract value in the supply chain. Processed and fast foods, including processed meat substitutes, were seen by participants as emblematic of this – a sign of a throwaway consumer culture and a society that has lost touch with the value of food.

This was felt to be different from a society that values ‘*affordable*’ meat, which would involve a system set up to ensure people have support and skills to eat well and can afford to eat a nutritious diet (of which meat and alternatives would be a part), and which is geared towards human health and wellbeing.

While there was a range of discussions on animal welfare and affordability, participants believed the dietary choices we make as a society, and the way we treat animals, were generally matters of public interest rather than of individual choice.

The role of GEFA in this context is now discussed.

Participant views on potential applications of GEFA

4

Participants' views on different applications GEFA are discussed in this section. In considering potential applications, participants generally discussed the good for society (rather than themselves as individual consumers) and focused on three issues: the reason for using GEFA, the problems GEFA aims to address and who benefits from its use.

Applications of GEFA to improve animal and human health were perceived by participants as having greater potential to address problems in the food and farming system than those that aimed to improve farming productivity, dietary choice and the environment. A range of aspirations participants had for the future of food and farming are also discussed, which give a guide to other purposes for which GEFA may potentially be used.

Key themes include:

- Participants wanted to understand GEFA's purpose, impacts and wider consequences to be able to establish its value and potential use. They also wanted to understand what the alternatives are.
- In exploring different application areas, a series of principles were articulated by participants as they discussed the potential application of GEFA.⁴⁰ Benefits to animals were of central importance, with benefits to humans often defined in relation to these.
- Potential applications to support farming productivity were more associated with '*breeding technologies*' than with other application areas. In turn farming productivity applications ran the risk of being driven by profit purpose and used to extract value across the supply chain.
- Participants felt that setting out a clear vision for the future of food and farming – that served the public rather than just consumer interests – was important to provide clearer direction concerning the conditions under which GEFA may be developed.

To inform their discussions, participants explored 14 potential application areas of GEFA, which were clustered into five categories – each with a different primary purpose.⁴¹ The purpose and application areas are summarised in table 1. Full details of the information can be found [here*](#).

Table 1

Purpose and potential applications of GEFA discussed in the dialogue

Primary purpose	Potential GEFA applications where information was provided to participants
To improve animal health and welfare	<ul style="list-style-type: none"> • To reduce the susceptibility to and transmission of porcine reproductive and respiratory syndrome (PRRS). • To prevent the need to cull male chicks. • To prevent the need to castrate animals, by keeping them in a state of pre-pubescence. • To prevent the need to remove horns of cattle.
To address environmental problems resulting from farming animals	<ul style="list-style-type: none"> • To reduce GHG emissions by genome editing animals to produce less methane. • To reduce the resources needed to farm animals, via improvements in production efficiency.
To improve farming productivity	<ul style="list-style-type: none"> • To improve farmed animal breeding and spread elite genetics efficiently. • To improve resistance to sea lice infestation in farmed salmon. • To increase an animal’s tolerance to environmental changes.
To improve human health	<ul style="list-style-type: none"> • To control zoonoses such as brucellosis and influenzas. • To engineer anti-microbials and prevent the overuse of antibiotics in farming.
To provide consumer benefits, such as the affordability of meat and addressing dietary health issues	<ul style="list-style-type: none"> • To improve the nutritional quality of meat. • To increase the affordability of meat products, through improving reproduction or growth rates. • To reduce the allergenicity of meat.

*<https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals-2>

4.1 Participants questioned the purpose and consequences of GEFA and how various problems in the farming system have arisen

The purpose and consequences of GEFA were very important to participants and were among the main questions asked about the technology, in addition to safety. When considering GEFA, participants' questions fell into two broad areas.

The first concerned general reactions to the technology. These questions were articulated by participants in workshop 1, when genome editing was first introduced. These questions included:

 — What is the overall purpose of GEFA?

 — Why are we considering it now? Are we at the point where we really need it?

 — Where will it lead?

 — Does this '*open the door*' to wider uses of the technology?

 — How can you contain its use?

 — If it goes wrong, can it be undone?

 — What are the costs associated with the development of the technology? Is this money better spent on other things?

 — What will happen to '*conventional farming*'?⁴²

Related to these general questions, a second set of questions considered specific potential applications of GEFA. These were articulated by participants in workshop 3. The questions included:⁴³

Through seeking answers to both series of questions, and in deliberation with specialists, participants considered the potential use of GEFA in terms of its benefits to society. This was informed by the two perspectives discussed in the last chapter (section 3.2) concerning animal welfare and affordability.



— What is the purpose of GEFA in this application?



— How has the issue arisen?



— Who benefits from using GEFA to address the issue?



— Is the use of GEFA complex?⁴⁴



— Are there alternatives and how do these compare to GEFA?

4.2

GEFA applications to improve animal and human health were felt to have greater potential for society than those to improve farming productivity, the environment and diet-related health

When considering applications of GEFA, participants discussed a complex interplay between GEFA's purpose, benefits and potential for unforeseen impacts and in the light of potentially available alternatives to genome editing to address each issue.

Broadly, participants believed GEFA applications that aimed to improve animal health and wellbeing, and to a lesser extent human health, had greater potential in terms of just outcomes for animals and society. Animal benefit was an important consideration, and seen as appropriate in return for altering an animal's genome.⁴⁵ Human health benefits were seen as appropriate in the context of the impact of zoonotic diseases on society. COVID-19 was a dominant reference point in terms of damage wrought on human health, healthcare systems and the economy. In the context of COVID-19, GEFA was seen by participants as a potentially powerful tool to prevent zoonotic disease.

Applications where the primary purpose was to increase the productivity of farming were seen as having less potential for society. The beneficiaries of such uses of GEFA were seen to be large agribusinesses, with the technology helping to achieve efficiencies for profit purposes. While there was debate in the groups concerning whether such uses of GEFA would be appropriate if it made meat, fish and dairy more affordable (and for many participants this was a key concern), overall participants were sceptical that such consumer benefits would materialise.

Applications for environmental purposes – such as reducing the carbon footprint of animals or their feed – were seen to have greater potential for society in certain contexts, particularly when benefiting farmers and animals in low- and middle-income countries (LMICs). As part of the dialogue, participants were provided with information showing trends in population growth, food demand and world hunger. Specifically, LMICs were seen as having less secure food supplies and greater vulnerability to climate change, which potentially made the use of GEFA appropriate.

In contrast, participants felt there was an overproduction of meat in the UK (as evidenced by high levels of food waste) and relatively high levels of consumption (with older participants discussing changes within their lifetime, when meat was only consumed on a couple of occasions a week).

Participants saw applications to improve nutritional quality of meat to have mixed potential for society. For dietary health applications, participants saw dietary change as a preferred solution to genome editing. Greater potential was seen for GEFA applications that may reduce the allergenicity of animal products. This was because participants did not perceive allergies to be an individual's fault, and there were limited alternatives for those with severe allergies beyond avoiding foods.



I worry for the potential for it not to lower the prices, as profit is put before people. It will just mean we consume more.

Participant, workshop 3

To consider the potential of GEFA for society, participants articulated a set of principles and considerations. These were sometimes ambivalent and in tension. Across groups, the most common principles and considerations were as follows.

- We have a duty of care for farmed animals.
- Meat, fish, and dairy products should be healthy and affordable for all.
- Farmed animals should directly benefit from having their genome edited, and ideally it should support their ability to live a good life.
- Genome editing should not be used to lower the welfare standards of animals.
- Less intrusive alternatives should be looked at (and potentially prioritised) when considering GEFA.
- In certain instances, and where alternatives are lacking, GEFA is permissible mainly for the benefit of human health.⁴⁶
- We should focus on addressing the cause of problems in farming, not just the symptoms.
- Smaller farms and those in LMICs should benefit from the technology, should it be adopted.
- To reduce the risk of unintended consequences, we should focus on simple uses of GEFA (those perceived by participants as actively impacting on a discrete part of a farmed animal or producing traits that are seen in nature).

These principles and considerations were echoed in the ‘friends and family’ dialogue, where there was particular concern that GEFA would drive down standards of animal welfare and would need strong ethical oversight. GEFA applications that supported disease resistance, reduced the suffering of farmed animals or reduced the environmental impacts of farming were perceived by ‘*friends and family*’ to have greater potential for society.

To illustrate the richness and complexity of these discussions, and how these principles were applied, two broad areas are now reviewed in depth, where participants discussed whether it was better to edit the genome of an animal to address a problem or address the source of the problem, often linked by participants to the food and farming system. These options were not seen as mutually exclusive.



4.3 **The ethics of ‘fixing the animal’ or ‘fixing the system’ were discussed throughout all applications, with the alternatives to GEFA important considerations**

Application areas where participants tended to think that ‘fixing the animal’ may be preferable for society included:

- Animal health applications, perceived to address naturally occurring infectious diseases in livestock.
- Human health applications, either where there were perceived benefits for both animals and humans in tackling the diseases (e.g., zoonoses); or where limited alternative interventions exist (anti-microbial resistance, food allergies).
- Applications that were perceived to support farmers and small businesses in LMICs, particularly those that improved an animal’s tolerance to changing climatic conditions given the potential impact of climate change on farming in many developing countries.

Application areas where participants tended to think that ‘fixing the system’ may be preferable for society included:

- Animal welfare applications perceived to have been caused as a direct result of current farming practices.
- Environmental applications, particularly concerning the use of animals to ‘clean up’ human-made problems.⁴⁷
- Human dietary health applications (such as meat with less fat or greater nutritional content), where an individual’s behaviour and dietary choices were perceived to be the cause of the problem.

Participants were often split (collectively and individually) as to whether it was better to change the system (seen as morally better but potentially not feasible or practical to do so), or prudentially to use genome editing as a technical fix, given the scale of challenges facing food system.

Different values were used by participants when considering these applications, and they are explored next.

4.3.1 Fixing the animal

- i. GEFA applications to address infectious disease in animals and humans were seen as potentially less complex and more discrete than alternatives

Overall, participants saw greater potential for applications of GEFA to prevent disease in livestock and fish and to prevent diseases passing from animals to humans.

There were five reasons for this.

First, the emergence of animal diseases and zoonoses was seen by participants as occurring '*in the wild*' and as a consequence of livestock farming. While participants debated the extent to which intensive and extensive farming systems contribute to the spread of infectious disease, all farming systems were viewed as at risk.

Consequently, diseases were seen to arise '*naturally*' which potentially made the use of GEFA appropriate (in contrast to how participants framed '*human made*' problems such as climate change, or diet-related health).⁴⁸

Second, the seriousness, scale and potential spread of infectious diseases were seen as an immediate threat by participants, relative to other application areas. Zoonoses especially were seen to have far-reaching, global impacts, with COVID-19 a dominant reference point.

Given this context, human health was one of the few applications where participants framed potential benefits for people above those of animals.⁴⁹ For animal diseases, in addition to animal health impacts, participants identified wider benefits, such as the potential for animals to spend more time outdoors. The benefit of avoiding a need to cull infected animals was also recognised.



I think, honestly, that's a brilliant idea – how we can use the gene editing to turn off the genetics in animals, for diseases that could cause them and us any danger. Like the COVID outbreak that started in China with an animal. Our health services around the world [would not be under] such strain and it would make a healthier planet.

Participant, workshop 3



Well, in relation to the pigs and PRRS. They will no longer be subject to such a virulent disease, such an awful disease. If that could be eliminated, then it gives them a better lifestyle, a healthy lifestyle, and they enjoy their lifestyle better than having to suffer the symptoms of such a cruel disease.

Participant, workshop 3

Third, the idea of being able to prevent a disease was far more compelling for participants than applications that only treat its symptoms. In the example of PRRS, (Porcine Reproductive and Respiratory Syndrome) the potential to alter the genome to ‘*change the lock, so the disease key will no longer fit*’ – in the words of one specialist – could help prevent disease variants. This idea that genome editing could produce a technical fix superior to alternatives was powerful.

