Farming the future:
Ethical challenges in the age of AI and digitalization

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Sinan Akıllı and Franck L.B. Meijboom



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Preface: Artificial intelligence in agriculture and food: just another discussion on the ethics of technology?

AI has become an integral part of our society. Its applications are endless and are no longer confined to advanced search engines or specialist IT devices. AI is also playing an increasingly important role in agriculture and food production, as well as in how we treat animals and the environment. Therefore, the 19th Congress of the European Society for Agricultural and Food Ethics, which focuses on AI in the context of agriculture and food supply, is very timely.

But why should the EurSafe community devote an entire conference to AI, other than because it is a popular topic? Does it raise many more questions than those we have already discussed at previous conferences in the context of various technologies? In particular, I am thinking of the discussions we had on ethics of biotechnology in agriculture and food production at the first EurSafe conferences between 1999 and 2003. Aren't this year's issues just the usual questions and discussions, only with a different label?

Looking at this volume of papers, I came to the conclusion that while the authors build on existing work in the field of the ethics of technology and draw on the EurSafe community's experience, new questions arise and are addressed. While not all topics are exclusively relevant to the ethical assessment of AI and its applications, they require new or renewed attention.

Furthermore, AI clearly demonstrates that ethics encompasses more than merely evaluating the novel aspects of a technology. Focusing exclusively on the novel aspects of a technology runs the risk of overlooking relevant ethical dimensions. For example, adding large language models to an existing practice can have far-reaching consequences that expand dimensions already present in the existing situation. Moreover, focusing solely on what is novel implies that the existing practice is morally neutral or the accepted default (cf. Kramer & Meijboom, 2022). However, agriculture, food production and consumption, and our treatment of animals and the environment are in transition. Grand societal challenges such as a growing world population, climate change and geopolitical developments directly impact discussions about food security, safety, quality, food sovereignty and the position of farmers. Changing views about the moral status of non human animals and other aspects of nature also influence discussions about the future of food and the need for a protein transition, as well as the development of more nature-inclusive agriculture.

As a result, we are not simply adding AI to an existing discussion on the ethics of agriculture and food. AI raises interesting new questions and concerns in an ever-changing context. At the intersection of this novel technology and its various application areas, as well as the dynamics of agriculture, food, and the environment, the EurSafe2026 congress will present many interesting papers. They showcase the wide range of topics that arise when AI is combined with agriculture and the food supply chain, as well as our interaction with non human animals and the environment.

This volume also marks 10 years of collaboration between EurSafe and the Turkish Agriculture and Food Ethics Association (TARGET). With prof. Cemal Taluğ and prof. N. Yasemin Yalım as driving forces, TARGET has already organized five International Congress on Agriculture and Food Ethics in Türkiye. TARGET and EurSafe share an interdisciplinary approach to ethical issues related to agriculture and food and the wish to combine ethical assessment with applied questions and the involvement of all who

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are professionally involved in ethical questions related to food and agriculture. As the EurSafe board, we are delighted that our congress is being held in Türkiye for the first time.

I hope you will enjoy reading the papers in this collection, and that they will encourage you to engage in discussion and reach out to the authors. Although each publication has academic merit, the EurSafe community has demonstrated since 1999 that thought-provoking and innovative ideas arise from interaction and exchange between scholars from different disciplinary, national, cultural and professional backgrounds. Therefore, please consider this collection of papers also as an invitation to join the EurSafe community.

On behalf of the EurSafe Board,

Franck Meijboom

President of the European Society of Agricultural and Food Ethics (EurSafe)

June 2026

Introduction: Farming the future: ethical challenges in the age of AI and digitalization

F.L.B. Meijboom and S. Akıllı

Agriculture and the food supply chain have always been dynamic fields, with innovation playing a key role. Since the first steps including domestication and irrigation many thousands of years ago, agriculture has constantly evolved. The development of agriculture and food supply has always been in response to challenges such as urbanisation, plant and animal diseases, and new technologies. From this perspective, the rise of artificial intelligence (AI) in agriculture easily fits into this tradition of dynamics and innovation.