Related to this, participants also viewed health applications as precise: targeting the genome in such a way that it had a discrete effect (such as the influencing receptor for a virus) rather than changing traits that were seen to affect the whole animal (such as an animal’s growth or reproduction). It was also perceived as making small, targeted changes concerning the removal of DNA, which in turn was seen by many as less risky than adding traits.⁵⁰



Why do I like this one [PRRS]?
It’s promising, because you weren’t changing any big aspects of the animal, really, apart from just making it more resistant to certain diseases.

Participant, workshop 3

Fifth, as a breeding technology, GEFA could provide animals with inherited immunity across generations. Participants viewed this as ‘*more humane*’ and ‘*less invasive*’ than repeatedly treating each generation of animals with vaccines that provide them with immunity. Participants saw certain animal and human health applications of genome editing to address infectious diseases as potentially ‘*cleaner*’ than existing treatments.



So, the antimicrobial stuff, stopping mass outbreaks, getting rid of diseases, replacing vaccines with edited genomes things like that. For lack of a better term, these applications are cleaner. I think that could be very beneficial.

Participant, workshop 3



Yeah, I guess it goes back to what I opened with, which is prevention rather than treatment, which I think is beneficial in terms of use less drugs on this animal, which is good for their welfare and human health as well.

Participant, workshop 3

Despite the points raised above, many participants contested animal and human health applications of GEFA. They were sceptical that such benefits would be realised or had concerns about the possibility of new diseases arising, requiring an endless cycle of genetic ‘*tinkering*’ with an animal.

ii. GEFA applications to support farmers in LMICs had greater potential given the perceived need to produce more meat and combat the impacts of climate change in these countries

In general, participants questioned the potential use of GEFA applications to support farming productivity in the UK. However, participants saw GEFA applications in LMICs to support farming productivity and the tolerance of animals to a changing climate as having greater potential.

There were two reasons for this.

First, in workshop 2, participants discussed the challenge of population growth and that almost 10% of the global population already struggled to get enough food to eat. Both were seen to be pressing factors in LMICs.

Second, participants felt the supply of food was limited in developing countries, and likely to worsen in the coming decades given the impact of a changing climate (perceived as a greater threat than animal disease).

It was felt there was hence a strong need to increase meat production in LMICs given potential challenges in producing plant-based foods in harsh environments, to enable people to survive.



Farmers [in LMICs] have got greater problems with climate change and drought than they've got with diseases from animals. You just look at the news now, the great droughts that are on and they're looking at all these farmers' livelihoods. Their families have been decimated because all their animals have died because there's no water and they can't plant crops next year.

Participant, workshop 3

As well as providing food and livelihoods to people, participants had significant concerns that farmed animals in LMICs could be significantly affected by heat stress, a lack of grazing opportunities and a lack of water. Consequently, changing an animal's genome to enable it to tolerate environmental conditions to which it is not adapted had potential welfare benefits.



I think it is important to think about how this could benefit a lot of countries outside of the UK, outside of Europe. It's going to open up a lot of opportunities in countries where weather is super harsh and is quite difficult to rear animals in that sense, I guess with a lot of droughts and that sort of thing. If this can help, I think it's really important to consider.

Participant, workshop 3

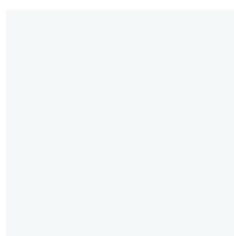
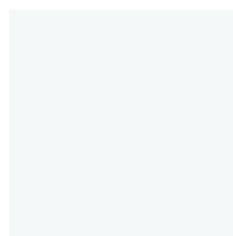
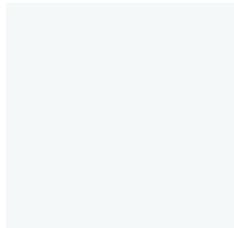
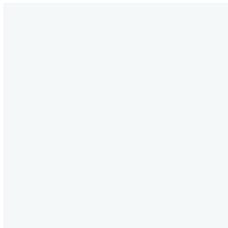
Despite the above, certain participants expressed cynicism as to whether GEFA would really improve the lot of ‘*poor farmers*’ and believed it would more likely be exploited – with the record of large agribusinesses in controlling genetically modified seeds referenced in this context. There were related concerns that the development of hardier animals would provide an incentive to further intensify farming and keep animals in worse conditions (irrespective of climate change).

For GEFA to be used in LMICs, participants discussed whether the technology would or could be made open source. This included considering issues of intellectual property and the ‘*ownership*’ of an animal’s genome, the technical ability in LMICs to develop GEFA and the likely expense involved in the process. Overall, should GEFA be developed, participants were keen to see the technology being made available at low cost, and with appropriate support, to help developing countries.



Are these animals being offered for free to farmers in developing countries or do they come with a payment? Because obviously the genetics are owned by a company, they have to make money on them somehow. So are they, what do you call open source, or are they owned by someone, in which case a payment is made? In which case is that payment too high for farmers or not?

Participant, workshop 3



4.3.2 Fixing the animal

i. Animal welfare and problems arising from intensive farming methods

A duty of care for animals was a significant principle for participants, and several GEFA applications had the potential to be targeted at animal welfare. When examining animal welfare, participants considered this principle in terms of the practices in the current farming system. Specifically, participants saw using genome editing to compensate for poor welfare standards as less desirable than addressing the root causes of why such practices existed at all.

For example, the culling of male chicks of egg laying breeds by maceration was not commonly known about, and seen by participants as wasteful, ‘*shocking*’ and unethical. For removing the horns of cattle and the castration of pigs, the use of genome editing technology to enable an animal to adjust to poor welfare conditions, improve the taste of meat or make them more ‘*manageable*’ were notable concerns.



My immediate reflections of what I’ve just seen is I didn’t realise that there was so much culling and so much destroying. I find it all very horrific and I don’t agree with finding ways that animals can be born correctly. But I’m not into this culling and I found it quite upsetting.

Participant, workshop 3



I worry about we might actually be impairing animals’ ability to show us what welfare problems they’re having. The signs of chickens stripping feathers off each other, [pigs] biting each other’s tails. These are signs something is wrong. They’re telling us about welfare problems and what we’re saying is, let’s take away the tails, the beaks, the horns, so they can’t demonstrate that they’re experiencing poor welfare. That’s not really a solution.

Participant, workshop 3

Participants saw culling male chicks, dehorning cattle and castrating pigs as undertaken for the economic benefit of food producers, with the welfare of the animal a relatively low concern in this context. Participants wanted to know more about alternatives to address animal welfare problems in farming beyond genome editing an animal.

Whether ‘*finding ways that animals can be born correctly*’ or keeping pigs in ‘*eternal adolescence*’, participants were uneasy about the ethics of ‘*changing an animal’s nature*’ for the purposes of preventing such practices. Changes to the ‘*nature*’ of different species of animals were perceived by certain participants to potentially arise from changes to the animal’s genome over time.

ii. Fixing human made environmental problems, and the role for alternatives

Participants were provided with information showing that animal farming required the use of considerable resources – water, feed, land use and so on – which in turn has an environmental impact. Additionally, the information showed direct impacts on the environment from animal waste and the methane that livestock (predominantly cattle) produced.⁵¹

As with the animal welfare example, participants had concerns about the ethics of changing the genome of an animal to fix ‘*human-made*’ problems, such as climate change.

As an example, one application explored by participants was the potential use of genome editing to help reduce the amount of methane produced by livestock. Overall, participants felt that making changes to the crops animals are fed is preferable and less ethically contentious than making changes to the animal.

Genome editing crops for animal feed was discussed together with alternative feed supplements. For example, one specialist participant noted that adding small amounts of seaweed to livestock feed had also been shown to reduce methane emissions. For participants, this underscored the need for other options to be explored, including more ‘*natural solutions*’.

More importantly, participants questioned why we are trying to address climate change by genome editing animals or their feed, rather than changing the farming practices that contribute to climate change. For example, in the context of cattle farming, they felt that focusing on preventing deforestation may be a better solution. Linked to this, participants also raised what some saw as the more fundamental problem of how much meat and animal products we are consuming. They perceived a need to educate people to change their behaviour, concerning the amount of meat they eat, and through this reduce the contribution of animal farming to climate change.



The environment and climate change is the biggest issue facing our global community today. I didn't really agree with that one [editing the genome of an animal to reduce methane production] quite as much. If we didn't keep cutting down all the Amazon rainforests and things, we wouldn't have as much problems. I don't really see why we should have to change cows to cure what is a human problem that we could probably fix in other ways.

Participant, workshop 3



I would say we shouldn't change animals, we should just start changing people. We should just start to educate them, push them to do things for environment. There's something about how we currently produce and consume everything. We don't care about how much it's going to cost.

Participant, workshop 3

Redefining the problem, away from the animal to the system, became a relatively common approach that participants took when discussing the environmental impacts and the need to produce more food.

In this context, taxation was explored as a potential tool to reduce meat consumption. Participants saw a ‘*meat tax*’ as problematic for society, as it disproportionately impacted on those least well off. Rather, support to make better dietary choices was preferred.

In contrast, participants saw tackling food waste as a greater priority for society. Food waste was seen by participant as morally unjustifiable, as well as relatively easier to address, compared with technical solutions.

Participants struggled to understand why greater resources were not given from government and business to eliminating food waste. This was not just about eating more of what we purchase (a consumer issue), but rather dealing with the problems of waste throughout the food system and supply chains.

“

We have milk cows and we have meat cows, we have egg chickens and we have meat chickens. And so the number of animals on the planet are to some extent a reflection of the way modern farming works as opposed to the way it used to work... [And when thinking] about food shortages – we do produce enough food to feed 14 billion people, but we waste so much. And so not getting food to people is really not a problem of not producing enough food. It’s a problem of the way the system works and where the food goes.

Participant, workshop 2



iii. Concerns over editing farmed animals to increase the production of meat or produce *'better quality meat'*

Linked to the themes above, participants discussed the role of GEFA to potentially improve farming efficiencies and produce more affordable meat. Participants defined farming productivity in terms of making more food, more efficiently.

In this context, how participants conceptualised breeding in farming is noteworthy. Participants associated breeding practices with two kinds of objectives.

The first was breeding linked to production traits – the size of an animal and growth rates, and to a lesser extent its reproduction rates.⁵² This type of breeding was commonly seen by participants as excessive, and *'unnatural'* – insofar as it produced traits that were perceived as unlikely to have happened in nature and generally to the detriment of the animal.

These types of traits were associated more with animals kept in intensive farming systems – such as broiler chickens. To a lesser extent, changes to dairy cows enabling them to produce higher volumes of milk were also seen as a negative effect of selective breeding. The concept of *'overbreeding'* was often associated by participants with these types of application.



I think my biggest thing that I'm curious about is how much has like meat and dairy and things changed over the years to humans, like excessively breeding and modifying animals. I've seen pictures of how chickens are different, how far from how it's meant to be.

Participant, workshop 1

Importantly, GEFA applications to improve productivity were more readily (though not exclusively) associated with intensive farming applications, *'overbreeding'* and lower animal welfare.

Certain participants had very significant concerns about this – stoking a belief that it was these types of lower welfare, high-production applications of GEFA that businesses and government were really aiming for, with *'welfare used as a smokescreen'*.



We've got a debate going on in the country... where chickens already have their growth promoted disproportionately in the most appalling way. They basically can't even stand on their own legs because of the weight issues. And this [GEFA to increase production] just seems to be another side of this, more of the same when it comes down to fast-tracking animal growth.

Participant, workshop 3



I think we're trying to be encouraged to believe that welfare is very high on the agenda with genome editing. But it seems to me, looking between the lines, that the priority here is maximising the generation of food irrespective of the cost to the welfare of animals. It's a greenwashing effect.

Participant, workshop 3

Consequently, despite farming animals fundamentally being about food production, participants saw the use of genome editing to support farming productivity as having less potential. Specifically, there were concerns that animals would be exploited and intended consumer benefits – such as the affordability of food – would not materialise.

The second association with breeding made by participants related to quality traits and prize breeds. Here, the focus was producing animals that had good-quality meat and was typically associated with beef. This type of breeding was generally seen by participants as ‘*more natural*’ – linked to what could have happened in nature, where the fittest animals pass on their genes.

“

When it comes to a beast such as steak and a cow, because I can really taste the difference and see the difference and the money required to breed real quality meat, whereas chicken is chicken.

Participant, workshop 1



For many participants, genome editing did not sit well with this ‘*natural farming*’ concept of better-quality meat and nutrition. Moreover, in the context of producing leaner meat to help combat obesity and diabetes, participants’ preferred solution was to support people to change their diet, including consuming less meat and more plant-based proteins.



Nutrition is generally a problem because people can't afford or don't get access to nutritional food. When people have access to that, they can have a perfectly good diet. That's a political and economic thing. And I think a lot of the time people prefer to think you just have a little nice little technical fix. But it's the food system. And if you don't fix the food system, the people who are under nourished at the moment are going to stay under nutrition.

Participant, workshop 3

Alternative proteins were also looked at by participants in the context of dietary health and eating meat. While participants had different views on the role alternative proteins in the food system, one potential use was in replacing processed meats in products.

Across all alternative proteins there was an underlying unease from participants around how sustainable, tasty, nutritious and healthy the products would really be, and therefore whether it was realistic that they would address issues such as obesity. At best, these solutions felt like a compromise to address the impacts of poor diets in the UK.

4.4

GEFA and a future vision for the food system

When reflecting on all applications of GEFA, participants wanted a clear vision for the future of food and farming to enable them to understand how GEFA may support this vision. This not only relates to purpose, but how to link up the wide variety of different potential uses of genome editing into a coherent direction.



What is the strategic aim and vision? How is it going to change the industry? Is it going to save carbon emissions? Is it about future proofing, and making sure that the world is better in the next 50 years?

Participant, workshop 1

Such a strategy would situate GEFA in terms of the mix of the farming systems the UK is aiming for, and the role of meat in people’s diet.

While participants were not tasked with creating this vision during the dialogue, prior to the final workshop, they were asked to reflect on how the group deliberations had shaped their views of the potential role of GEFA in the future of farming. This was an individual exercise completed as a pre-workshop task.

The following five themes emerged:

1 > Promoting animal health and animal welfare needs to be at the heart of farming

Promoting animal health and animal welfare, while important to people from the start of the dialogue, strengthened in importance over the course of discussion. In part this was in relation to participants finding out more about the current conditions in which farmed animals are kept. But it was also in relation to a duty to ensure animals benefit from any potential use of genome editing. This was linked to participants' strong perception that using GEFA may result in animals being exploited.



2 > A food system driven only by costs, efficiency and shaped by market forces, and without regard to values, is likely to be a poor system

Participants' views evolved from the initial workshops where they suggested consumers should have '*free choice*' to eat meat. In later workshops, their perspective broadened to consider how choices shape and are shaped by market forces, and the need to anticipate '*downstream effects and long-term implications*' of GEFA in such a system. There was a significant concern – growing over the course of the dialogue – that leaving the technology to the market may result in '*short-term gain, at long-term cost*'. This view was driven by people reflecting on who was likely to own the technology, the global economic drivers of the farming system and the profit motives of a small number of large businesses that were likely to benefit from this system.

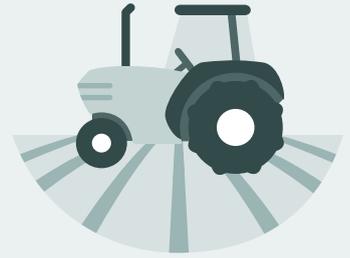


3 > With caution, and in certain circumstances, GEFA could have a role in farming, though it is not akin to conventional farming

Over the course of the dialogue, participants grew ever more informed about *'what's involved in animal health and welfare, and the impacts of genome editing'*.

They also learned more about genome editing relative to other breeding practices. Participants specifically questioned the idea that GEFA was *'little more than what's already happening when breeders select traits'*. Rather, participants felt that such a narrow positioning of the technology *'undermined lots of valid questions and concerns'*, and that genome editing has the potential to create *'a new kind of organism'*,⁵³ worthy of specific attention. In short, properly debating the nature and implications of the technology was valued.

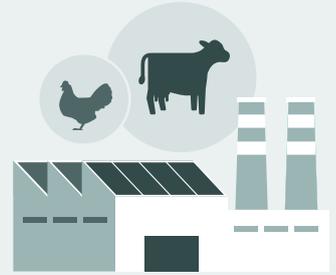
Participants were mixed in their views as to whether such debate made them more open to GEFA, but several remarked that they had changed their mind, particularly in relation to animal health interventions. The *'changing the lock'* metaphor (see 4.3.1) was a particularly potent idea for communicating the efficacy of the technology in this context.



4 > Time needs to be given to consider long term consequences of GEFA

The time horizon over which food production and consumption is considered also changed over the course of the dialogue. Initial discussions on food were shaped by participants' experiences of purchasing and consuming food, situated in the moment and associated with speed and immediacy. Giving participants space to reflect on the food they eat, where it comes from and how it was produced allowed them to think beyond moments of consumption to the longer-term implications. This longer-term outlook was also reflected in how they conceptualised GEFA and the issues impacting on farming – with certain groups keen to consider what farming and the animals themselves may look like *'20 years plus down the line'*. As will be discussed below, this has implications for regulation.





5 > We need to tackle the causes of the problems associated with farming animals and explore alternatives to GEFA to address this

A significant way in which participants' views developed was in terms of how they thought about food, from feeling very disconnected from how food was produced at the beginning of the dialogue to feeling more informed (and less disconnected) from the complexity of food as a system of production.

This systemic view of food was noteworthy in the latter workshops, where participants were keen for decision makers to tackle the underlying problems associated with farming animals rather than just the symptoms. Applications of GEFA were often associated with the latter – *'a quick fix to the poor consequences of this farming model'* in the words of one participant. Consequently, participants were very keen to see alternatives to GEFA properly explored.

Overall, participants felt it is important that if GEFA is developed and used, it is done so in the public interest, to include consideration of social and ethical values and govern food production in a way that encourages the features described above. The conditions to enable this are explored in more depth in the next section.

Conditions under which GEFA may be developed and applied

5

This section describes the conditions under which participants found the prospective uses of GEFA acceptable and/or desirable. The discussion is in two parts.

The first concerns the potential consequences of the technology, with GEFA needing to be safe in the long-term and wider implications anticipated – for humans, farmed animals and the farming system.

The second concerns how organisations supporting the development of potential applications of GEFA should respond to this challenge and how research, policy and regulation may be developed to promote the public interest.

Key themes identified by participants include:

- Intervening in natural systems was seen as complex and likely to create unanticipated problems.
- Time should be allowed to understand the impacts of GEFA.
- Going down a ‘*technological fix*’ route by using GEFA to address societal challenges may lead to a ‘*constant tinkering*’ with an animal’s genome as new problems arise.
- Wider implications need to be considered. These include:
 - Undesirable uses in humans;
 - ‘*Overuse*’ of genome editing in animals;
 - The impacts of GEFA on the farming system, including the concentration of power in large agribusiness.
- While legislation governing animal research was seen as robust, it was felt that greater transparency in the research process is needed in terms of the procedures employed and the outcomes of the research (including negative results).
- Research should be directed to meet social aspirations for GEFA (e.g., improving animal welfare).
- Regulatory approaches for GEFA raised questions including how long-term impacts are understood and how the technology would be steered in the public interest, rather than directed by market forces.

To support their deliberations on the governance of the technology, participants were provided with information on:

1

The statutory codes of practice covering the welfare of different farmed animal species.

2

An overview of the laws on research using animals, as set out in the Animals (Scientific Procedures) Act 1986 (APSA).

3

Additional processes governing animal research, including reviews by Animal Welfare Ethical Review Boards, as well as consideration of research ethics and wider ethical implications.

4

Principles involved in the development of legislation and policy around GEFA.⁵⁴

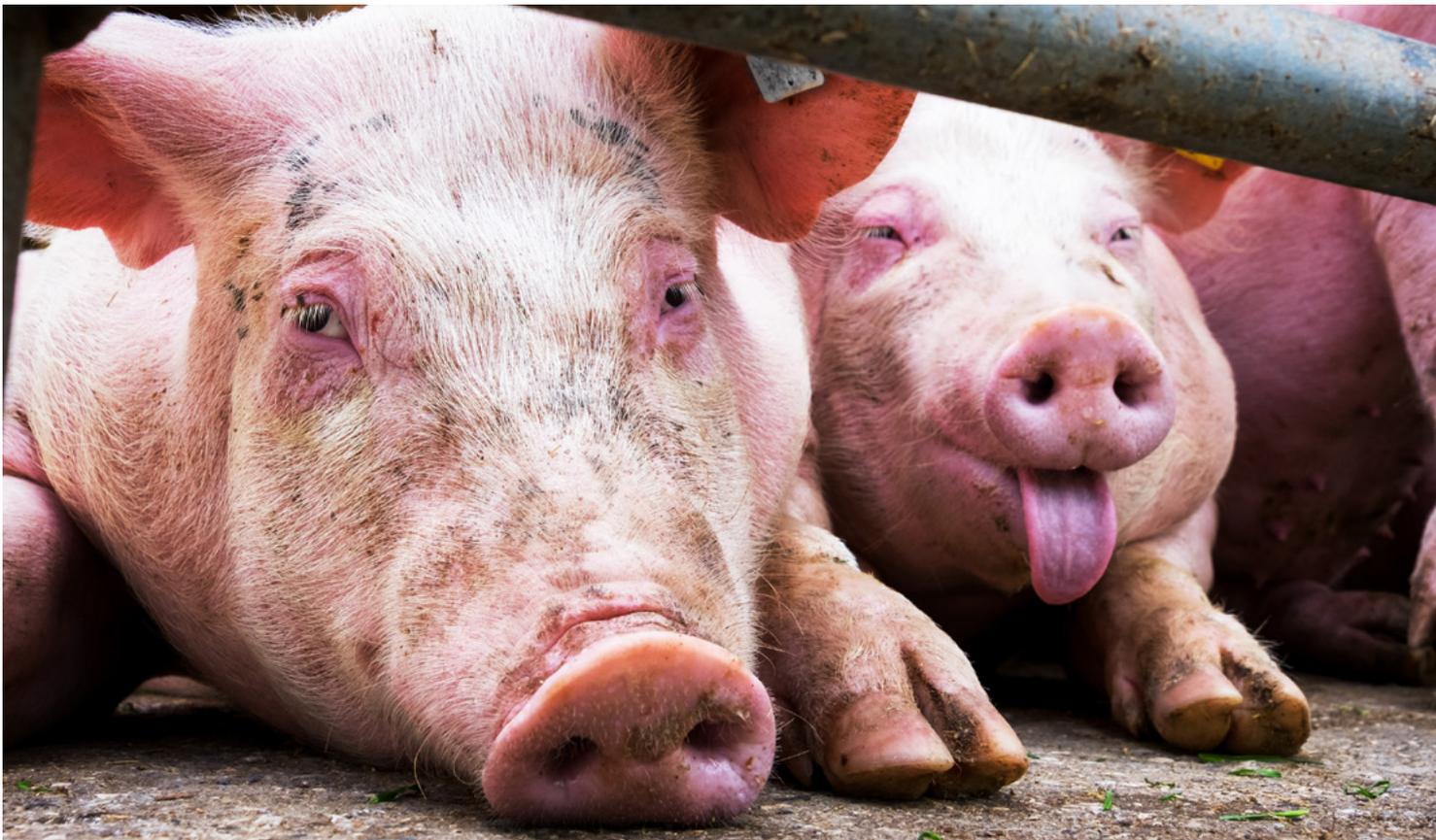
5

How novel foods are currently regulated.

6

Proposals for a two-tier system of regulation for precision breeding/genome edited foods.

Full details of the information provided to participants can be found [here*](#). Additional information is also given in the commentary below.



*<https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals-2>

5.1 Unintended consequences of GEFA

The safety, long-term impact and unintended consequences of GEFA for both humans and animals were seen as fundamental and commonly raised concerns among participants – featuring in some 500 conversations over the course of the dialogue (more than any other theme).⁵⁵

To understand why this is such a deep-seated issue, it is worth reviewing some of the primary associations made by participants with the technology, how participants conceptualise safety, how nature is seen to *'find a way'* and that, despite best intentions to address problems through technologies, new problems arise. Each is now explored.