At the same time, AI-driven technologies are being introduced at a time when the world is facing major challenges such as climate change, biodiversity loss and a growing population, which directly impact agriculture and the need for, and possibilities of, food production.

The Intergovernmental Panel on Climate Change (IPCC) stresses the need to strive for synergy between climate change policies, sustainable development and improvement of environmental quality aiming at the mitigation potential in the agriculture and food sector (IPCC 2019; Smith et al. 2007). In this context, AI-driven technologies offer potential solutions for optimising resource use, reducing greenhouse gas emissions, increasing resilience to climate impacts and more attention to animal health and welfare (Pandey and Mishra 2024; Ahmad et al. 2024; Dawkins 2025).

However, the potential of AI also raises questions and presents challenges. These include the need for more and better data, and the question of how to develop more context-specific agricultural algorithms. The questions are also of a normative nature. AI comes with value assumptions and is based on ideas about what should be promoted or prevented. Consequently, AI in the context of agriculture is inherently linked to ethics (Manning et al., 2022; Ryan, 2019). While there are more generic ethical issues related to, for instance, the responsible use and processing of data, or issues related to fair and open data, there are also ethical issues associated with AI that are specific to agriculture and the food supply chain, as well as to human interaction with animals and the environment.

This calls for ethical reflection. This is particularly relevant given that current legislation offers little guidance on AI in agriculture and food production. For example, the European Union's Artificial Intelligence Act (AI Act) says little about AI in this context. The AI Act generally pays little attention to non-human centred values such as the environment, biodiversity and animal welfare (Val, 2026), reflecting a more general societal tendency to overlook the environment and animals (Giersberg, 2026). Consequently, it offers little guidance on how to address the ethical issues of AI in the agri-food sector.

This makes this collection of papers particularly timely. The individual papers present and discuss not only ethical questions, but also broader philosophical issues specific to AI in agriculture, food production, and consumption. They also address the search for responsible AI governance and the need to consider values such as biodiversity and animal welfare, as well as environmental justice concerns. This volume also shows that addressing the ethical dimensions of AI in the context of agriculture and food result in a variety of methods and tools. These range from conceptual and analytical analyses to qualitative methods and literature reviews. They have all been applied. This is not merely the result of

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a lack of standards or a search for the best strategy. Rather, it demonstrates the complexity of the issues involved in the ethics of AI, and the value of a more pluralistic approach in the current phase of research and implementation.

This volume consists of eight sections that relate to the key theme of the EurSafe 2026 conference and add to more overarching themes in the interaction with technology, the environment and animals.

Section 1, entitled 'AI Futures in Food Systems', includes papers on innovations in food production, such as alternative protein production systems, drone use, and water management. The papers present these innovations and discuss not only the technical hurdles, but also the societal dimension.

Section 2 is about AI and governance. Given the potential disruptive role of AI, the papers in this section elaborate on the need for, and the possibility of, ethical, professional and regulatory frameworks that can address the dynamic nature of the agricultural and food sector.

Section 3 explores the role of AI in food production involving animals. This includes both farm animals and fish. The authors elaborate on the potential impact of AI on the daily lives of these animals, as well as on their health and welfare. They also discuss the changing role and position of veterinarians in this context.

Section 4 shifts the focus from the impact of AI on individuals (human or animal) to the natural and social environment. This section includes papers on environmental ethics dealing with biodiversity, digitalisation, and environmental justice. It also addresses the social dimensions of AI in relation to culture, work, labour, and the position of farmers.

Section 5 is about ethical food consumption and governance. Ethical issues and questions of justice arise not only at the production stage, but also during food consumption. This makes it an interesting topic to explore in combination with AI-driven innovation. Topics covered include consumer shame and moral responsibility, and the ethics of sustainable food system transformation.