5.2 Primary associations with GEFA are ones of complexity

Participants saw GEFA as inherently complex.

When first introduced to genome editing, participants were asked to undertake a projective exercise. This method used abstract images to elicit subconscious thoughts and feelings about GEFA. Each participant was asked to pick an image they most closely associated with GEFA and to explain why they had selected it.

Participants' associations were not ones of speed and precision (which was the broad focus of the written information provided) but rather related to the complexity, technical challenges, unintended consequences and ethical implications of the technology. Associations and metaphors included storms, cramming information into cells or traits into animals and the creation of 'better' animals.

GEFA was also commonly framed as *'interfering with'* or *'messing with'* nature, which in turn was associated with having long-term impacts that are hard to predict.



It is kind of like a storm with an eye in the middle, which to me is like the whole process of trying to work it out. Genetics to me would be like a bit of a storm and getting the balance and the actual ethical background on it right, would be the eye.

Participant, workshop 1



It reminds me of the nucleus of the cell for some reason and all of the genetic information, and it looks quite complex. How on earth are you going to get information out of there and put information in? I feel that's sort of representation of what it would be like.

Participant, workshop 1

Participants identified three main questions linked to unintended consequences:

— Is GEFA safe in the long term?

— How much genome editing is too much?

— What are the wider social implications of GEFA?



5.3 Participants wanted greater consideration of longer-term impacts

Participants' concerns about the safety of GEFA generally related to impacts that may happen over time.

As will be discussed later, when learning more about how the safety of food is regulated, participants were reassured that it is both thorough, and applies to both public and private institutions. The big question for participants was whether sufficient consideration had been given to anticipate longer-term impacts that may not be identified through initial research and testing.

Given GEFA is a breeding technology, it was seen by participants as having the potential to make fundamental changes to the genetic makeup of animals, which in turn would be passed through generations. Consequently, participants saw GEFA as potentially influencing the whole food system if it was employed across different farmed animal species. This association of a permanent and far-reaching change was of particular concern for participants – as any problems found would be hard to correct.

This was seen not only in terms of consequences for animal health and welfare, but also the long-term safety of food we eat.



What is the implication that [GEFA] would have on humans, because it's something we don't know about. Unless there's lots of research. Will we know what we need to know now? Will it be ten years time? Will it be 20 years time? We don't know those effects. And that is a major concern.

Participant, workshop 4



Do we know enough about what side effects down the line could be caused by messing about with nature? So I am generally a bit worried about that kind of thing?

Participant, workshop 1



The problem with saying yes to things is that once you say yes, then the door is shut. And what kind of oversight which isn't just contained within universities or in research labs, what kind of oversight is there after that?

Participant, workshop 4

In this context, participants saw 'simple' uses of GEFA (see 4.3.1) as safer and/or more predictable. Limiting wider impacts of GEFA on humans, animals and the environment was seen as a key condition for acceptable development.



What does simplicity mean in this whole world of genome editing? What is simple? Simple would presumably be a piece of genome editing that literally only does cause and effect. I mean, I can't think of an example... If you could make animals more resistant to warm temperatures, you'd need to be certain in nature that wouldn't have a bad impact on something that we haven't thought of. So, simplicity means it doesn't affect anything else.

Participant, workshop 4



5.4 Participants believed '*nature finds a way*' and using GEFA is likely to create other problems

Participants saw GEFA as an example of humans trying to control nature in a way that was unrealistic. They described a concern that '*nature finds a way*' and that unintended variation is inevitable, including the emergence of new diseases or impacts on other (non-targeted) traits.

Genome editing to fix one problem was expected to lead to the '*creation of other problems*', which in turn would require further changes to the genome to fix. Participants questioned what limit would be placed on genome editing in this context.

This idea of nature finding a way to change or alter the intended outcomes for GEFA was particularly seen in the context of human and animal health applications (despite participants seeing such applications of GEFA as having greater potential for society).



The stronger diseases are going to repopulate. They are going to mutate again, so then we will have to change the genome again to cope with those. It will lead to this constant tinkering of the genome. It's an unwinnable thing.

Participant, workshop 3



When is it too far? When is enough, enough? There will be new disease developing. It's going to be non-stop, a sort of tinkering and editing.

Participant, workshop 3



It would be nice for the pigs to not have any risk of this disease, but then, of course, there's loads of other diseases. Recently there was suspected foot and mouth in Norfolk and the latest news is that it probably isn't, but once you've done something for one disease, you're going to have to start doing something for all the other diseases that people get and where does it stop?

Participant, workshop 3

Participants also questioned whether multiple applications of GEFA may be used in a single animal: for example, a pig that was immune to PRRS plus other infectious diseases including zoonoses, that was tolerant of a changing climate, did not create dietary health impacts and so on. This led participants to imagine '*super animals*' that combined many artificially altered traits. The potential for unintended consequences from such '*super animals*' was thought to be more significant than single applications of the technology.

While less common, there was also concern raised by participants about how many changes would be needed to '*perfect a trait*' – this was more seen in applications to improve the productivity of farming, with the impacts on animals being compounded over time. As one participant questioned: '*What do animals start to look like in 20 years' time?*'

5.5

The wider social implications of GEFA were considered in terms of use in humans, 'overuse' in animals and impacts on farming

A final area associated with unintended consequences was the broader uses and implications of using the technology. Participants discussed these in a variety of ways but three main themes emerged: undesirable uses in humans, overuse in animals and the wider impact of GEFA in farming. Each is now explored.

i. Use in humans

As the use of genome editing becomes more routine in animals, participants were concerned about where it might lead. The potential to use genome editing to 'design humans' was frequently raised by participants across workshops, including use for 'designer babies' and eugenics. The responsible direction, use and control of the technology was seen as important.⁵⁶

“

I think whatever they do, it should be a limit, a red line you don't cross. Or you will see a handful of scientists who will be trying out on human beings, to change their genes, to have like a designer baby.

Participant, workshop 4

“

Innovation is great, but you can't help but think how far is it going to go? Are we going to start using all of these technologies on things that are actually quite dangerous territories, like in humans and stuff? I think that word responsible is really important. We need to think why is it needed at the moment? Is it for essential things?

Participant, workshop 4



ii. Overuse in animals

As well as use in humans, the ‘overuse’ of genome editing was raised as a concern by participants in the context of farmed animals.

This included creating new farmed animals with exaggerated traits that were purely for the purpose of commercial gain but would never be found in the natural world. Participants described this in dystopian terms – such as animals being edited to have no legs to increase stocking densities, or changes being made to their bodies (such as additional parts) to produce more meat. This disturbing vision for GEFA was in large part driven by a lack of trust in the system – both food production businesses and how they are regulated – in which the technology would be deployed.

This type of use was particularly associated by participants with ‘*creating a gene that does not exist*’ in nature to develop radically different animal characteristics. In this context, uses of genome editing to bring about traits associated with conventional farming was seen as more acceptable.



It’s the difference between whether the gene already exists somewhere within the animal population. And whether we are, as I understand it, there is the possibility or the potential to be able to create a gene which doesn’t exist anywhere else. To make the animal do something else. So I would like to see some differentiation between the regulation of those two processes.

Participant, workshop 4



Something I would like to know more about is the inserting a gene which already exists in an animal, but we are specifically putting it in there and we’re guaranteeing that it’s going to be in there. I’ve also heard about the innovative genes where we actually try and make the animal do something for which there isn’t already a gene in other parts of the population. I think we probably need to distinguish between those two when we’re looking at the safety implications of taking what’s being produced forward into the food chain.

Participant, workshop 4

In a similar vein, there were also concerns about the use of genome editing with transgenic genetic modification techniques – where the genes from another species would be used to provide new traits (for example, ones that improve productivity or resilience).⁵⁷

Even in the context of using proteins from jellyfish, which was discussed as a fluorescent marker in the application to identify the sex of chicken embryos, there were concerns raised by certain participants about *'not knowing what you are going to create'*, the development of a *'chimera creature at the molecular level'*, through to concerns about what it would do in the food chain: *'I'm not sure how I feel like eating something from a glowing jellyfish'*.

A final concern about overuse of GEFA related to the research process itself (the need to test and learn through experimental techniques). Participants expressed concerns around the power of the science to change an animal at the genetic level, and the fact that experiments can have adverse results. There was a concern that many animals may be born through such genetic experiments, resulting in creatures that are *'horribly deformed or genetically mutated'*. More generally, the number of animals, resulting from experiments, that may need to be humanely destroyed was a concern. Participants' views on the protocols governing research on animals are discussed in section 5.2.1.



iii. The type of farming we develop in the UK and the potential control of GEFA by large agribusinesses

Beyond the specific impacts of the technology on people and farmed animals, participants discussed the implications of GEFA for the type of farming we develop in the UK, and the potential for the technology to be controlled by large agribusinesses. They raised two main points.

The first was the extent to which genome editing may be applied in the farming system, whether there would still be the opportunity for consumers to choose the type of meat they ate (genome-edited or non-genome-edited). This concern was related by participants back to the vision of food and farming the UK wanted to develop (see section 4.4) and how regulation accounts for concerns beyond those relating to food safety.

Second, participants questioned whether smaller farms would be able to afford the technology, and if not, whether they would then be at a disadvantage, making it not viable to farm without genome editing. As noted, participants generally associated the use of the technology with larger agribusinesses. Linked to this, and mirroring discussions about the use of the technology in LMICs (section 4.3.1), participants were concerned about ownership of the technology and the power of a few large businesses having so much control over the food that they eat. Concerns centred on the risks a monopoly could have both for consumers and for smaller producers in restricting choice and controlling prices.



The implication is always that these things are being done by big corporations. You don't want to be putting the little farmer who's just making a living out just because of all these things that are happening that they're not able or wanting to take part.... And I just don't think it's fair to give so much power to a corporation. They get control who gets fed and where and at what price.

Participant, workshop 4



[Genome editing] is going to be too expensive. They're all going to be pushed out. What's going to happen? I mean, what is actually going to happen? All these people. Northern Ireland depends so much on farming as well, there's so many small farmers. I don't know how it's going to work?

Participant, workshop 4



What risks does it carry? How far do they go with it? Do they do 50% of their animals [as GE] and 50% organic or do they do it across the board? And then where does that leave us for the future if it all goes wrong?

Participant, workshop 1

5.6

Governing GEFA

Given the range of concerns described above, participants saw the potential use of GEFA as dependent on being able to steer the technology away from applications more likely to result in unintended consequences and towards those in the public interest. Their views on how this could be achieved through research, policy and regulation are described next.

5.6.1 While policies on research ethics and conduct are reassuring, participants were keen to see more fundamental questions asked about the purpose of research on GEFA

Participants found research involving animals a challenging issue to discuss. Generally, they saw a need to conduct research on animals to advance scientific and medical understanding. Participants felt that research using animals should only be undertaken with great respect for their sentience and be very closely monitored.



Without research [on animals], we wouldn't be as far advanced as we are with cancers and diabetes and everything else. Unfortunately, it is a fact of life.

Participant, workshop 4



We all know that animals in research do suffer pain, and so who monitors that? And that's just not good for me. I don't like it at all... Just because it says it is regulated, it doesn't mean that it isn't allowed to happen.

Participant, workshop 4



Nothing should be made to suffer. I think the animal sentience is the most important thing. If anything is ever going to come out of genome editing, it has to have the greatest respect for the animals, the greatest of respect. And it needs to be shrouded in law, it needs to be checked on, it needs to be looked at to make sure nobody is doing anything that they shouldn't.

Participant, workshop 4

As part of their discussions, participants briefly explored the implications of some provisions of ASPA. Participants were keen to know more details on how the ceiling for pain or harm is set, and how the limits to suffering are understood and reviewed.⁵⁸ Participants also questioned the safeguards on animal research in industry, and whether it is subject to the same protocols. Overall, when hearing more about research using animals, including from a RSPCA spokesperson who noted '*a harm benefit analysis for every project involving animals*', participants were generally reassured and saw the existing regulatory procedures as detailed and specific.



I do feel a lot more reassured just because there's a very specific sort of like regulation. In terms of the pain, [ASPA] seems like a lot more controlled, it's quite easy to grasp because it's spelled out. Certainly, they have more control of the laboratories than they would necessarily have of farms and farming practice.

Participant, workshop 4

Participants' concerns focused less on the detail of regulation of research and more on fundamental questions: Why are we doing this research? Who does it benefit? Do these ends justify any animal suffering involved?

Participants had different views on the level of benefit or harm that would justify a research purpose. This was a complex area, as participants recognised that specific research applications of genome editing may be used for multiple purposes. Participants also wanted a clearer link between each individual experiment and research project and the overall direction of GEFA.

To help build trust in the process, participants suggested greater efforts be made to provide accessible and timely information on what research was funded and why. They also suggested that results of GEFA experiments (positive and negative) should be made available to the public.⁵⁹



Genome editing farmed animals research, all that research should be transparent. People should be able to access what was done, how it was done, and it should be in the language that they can understand as well.

Participant, workshop 4



How do we balance potential harms to animals in these research settings, to the potential wider good and benefit that might come from the different applications of genome editing? I think if there's something that causes minimal harm or distress and I think it's already kind of that can be a bit more accepted, I also think it depends what we're doing it for.

Participant, workshop 4



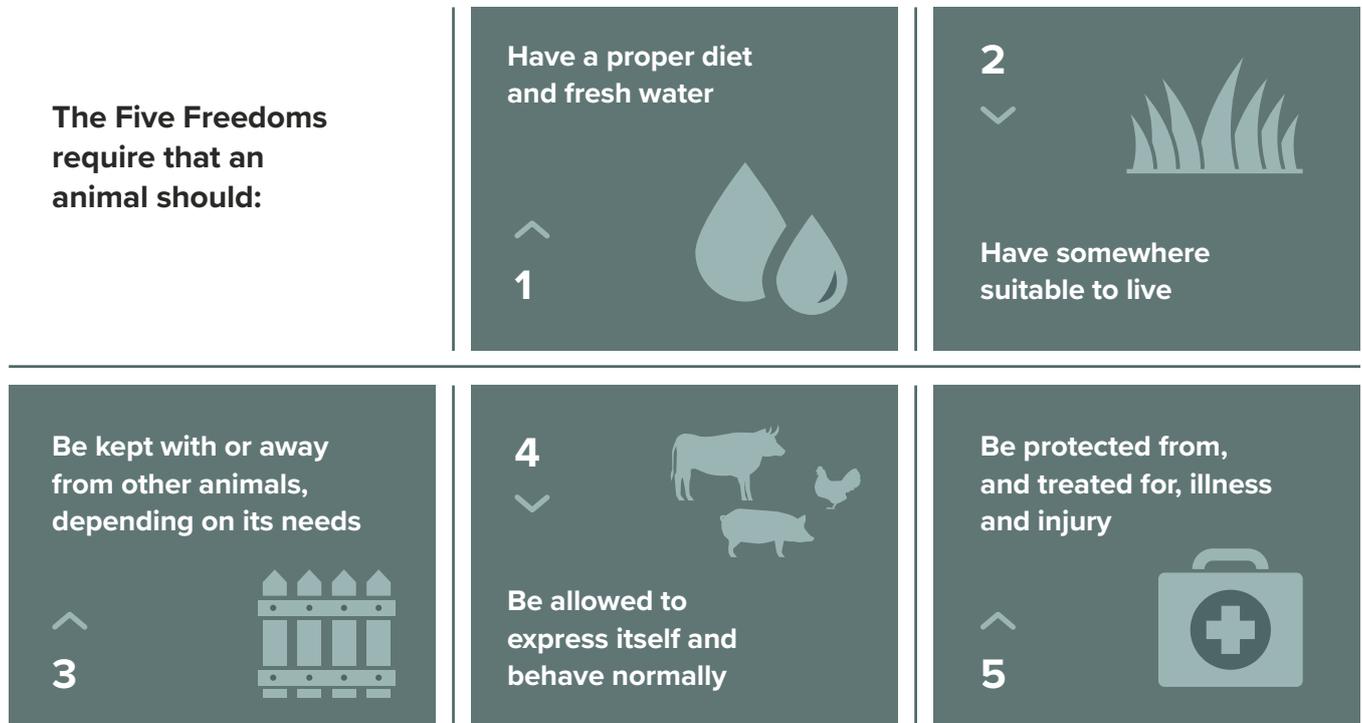
It depends on the purpose of the research. I just want animals to be safe and not be harmed. But I've really kind of pushed myself to think, okay, what's the line? I think it comes down to the purpose of the research and what the benefit of finding things out is going to be.

Participant, workshop 4

Overall, and despite being a contested area, regulations governing research using animals were assumed to be effective based on the information given. Participants believed it would be easier to monitor animals, assess welfare and deal with any problems in laboratories than it would be on a farm. This in turn has consequences for regulations surrounding animal breeding.

5.6.2 Participants perceived a gap between statutory codes for animal welfare and the reality on farms, which has implications for GEFA

Before exploring potential future regulations on GEFA, participants were reminded of the minimum standards governing welfare of different animals. The Five Freedoms framework⁶⁰ of animal welfare was presented to participants.



Overall, participants identified a sizable gap between how they viewed an animal being able to *'express itself'*, *'behave normally'* or have *'a life worth living'* and their view based on information in previous workshops on how farmed animals are reared.⁶¹ Certain participants viewed this discrepancy between what they desired for animals and what current standards and practices allow as *'cynical'* and *'dishonest'*.⁶²

Participants also expressed concerns over how such standards are enforced, not least given the practicality of monitoring and overseeing standards on all farms in the UK.

“

I don't know if you recall from last time [the last workshop], but we eat about a billion chickens a year in the UK, of which 95% of those are kept in intensive conditions. So that's 950,000,000 birds which are housed in intensive conditions. So how can they say that the animals that are being kept in a cubic foot of wire mesh are being allowed to express itself and behave normally. So there seems to be a disconnect between the words and the reality.

Participant, workshop 4



I was infuriated listening to that talk about all the protections and all the legislation, and I've seen the way animals are kept in poultry farms, pigs in boxes. It's just dishonest. If all that is there, then whoever is managing it has different standards to me. They see animals in a way differently to me.

Participant, workshop 4



They're talking about they've got all these safeguards in place, but in the real world, I wonder just how much they are. I'm sure a lot of the current animal practices are quite a bit short of the welfare rules. So just because they've got rules there, doesn't necessarily mean that they're all going to be followed.

Participant, workshop 4

Despite this general concern, there were different views on standards of animal welfare in farms. For example, a participant who worked on a farm generally felt they '*went above and beyond*' the minimum standards. The participant was keen to stress animal welfare was not a function of the size of farm but rather the attitudes of those in charge. While farms were businesses and needed to make money, this did not have to come at the expense of animals.



I used to work for a business that had three 500 sow pig units that we consolidated. So that's 1500 pigs. It meant we could have a lot more people looking after all the pigs together. Their care and welfare went up. We looked after them well. It's not the size [of the farm], but what how you care that matters.

Participant, workshop 4

Overall, participants not only desired greater detail on what these standards meant in practice, but also wanted them broadened to capture their conception of a '*good life*' – which included specifics on qualifying the space and time animals should be given to roam. This was identified as a specific issue for GEFA, given the potential for it to be used to create animals more tolerant of intensive farming conditions and keep them in lower welfare conditions.



We were having a conversation about those five categories. They didn't include like, access to daylight or free range time or things like that. I would like to think that when these genome legislation laws come out, that they don't make a void or a loophole for those criteria.

Participant, workshop 4

Given the potential for ‘a few large players’ to own the genome editing technologies, participants also questioned how practical it would be to hold businesses to account, given our reliance on them for food. The trustworthiness of businesses to act in the public interest was also identified as a concern.

“

Like, what happens if one of the big producers of meat doesn't meet one of these? Well, you're going to have to really decide whether you shut them down or not, aren't you? Because they're such a big contributor to our food supply. So I think, how much power can you really have when we need the food?

Participant, workshop 4

“

We want to be able to trust these institutions because we don't have the cognitive capacity or time to learn everything I can about genome editing. We need to be able to say you guys are the experts and I need to be able to put trust in you. There are so many things that we do have to trust people and it's only afterwards we actually learn.

Participant, workshop 4



5.6.3 Regulation and policy to govern GEFA needs to account for the wider public interest

As part of their deliberations, participants discussed how precision breeding technologies such as GEFA may be governed.⁶³ Given the breadth and complexity of this area, discussions focused in on three areas most relevant and appropriate to cover in this dialogue:

- Defra's commitment not to lower animal welfare standards and ambition to consult thoroughly in the development of legislation, regulation, and policy on GEFA.
- A proposal for two-tier regulatory approach to precision breeding from the Food Standards Agency (FSA). This would regulate foods produced from genome edited animals in proportion to risk. The FSA defined this risk comparatively, in terms of the extent to which changes brought about through genome editing could be achieved via conventional breeding. For comparison, participants also discussed the regulation of novel foods.⁶⁴
- Perceived gaps in the approaches described above, including perspectives from specialist participants.

Overall, participants had mixed views on approaches to regulate GEFA.

Certain participants were reassured about Defra proposals to involve a wide range of stakeholders in the legislative process and to hold off on introducing genome-edited products to market until appropriate regulation is in place.

Participants saw public debate and scrutiny as an essential part of the checks and balances to control the use of the technology – not only public engagement such as this dialogue, but more mainstream coverage in news and media, and a wider conversation about the implications of GEFA.



I think it should be investigated ethically. None of this should be slipped under the door without us knowing. Again, it's all down to transparency, isn't it? Defra is a government agency, but it needs to be debated in a very public way. Certainly, this sort of dialogue, but also a lot of responsible media coverage. It certainly should be in the public domain and debated in Parliament committees and their results published so that we're not hoodwinked into this.

Participant, workshop 4



I think it boils down to trust and transparency, really. [Defra's approach to developing legislation] all sounds quite good and quite acceptable, but it's all down to how effectively it works and how well we could trust it and how transparent the whole process is. Because already with food that we eat now, we don't really know what we're eating... There needs to be a push to inform people.

Participant, workshop 4

Other participants were more cynical about whether such consultation would really have any meaning and believed that the Government has already made the decision. For these participants, GEFA is going to happen whether people like it or not. Participants questioned why this is happening now, the speed at which it was happening, and under what controls.



We ask a question and we're told everything is okay. But everything isn't okay. And it amazes me that Defra's doing this. This is going ahead. We are being consulted now at the end of the process. This is going to happen. You don't put this sort of money into something and it's not going to happen.

Participant, workshop 4

When considering regulations in more detail, participants discussed the extent to which genome editing is an extension of conventional breeding practices. There were two aspects of this debate.

- The first concerned whether participants saw GEFA as fundamentally different from conventional breeding (attitudes to this differed between participants and evolved over the course of the workshops).
- The second concerned how regulators should deal with uncertainty and the potential for unintended consequences arising from the technology.

Overall, participants generally believed there is something distinct about using genome editing to alter the characteristics of a farmed animal, even if the traits would be similar to those achieved via conventional breeding. It was challenging for participants to articulate why they believed that a genome-edited farmed animal was any different from a farmed animal bred for the same characteristics by conventional methods. However, the speed and cumulative impact of GEFA, as well as making changes to the '*naturalness of a regular chicken*', for instance, were concerns.

Participants concluded that a different regulatory process should apply to precision breeding than that applied to conventional foods, which put the idea of this particular responsibility for genomic interventions at its centre.



We are creating a complete new entity. So I think we can't necessarily apply the same sort of regulations that we applied to regular chickens or whatever, to the sorts of things that will arise or potentially arise from gene editing. We're going into a totally new area.

Participant, workshop 4



This is a different kind of challenge for us since we're creating new kinds of organisms. We need to think about this in different kinds of ways. So I think the question is, well, what does it mean to be responsible in doing this?

Participant, workshop 4

When considering how regulators should deal with uncertainty and the potential for unintended consequences arising from the technology, an example of a two-tiered system as proposed by FSA was discussed.

While participants agreed with the principle of regulating in proportion to risk, of more concern were the thresholds associated with the different tiers. The proposal that Tier 1 genome-edited foods would be authorised rapidly, as *'traditionally bred food and feed is not subject to an authorisation process'*, was seen as particularly problematic.

As noted previously, participants did not accept the idea that GEFA was just an extension of conventional breeding. Given participants' views that GEFA would create a new animal, concerns related to the unintended consequences (described in section 5.1) – including long-term impacts and the *'naturalness'* of the technique. They raised the question as to who makes the decisions on tiers, and how strictly the lines between them would be followed. Even in the context of Tier 2, certain participants wondered why genome-edited foods are not going to be looked at with the same level of scrutiny as novel foods and processes.



I feel a bit funny about Tier 1 kind of going ahead. I know it's very similar and it's something that apparently has been done for generations of cows, but I'm still thinking again about long term impacts. There were other things we thought we knew about food for generations as well, until over time you realize, hey, this is actually a problem.

Participant, workshop 4



I just think if it's been genetically changed at all, it should have some authorization process because it's not natural. It's not totally natural, is it? Would have expected some checks and some balance.

Participant, workshop 4



There's Tier one and Tier two. Who makes the decision, which is tier one? [Tier 1] is a business-as-usual approach. And who decides whether it's tier two which needs more collective governance than currently is?

Participant, workshop 4



I suppose it's the last bit. It should be quicker than authorizing a novel food or feed. And you think why? I'm not quite sure why it should be quicker. It implies a sort of less rigorous assessment, less rigorous standard being applied.

Participant, workshop 4

As part of these discussions the role of labelling was briefly explored by participants. They acknowledged that labelling is challenging in the context of genome-edited foods – in part due to being unable to identify the changes made (relative to conventional breeding), and also due to its potential pervasiveness as a breeding technology – and that once traits are in the farmed animals, they would be inherited over generations.

Overall, despite these challenges, there was a strong belief that food products from genome-edited animals should be labelled, and there was concern that this may not happen *'regardless of what people want'*.

Notwithstanding this, labelling was also viewed by participants as a simplistic way of dealing with such a complex issue. Rather, participants felt that regulators and the food industry needed to take active steps to reach out to people and discuss what is happening with farmed animals in the food system and why.



It all comes back to the transparency. If they're not being honest on the labelling, how can we trust what they're saying?

Participant, workshop 4



Reaching out rather than just putting out labelling information is important. Because already with food that we eat now, we don't really know what we're eating. But you're going to see a label and not know. I feel like there needs to be some kind of push to inform people more than just telling them this information if you need it. Yeah. Really drive home what's happened and why.

Participant, workshop 4

Finally, when considering proposals for regulation, participants were concerned that food safety regulation does not adequately account for a wider set of considerations beyond safety. Participants saw these wider considerations as very important. They ranged from the ethics of using the technology on farmed animals, to the wider purposes of the technology, who owns it and who benefits.



When they're looking at precision food, they're looking at it in terms of is it alright for human health, animal health, is it right for the consumer? How different or not is it from other foods that are there? But they should also be looking at things like who owns the technology? Who's patenting it? Who's involved in this? Why does that not matter?

Participant, workshop 4



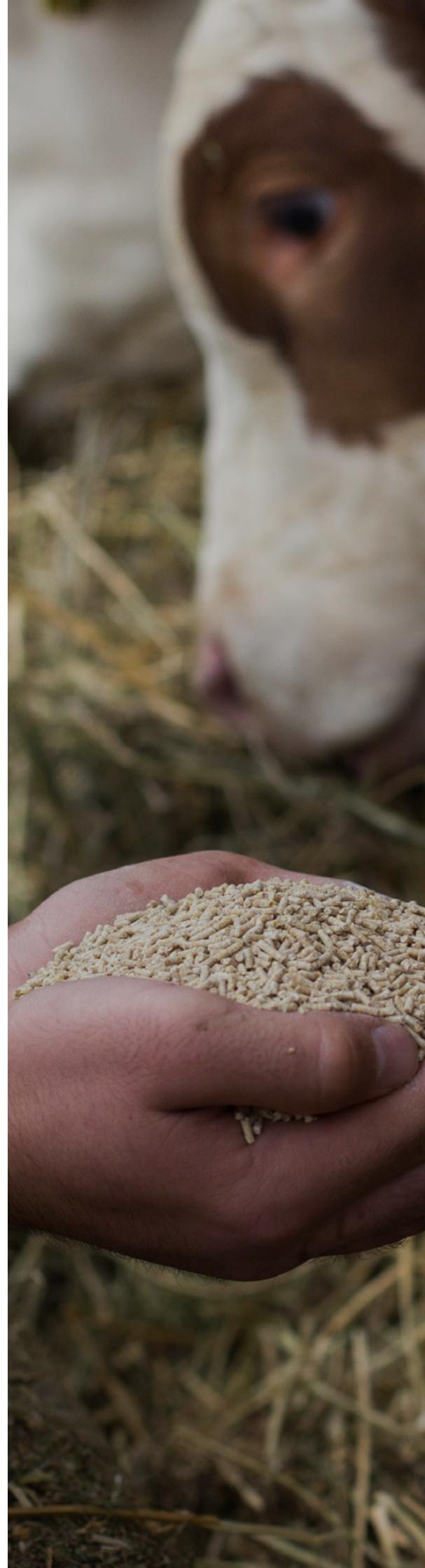
This is really important. In the Norwegian model⁶⁵ they talked about, they also consider the ethics, whether it's been done in a societally responsible manner, that it makes a contribution to sustainable development. This model mentions none of that. They don't consider any of these things. It definitely needs to be considered.

Participant, workshop 4

Overall, participants felt the way in which the proposed regulations are framed seemed to focus on getting products to market as soon as possible, rather than taking the time to really consider impacts. Other unintended consequences from food were cited, from the impact of *'mad cow disease'*⁶⁶ to concerns over potential health hazards from genetically modified crops. Left to market forces, they believed, businesses would focus on *'making more of the stuff that makes the most money'* and GEFA would lack a socially desirable purpose.

Participants felt that the approach to regulating this area should not focus on short-term gains but rather on serving the long-term public interest and the type of food and farming system we could potentially develop using GEFA.

Participants valued the opportunity afforded through the dialogue to contribute to the debate. Despite participants' cynicism over their own ability to influence policy and practice, they wanted decision makers to account for the aspirations their decisions embodied.





SECTION

6

Conclusions

There are seven conclusions about how participants considered the potential role of GEFA in the future food and farming system.

1

Primary concerns around GEFA were linked to the social and economic systems into which it may be deployed

Genome editing was seen by participants as a powerful tool because of its capacity to accelerate changes to an animal's characteristics. It was also seen as setting off on a pathway that would involve a societal commitment to the technology from which there may be no going back.

Participants identified the purpose, ownership and control of GEFA as particular concerns.

Participants raised three issues.

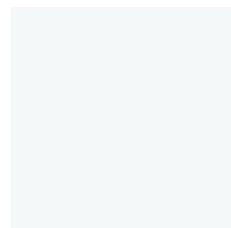
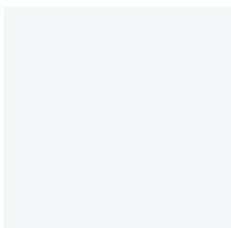
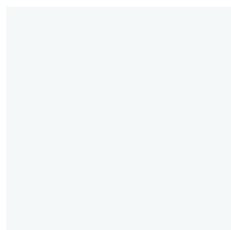
- The likely adoption of genomic editing by large agribusinesses, and the question of whose interests are served through this.
- The motives of those involved in its development, and whether the use of GEFA would be put to purposes such as improving animal and human health.
- The potential for misuse of the technology.

Participants valued relatively cheap and plentiful food, and they were concerned about the equitable access to meat, fish and dairy products.

However, current approaches to food production and consumption were viewed by participants as out of balance with what could be considered sustainable and morally desirable (accounting for human and animal interests). Development of the technology by large agribusinesses, without adequate safeguards, was seen to worsen these perceived problems in the food system.

Participants were also concerned about the multiple ways in which specific applications of GEFA could be used. For example, GEFA applications judged by participants to have greater potential, such as those to manage human and animal disease or (to a lesser extent) the tolerance of farmed animals to changing environmental conditions, are precisely those that can be used to develop more intensive farming practices at the expense of animal welfare.

How to anticipate and govern the use of GEFA towards socially useful goals became participants' central question.



2

GEFA was seen as distinct from conventional breeding

While there was an acknowledgement by participants that GEFA would likely produce traits akin to those produced through conventional breeding, GEFA was nonetheless seen as a distinct practice. Specifically, editing the genome of an animal was seen as creating a *'new kind of organism'*. This characterisation by participants goes beyond considerations relating to an animal's physical constitution and hints at something deeper about the nature of what it is to be a certain kind of animal. Central to this was the idea of a *'good life'* and an animal being free to express itself in terms of its essential nature – for example, a pig being able to reach maturity rather than being held in state of *'eternal adolescence'*.

This is a complex area and while the innate nature of *'pigness'* was not directly explored by participants, discussions on animal welfare applications were revealing.

Most participants disapproved of changing animals to reduce the suffering caused by keeping them in particular environments. Rather, they preferred changing the conditions under which they are reared.

Making genetic changes to farmed animals was seen to come with distinct responsibilities, related to creating animals that were potentially *'unnatural'* and the cumulative impact of such changes across generations. Whether industry adopts responsible breeding standards, and how these may impact on an animal over time, were concerns.

This is not to say that participants felt that GEFA should not be developed. Rather it highlights that a narrow framing of the technology as akin to conventional farming can limit the scope to raise *'valid questions and concerns'*.

3

Participants had concern about using GEFA to improve farming productivity

Despite the farming of animals being fundamentally about food production, participants perceived GEFA applications focused on improving farming productivity as less desirable compared to other potential uses. A duty of care for animals was often at the heart of these discussions.

In general, when considering potential applications of GEFA, participants wanted there to be clear benefits for the animal – this was generally framed as positive benefits, rather than an absence of disbenefits.

In this context, the issue with certain farming productivity applications (particularly those associated with improving growth or reproductive rates) was that there did not appear to be any immediate benefit for the animal.

Participants believed that genome editing applications to improve farming productivity could be appropriate in certain contexts.

Rather, it was the primary purpose of the application that mattered. Providing animals with a good life within the context of domestic production systems was key to this, ideally coupled with wider benefits for humans.

4

Participants were concerned about the level of dependency on the technology

Participants questioned whether fixing one problem in the farming system with GEFA may lead to other problems.

For example, who benefits commercially from the development of technology was a concern for participants. Participants raised this issue in terms of *'industrial'* versus *'local'* farmers, how the benefits of technologies get distributed and how further competition can perpetuate a cycle to develop new innovations for the animal's genome.

Once GEFA is applied to the farming system, there is the potential for dependency on the technology – requiring an *'endless tinkering'* with the genome of an animal. This was also expressed in terms of creating *'super animals'* edited for multiple traits for competitive advantage.

Participants wanted to know how it would be possible adequately to control the technology given these systemic pressures, and how a precautionary approach to technology development might be incorporated within this.

5

GEFA needs to be considered in the context of alternatives

Understanding alternatives to GEFA was a key part of how participants understood its potential value.

For certain applications, particularly those associated with environmental impacts or dietary health, GEFA was seen as more problematic than alternatives. This was generally because fixing the food system was seen to be preferable to making genetic changes to animals. This was most notable in participants' views on the desirability of addressing food waste, but also in views about personal responsibility to eat a balanced diet.

In other applications, notably animal health, GEFA was seen as having potential advantages over alternatives. Specifically, in these applications of GEFA, participants saw the technology as *'clean'* and precise, and potentially preferable to ongoing treatment with vaccines or antibiotics. The idea that GEFA could provide a better *'technology fix'* for certain diseases was thought to have value by participants – specifically making changes to the genome that would make it much harder for a variant of the target disease to arise.

Overall, participants did not take the view that there had to be a choice between using GEFA and using alternatives. For instance, given the scale of climate change, participants noted that *'all options need to be on the table'*. Similarly, for animal diseases, participants did not advocate stopping the production of vaccines.

Rather, participants' key point was that the value of GEFA must be understood contextually, assessed as part of a range of possible options, and much greater attention needed to be given to the causes of problems in the farming system, rather than dealing with the symptoms of these problems.

6

Decision makers should account for public aspirations in considering policy and regulation on GEFA

Participants valued the opportunity afforded through the dialogue to discuss GEFA, and were concerned that their views should be taken into account. There was cynicism expressed by several participants that decisions to use GEFA have already been taken, and it would happen '*no matter what the public think*'.

Despite this cynicism, participants wanted the system under which GEFA may operate to provide clear guardrails to direct potential applications and limit the potential for the technology to be misused.

In the context of research, participants were, on the whole reassured by the measures currently in place, from ASPA to wider checks on the ethics of animal research and other ethical implications. At minimum there was an expectation that genome editing research on animals would be subject to the same, if not greater, level of oversight than that involving non-genome-edited animals. However, participants also wanted greater transparency in the research process in terms of the procedures employed and the outcomes of the research (including timely publication of adverse results).

One of the issues identified for funders of research was that the outcomes of funding need to be more than the sum of individual decisions. Specifically, a clearer sense of how public aspirations influence research direction was felt to be important.⁶⁷ Beyond this, how publicly funded research links to a societal vision and strategy for the future of food and farming was perceived to be missing.

More generally, as basic research is translated into potential applications (both in public and commercial research institutes) these checks and balances on animal welfare, as well as wider ethical and social implications, need to continue to be front and centre.

Safety was an important part of this and was defined by participants as follows.

- Producing foods safe for human consumption.
- Safety for animals, so that editing the genome does not produce undesirable, off-target effects.
- Safety for human and animal health, in terms of managing disease risks and the emergence of new diseases.
- Safety for the environment and preventing the '*escape of genes*' into the wild (this was less common and associated with genome editing of crops for animal feed and in salmon farming).
- Safety for farming and the food system (in terms of its security and sustainability), where the use of the technology is undertaken in a responsible way.

Each of these has implications for both the governance of research and the husbandry system in which it may be applied. For example, managing disease risk or the escape of genes is a biosecurity issue for research institutions and farms.

Participants expressed concern that current regulatory proposals seemed to focus more on getting GEFA products to market as quickly as possible, rather than on allowing pause for thought around such wider implications.

7

We need a clear vision for the future of food and farming

Participants wanted a clear vision from policy makers of the type of food and farming system the UK wished to develop in the future.

For example, in the context of UK farmed animals, participants were unsure whether the goal is to increase or decrease the amount of meat, fish, eggs and dairy produced and consumed, or to develop more intensive or agroecological farming practices. These issues mattered to participants as they provide a strategic context within which GEFA may be developed. They could also provide a '*north star*' to direct research and innovation, again linking back to participants' desire for clarity on how individual research projects relate to the overall purpose and vision for GEFA.

Left to unconstrained market forces, the likelihood that GEFA would create further problems in the farming system was seen as inevitable. Participants openly acknowledged that they felt disconnected from food production and animal husbandry, and they questioned their own ability to make fully informed choices about the food they eat. Moreover, they felt consumers could not be blamed for choosing the cheapest foods, particularly in a cost-of-living crisis.

There was a view among participants that higher standards should be set by authorities. How this plays out in a deepening cost-of-living crisis was seen as challenging. Participants did not see this as a trade-off between animal welfare and affordability, but rather how values guide food production. In short, they felt policy and regulation should guide the technology to socially desirable ends, and the purposes and principles involved in such assessment should be explicit.

Participants were supportive of a much wider public debate on the governance of GEFA and saw this dialogue as an important part of the process. But they were keen that those involved in the development of the technology should listen to their voices and anticipate their concerns, steering any use of GEFA towards creating a better future food and farming system.

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- ¹² Precision breeding is discussed in more depth later in this section.
- ¹³ See for example: <https://www.nature.com/articles/s41588-022-01046-7>
- ¹⁴ See for example: Carroll, D. (2016). Genome editing: progress and challenges for medical applications. *Genome Med* 8, 120.
- ¹⁵ Nuffield Council on Bioethics (2021). Genome Editing and Farmed Animal Breeding: Social and ethical issues. <https://www.nuffieldbioethics.org/publications/genome-editing-and-farmed-animals>. The report was complemented by a rapid online public dialogue: <https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals>
- ¹⁶ The Genetically Modified Organisms (Deliberate Release) (Amendment) (England) Regulations 2022. <https://www.legislation.gov.uk/ukdsi/2022/9780348231328>.
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- ¹⁹ Ibid.
- ²⁰ The National Food Strategy was published in 2021 and was an independent review conducted on the behalf of Government. The plan was led by Henry Dimbleby and supported by Defra officials. The strategy focused on England, but considered the relationship with the devolved administrations, the European Union and other trading partners. The Government’s response to the strategy can be found here: <https://www.gov.uk/government/publications/government-food-strategy/government-food-strategy>
- ²¹ Sciencewise is a UK Research and Innovation (UKRI) programme that facilitates research councils and other eligible bodies to carry out deliberative, impactful engagement on scientific or technological issues.
- ²² <https://sciencewise.org.uk/about-sciencewise/our-guiding-principles/>
- ²³ 80 participants started the dialogue, with 70 completing all four waves.
- ²⁴ The ‘friends and family’ dialogue used a novel conversational AI platform to engage an additional 139 people on GEFA, including potential applications and implications. Results of this exercise are shown in Appendix D.
- ²⁵ These were predominantly members of the Oversight Group, but also included other experts. See Appendix A for details.

- ²⁶ All workshop materials and information are provided in a separate document and can be accessed [here](https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals-2). (<https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals-2>)
- ²⁷ Trends were produced by the School of International Futures. The process for the prioritisation of trends for the project is described in Appendix C.
- ²⁸ Participants mentioned industrialised farming spontaneously, but the term was also used in the information provided to participants in Workshop 1, which in turn may have influenced its adoption. Participants used a range of terms to indicate the large-scale production of food including ‘intensive’, ‘industrial’ and ‘big’ farming. It was acknowledged that small farms can also be intensive farms.
- ²⁹ Participants used the terms ‘local food’, ‘local farming’, ‘locally produced’ and ‘locally reared’ to describe a perceived close relationship between those selling the food and where and how it was farmed. It was not used to signify that all foods were produced in the local area.
- ³⁰ Chlorine washed chicken (also referred to by participants as ‘bleached chicken’) is banned in the UK.
- ³¹ Since 1981, the EU has developed a series of regulations that prohibit the use of substances having a hormonal action for growth promotion in farm animals. Hormones were generally, though not always, discussed in a historical context by participants.
- ³² There were numerous concerns about leaving food production to market forces to deliver social value – not least affordability limiting choice and the impracticality of a relevant range of information being available to consumers to inform their choices. These are discussed later.
- ³³ See [here](https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals-2) for details (<https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals-2>)
- ³⁴ In the information provided to participants, potential applications of GEFA did not specifically associate different breeds of animals with different farming systems. Rather, of greater concern for participants was how specific applications to create a new breed may be used within different farming systems (and more importantly their purposes) – for instance, improving an animal’s tolerance to environmental changes could be used to improve or decrease an animal’s welfare.
- ³⁵ While participants acknowledged this romantic view of farming as deep rooted and ongoing, they also felt better informed about conditions farmed animals were kept in through taking part in the dialogue.
- ³⁶ Information provided to participants included clips from a video by Which? that explored welfare standards for animals under different farm assurance schemes. The full video entitled ‘Animal welfare behind the meat you buy’ can be found at: <https://www.youtube.com/watch?v=QMuU8pjclZI>. Further details on the information provided to participants can be found [here](https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals-2). (<https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals-2>)
- ³⁷ See **Appendix B**.
- ³⁸ <https://www.animalhumanesociety.org/health/five-freedoms-animals>
- ³⁹ While less common, some participants were ambivalent and would articulate different values depending on context. For instance, for certain applications of GEFA, human interests would be predominant even for those participants more mindful of welfare.
- ⁴⁰ These principles, while expressed by participants, have been derived through analysis of the discussions. They were not formal criteria used to appraise each potential GEFA application.
- ⁴¹ Participants recognised that different applications could be used for multiple purposes. Grouping applications in this way enabled discussion of the extent to which the primary purpose of GEFA mattered.
- ⁴² The meaning of conventional farming differed between participants and could refer to perceptions of conventional breeding techniques and/or ‘natural’ processes of livestock production. While technology was seen as a part of conventional farming, it was generally defined as distinct from farming that involved the genome editing of animals.
- ⁴³ Examples of how participants answered these questions for three different application areas are shown in Appendix E.
- ⁴⁴ See 5.2.1 for a discussion of how participants perceived complexity.
- ⁴⁵ Changing an animal’s nature was a complex issue for participants. Certain participants had deep concerns about this irrespective of potential benefits for animals. Others could see it may be appropriate in certain instances, but also believed ‘new animal entities’ would be created through the process. Overall, participants felt greater time was needed to consider the implication of genome editing as a breeding technology more fully.

- ⁴⁶ Using GEFA to reduce the risk of zoonoses from farmed animals was not supported by all participants, and it was qualified on a case-by-case basis.
- ⁴⁷ Uses of GEFA to mitigate climate change were less well received than those helping animals to adapt to climate change. Also, given the scale of climate change, certain participants felt ‘all options should be on the table’.
- ⁴⁸ Participants did see antimicrobial resistance (AMR) as a human-caused public health problem. As will be explored later, other principles were used when considering this application.
- ⁴⁹ For all application areas, see [here](https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals-2).(https://www.nuffieldbioethics.org/publications/public-dialogue-on-genome-editing-and-farmed-animals-2)
- ⁵⁰ This issue is explored in more depth later, in the context of unintended consequences.
- ⁵¹ In the information provided to participants, while impacts from farming in general were considered alongside animal farming, greater focus was given to the latter. Participants routinely noted that farming in general, and alternatives to meat, also had significant impacts on the environment.
- ⁵² This type of application is unlikely to be permitted in the Precision Breeding Bill.
- ⁵³ Over and above that from conventional breeding.
- ⁵⁴ Details of the Precision Breeding Bill were not explored.
- ⁵⁵ As context, all data gathered as part of this dialogue process was coded to aid analysis . A total of 4,414 pieces of data were coded over the course of the dialogue. Each of these we refer to as a ‘conversation’.
- ⁵⁶ There are a wide variety of human health applications of genome editing to treat and cure disease, including those that target non-inheritable (somatic) cells as well as those that could influence inherited characteristics in humans. These were not explored as part of the dialogue. For further information, the Nuffield Council on Bioethics published a report on genome editing in human reproduction in 2018: <https://www.nuffieldbioethics.org/publications/genome-editing-and-human-reproduction>
- ⁵⁷ Transgenesis was only referenced once in information provided to participants in the context of using a green fluorescent protein to identify the sex of chicken embryos. It was spontaneously raised by participants when discussing wider implications of the technology (often referred to as ‘Frankenstein’ foods), though overall transgenic foods were not a dominant frame of reference.
- ⁵⁸ Under ASPA, the level and nature of the harms to animals must be described within the project licence, which must also include ‘humane endpoints’ (usually expressed in terms of weight loss, failure to eat/drink within a certain time frame, specific pain-related behaviours such as limping or grimacing, and so on).
- ⁵⁹ The Research Councils publish information on the research they fund, the Animals in Science Regulation Unit publishes non-technical summaries and 128 UK organisations have signed the Concordat on Openness on Animal Research. There are also organisations – such as Understanding Animal Research – which aim to explain why and how animals are used in medical and scientific research. Lack of awareness of this suggests the need for greater awareness raising, though participants did not explore whether such information was sufficient.
- ⁶⁰ Detail on the Five Freedoms framework was briefly described in workshop 2 and discussed in more depth in workshop 4. The Five Freedoms framework has existed since 1965 and in recent years has been built upon to develop the Five Domains framework (which relates to an animal’s nutrition, environment, health, behaviour and mental state). The Five Domains framework is used as the basis in writing many animal care protocols and welfare audits developed for implementation on farms and in processing facilities. Further details can be found here: <https://kb.rspca.org.au/knowledge-base/what-are-the-five-domains-and-how-do-they-differ-from-the-five-freedoms/>.
- ⁶¹ In addition to the *Which?* farm assurance scheme video (see footnote 37 for details), participants were shown a small amount of footage showing how chickens and pigs are reared. This footage was chosen to reflect ‘typical’ farming environments, with clips taken from the BBC’s Countryfile programme on chicken meat production (<https://www.youtube.com/watch?v=mJEM3TUX-uU>) and a Scottish Association of Young Farmers video on pig farming (<https://www.youtube.com/watch?v=BKAEQT3hLgE>). Statistics on the proportion of animals reared indoors versus to free range and organic standards were also shared.
- ⁶² It should be noted that a range of participants felt the UK generally had reasonable standards of animal welfare, relative to other countries. In part, the gap between the wording and perceived reality on farms was the issue. The extent to which participants saw poor welfare as a problem for a few farms, or more systemic, varied.

⁶³ As noted in Section 1, precision breeding is a term used to define any plants or animals whose genomes have been altered using biotechnologies (such as genome editing). The term is applied to changes that could, it is argued, have resulted from conventional breeding.

⁶⁴ As part of information provided, participants were informed that novel foods involve an application to the Food Standards Agency and then it is assessed by the Advisory Committee on Novel Foods and Processes.

⁶⁵ A specialist video on governing GEFA provided information on a Norwegian model. This model accounted for sustainability, as well as wider social and ethical issues concerning decisions on biotechnology.

⁶⁶ Bovine spongiform encephalopathy (BSE), a brain disease that can infect cattle, sheep and goats. If this infected meat is eaten by humans it can result in serious illness and death.

⁶⁷ While the BBSRC research framework mentions public engagement, it is generally framed in procedural terms (the need to engage the public) rather than a vision of agriculture that the public want to see: BBSRC (2021). Research in Agriculture and Food Security Strategic Framework. Available at: <https://www.ukri.org/wp-content/uploads/2021/12/BBSRC-231221-agriculture-food-security-strategic-framework.pdf>

Project governance and stakeholder involved in stimulus development

This dialogue was overseen by a Project Team, who supported the day-to-day management, design and delivery of the dialogue, and an Oversight Group who provided strategic advice during the dialogue and reporting process.

Additionally, other experts were involved in helping to develop stimulus, and via direct engagement with participants in the dialogue process.

APPENDIX A

Project Team Members:

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Craig Lewis

PIC Genetic Services and Chair of the
European Forum of Farm Animal Breeders

Steve Morgan

Genetic Resources and GM Team, Defra

Louise Payton

Senior Policy Officer, Soil Association
Louise attended certain sessions in place of Jo Lewis

Jo Lewis

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Emma Walton

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Françoise Wemelsfelder

Professor of Animal and Veterinary
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Other experts were also directly involved in the workshop discussion sessions:

Julian Baggini

Philosopher and journalist

Jonathan Birch

Associate Professor, Department of Philosophy, Logic and Scientific Method, LSE

Rob Fraser

Emeritus Professor of Agricultural Economics, University of Kent

Huw Jones

Independent consultant working on agri-industry applications of genetic and genomic tools

Phil Macnaghten

Professor of Technology and International Development, Wageningen University

Liz O'Neill

GM freeze

David Rose

Professor of Sustainable Agriculture, Cranfield University

Bruce Whitelaw

Professor of Animal Biotechnology, Roslin Institute

While not attending in person, a video was also provided by Professor Wendy Harwood, Head of the Crop Transformation Group at the John Innes Centre and Member of the Advisory Committee on Novel Foods and Processes, that overviewed regulations for novel foods and proposals for precision breeding regulation.

Short videos were also provided from various Oversight Group and Project Team members, illustrating a range of different perspectives on the technology.

All stimulus used in the dialogue was made to enable participants to reflect on information and discussions between waves.



APPENDIX

B

Participants involved in the dialogue

The dialogue involved a total of 80 participants recruited to represent a variety of socio-demographic backgrounds, regional representation from across the UK, and different attitudes toward the use of genetics science to address food and agricultural challenges. Table 3 summarises these characteristics.

Table 2: Social and demographic characteristics of participants

Characteristic	Target quota	Achieved ²
Gender		
Male	40	38
Female	40	41
Non-binary	/	1
Age		
18-29	20	20
30-44	20	21
45-59	20	19
60+	20	20
Ethnicity		
White British and Other White	50	52
Mixed	10	5
Black African and Black Caribbean	10	9
Pakistani, Indian and Bangladeshi, and other Asian	10	13
Arab	/	1

1. 80 participants started the dialogue, with 70 completing all four waves.

2. Where category totals are less than 80, participants declined to respond.

Religious beliefs		
Mix of people with different cultural or religious backgrounds		
Christianity	Min 4	16
Catholic	Min 4	7
Islam	Min 4	6
Judaism	Min 4	6
Buddhism	Min 4	5
Sikh	Min 4	4
Hindu	Min 4	5
Jehovah Witness	/	1
Pagan	/	1
Atheists	Min 4	9
Agnostics	Min 4	5
No religion	Min 4	8
Humanist	Min 4	5
Region		
England	50	54
Scotland	10	8
Wales	10	9
Northern Ireland	10	9
Location type		
Farming, rural and coastal	35	35
Urban and suburban	45	44
I'm not sure	/	1
Household income band		
Less than £20,000	25	26
£20,000-£39,999	25	25
£40,000-£59,999	20	14
More than £60,000	10	12
Attitude		
'I am comfortable with the idea of humans using genetics science on farmed animals to address food and agricultural challenges'		
Agree	30	31
Neutral or No opinion	20	22
Disagree	30	27
Diet		
Vegan	5	5
Vegetarian	10	6
Pescatarian	5	3
Flexitarian	10	16
Regularly eats meat	50	50

All participants were recruited by an independent fieldwork agency (Roots Research) and were remunerated (£250, staggered over workshop waves) for their time in line with the Sciencewise guiding principles.

Dialogue design

The dialogue process consisted of four pre-tasks and four online workshops, held over an eight-week period between 28th May and 9th July 2022.

The focus of each was as follows:³

WORKSHOP

1

Food and farming, and genome editing

The pre-task involved participants making short films about their relationship to food and farmed animals.

The workshop explored:

- Participants relationship to food and farmed animals, building on the pre-task.
- Their awareness and understanding of the meat, fish and dairy we as a society consume.
- Their awareness of and top of mind thoughts to genomic editing, including reactions to information provided on genome editing.

3. For the full topic guides and detail on the information provided to participants, see [HERE](#).

WORKSHOP

2

Challenges facing the food system and different ways of addressing these

The pre-task involved engaging friends and family members in a discussion on GEFA (see appendix D).

For the workshop, the School of International Futures (SOIF) undertook a scan of trends influencing food and farming over the coming decades.

SOIF identified 45 trends which were prioritised at a workshop involving the Project Team and Basis Social. From these, seven themes were developed and shared with the Oversight Group, before being used to produce information provided to participants.

The workshop explored:

Four issues facing the future of food and farming:

- Environmental impacts and overpopulation
- The production, ownership, and cost of food
- Diet and health
- Animal farming and animal sentience.

Potential ways to address these issues:

- Intensive systems, and agroecological systems of farming
- Alternative proteins
- Reducing meat consumption, including using a 'meat tax'.

WORKSHOP

3

Applications of GEFA

The pre-task involved exploring how much people agreed or disagreed with various themes emerging from workshop 2, linked to the future of food and farming.

The workshop explored 14 potential applications of GEFA across the following domains:

The workshop explored:

- Animal health and welfare
- Environment and conservation
- Farming and productivity gains
- Human health
- Consuming meat, fish and dairy products.

WORKSHOP

4

The pre-task explored the findings about GEFA applications that emerged from workshop 3, the extent to which these findings chimed with individual's perspectives, and whether their views had changed through the dialogue process.

The workshop recapped on views from Workshop 3, before exploring governance and regulation across the following areas.

- Farmed animal welfare;
- Research involving animals and wider research ethics;
- The regulation of novel food technologies and precision breeding.

We adopted an iterative approach to this dialogue design, responsive to participants concerns and interests. Throughout the dialogue we made use of two online engagement platforms:

- **Zoom:** to host the workshop discussions
- **EngagementHQ:** to engage people between the workshops.

Analysis

To analyse the dialogue in a clear and structured way, our analytical process involved the following three stages.

Thematic coding:
sifting and structuring the transcript data into themes, specifically by developing a code frame based on the topics from the discussion guide and issues raised by participants.

1.

Interpretation:
grouping the themes into concepts and categories, and exploring patterns and associations, similarities and differences across the data.

2.

A review process, involving participants from the dialogue, the Project Team, and the Oversight Group.

3.



APPENDIX

D

Findings from the distributed dialogue with friends and family members

As part of our design, we used an experimental ‘conversational AI’ platform to see if we could engage friends and family in a discussion around GEFA. Specifically, using the platform, we undertook a survey to understand what friends and family felt about GEFA. We had programmed a chatbot to probe on answers, looking out for key words to ask appropriate follow-up questions. As well as providing contextual insight for the dialogue, the process also enabled us to experiment with new approaches to broadening public dialogue.

In total we received **139 responses**, with a rich range of qualitative responses.

In summary, friends and family participants:

- Had a keen interest in where their food comes from, and what goes into it.
- Were concerned about the following aspects of the food system: quality, provenance, animal welfare, the environment, costs, and localism.
- Were loosely aware of the term ‘genomic editing’ and defined genome editing as a process in which DNA is manipulated to promote desired characteristics.
- Perceived greater legitimacy for GEFA applications that supported disease resistance, reduced the suffering of farmed animals, or reduced the environmental impacts of farming.
- Also perceived benefits in terms of meeting the global demand for food, and improving production through better cost-efficiencies and speed.
- Had concerns about the use of GEFA would drive down standards of animal welfare and would need strong ethical oversight. The potential for unforeseen harmful outcomes to both humans and animals was also a concern.
- Certain participants:
 - perceived GEFA as interfering with nature;
 - questioned the need for GEFA, relative to trying to change the farming system
 - for instance by tackling issues such as food waste.

Illustrative conversations with the chatbot included:



Farmers have always crossbred animals to select certain traits and gene editing in my understanding, is a quicker way to achieve what might otherwise take several years of experiment.



There should be strong ethical oversight to ensure any changing of DNA in animals and plants doesn't get hijacked by those seeking to put profit before the welfare of the animals involved and their future impact in the wider community.



Sustainability is vital if we are to preserve the delicate ecosystem of the planet. And we have to search for sustainable methods of food production not necessarily generating more of the same.

APPENDIX

E

Principles used to explore GEFA applications

Table 5.

Participants key questions when considering GEFA and their views concerning three application areas.

	PRRS	Preventing culling of male chicks	Increasing an animal's tolerance to environmental changes
What is the purpose?	To protect the health and welfare of pigs.	To some extent to support animal welfare, though the purpose of culling chicks was perceived as improving farming productivity.	To improve animal welfare and protect the livelihoods of farmers.
How has the problem arisen?	Participants viewed infectious disease as arising 'naturally' in farmed animal systems.	As a direct result of industrial farming methods.	In the context of climate change, as a direct result of human activity
Who benefits from addressing the problem?	Pigs through improvement to their health. Businesses through economic benefits of 'disease-free' pigs.	Businesses. Chicks, though perceived to a lesser extent.	Large agribusinesses, and potentially farmers in LMICs. Animals to a lesser extent.
Is the use of GEFA seen as complex?	Use viewed as discrete, affecting the receptors for the virus, with limited wider impacts.	Potentially complex, with the use of fluorescent transgenes as a marker to identify the sex of chicken embryos a concern.	Seen as relatively discrete, targeting traits such as hide colour
Are there alternatives and how do these compare to GEFA?	Vaccines, but GEFA potentially seen as a 'cleaner solution'.	Questioned why the practice was even allowed, given animal welfare laws. Would like to know what the alternatives were.	Seen as limited, beyond housing animals in shelters



Public dialogue on genome editing in farmed animals