Section 6 is dedicated to 'One Health' and veterinary ethics. Although these papers have a broader scope, the concept of health as an integrated system encompassing human, animal, and environmental health can provide a useful perspective on AI in the context of public and veterinary care. Furthermore, this section includes papers showcasing the EurSafe community's expertise at the intersection of veterinary medicine, ethics, and professional normativity.

Section 7 covers work carried out at the intersection of animal use, ethical evaluation, and governance. Several papers address the challenges of ethical assessment in the context of animal testing. This is combined with work on how to regulate new technologies and their ethical dimensions, as well as presenting guidance to policymakers and other stakeholders.

Section 8 includes a set of papers presenting recent work on animal ethics and human-animal interaction. This ranges from more fundamental philosophical work on our obligations to animals and the reasons for them, to descriptive work showing the reasons why people choose not to have pets.

Overall, this volume showcases the diversity of research topics within the EurSafe community and highlights the multifaceted nature of discussions on the ethics of AI and digitalisation in agriculture and the food supply chain, as well as the interaction between humans, animals, and the environment. We hope that this collection of papers will inspire you, the reader, to engage with the discussion, contribute to it, and further investigate how artificial intelligence can be developed and introduced in a responsible

way that takes non-human centred values such as the environment, biodiversity, and animal welfare into account.

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Section 1.
AI futures in food systems

'Not for me, but hopefully for the others'. A study on the perception of in-vitro meat among vegans

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Abstract

In-vitro meat is considered an alternative to traditional meat production. The article presents the results of an online survey on the assessment of in-vitro meat among 235 vegans in German-speaking countries. The survey indicates that vegans tend to reject these products on the basis of animal rights considerations, with differences emerging between specific production methods: The use of plant-based nutrient solution is more accepted than the use of calf serum and is rated by the majority as more ethically justifiable than traditional meat. Those less disgusted by meat are more open to try in-vitro products; men show a higher willingness than women to try these products; and long-term vegans are less likely to try them. Since food is increasingly being discussed from a moral perspective in current society, research on the acceptance of (novel) food should distinguish between personal dietary preferences and assessments of general societal food consumption: In this study, the majority of vegans categorically rejects in vitro meat with regard to their own consumption but considers such products to be a better alternative to conventional meat production for society as a whole for reasons of animal welfare and animal rights. Therefore, their assessment can be summarized as follows: 'In-vitro meat? Not for me, but hopefully for the others.'

Keywords: consumer acceptance, cultured meat, veganism, animal ethics, cultivated meat

Introduction

Against the backdrop of high global meat consumption, associated environmental and climate impacts, and the ethical debate surrounding the moral justification of slaughter, there is a growing search for alternatives to "conventional" meat. "In-vitro meat" (IVM), "cultured meat" or "lab-grown meat" are terms used to describe meat that is produced in a laboratory via tissue engineering (Post 2012; Hong et al. 2021): First, muscle tissue is removed from a donor animal by biopsy in order to obtain stem cells; these are then added to a culture medium so that the cells can multiply. One of the most frequently used and most effective nutrient solutions to date is foetal calf serum. For this, blood is taken from an unborn calf in the mother's womb. The foetus dies in the process. However, it is also conceivable to use plant-based nutrient solutions instead. The goal is for people to be able to enjoy meat without killing animals, or at least with far less harm to animals (Kantono et al. 2022). However, in addition to technical obstacles, estimated costs, actual efficiency, environmental assessment, health risks, and legal regulation, there is also the question of consumer acceptance. One group that is often missing in this context is vegans: How is IVM perceived by people who consciously abstain from animal products?

Methods

The article presents selected results of an online survey aimed at the perception and acceptance of IVM among vegans in German-speaking countries. Potential participants were found using the social media platform Facebook and the newsletter of the "Vegane Gesellschaft Österreich". The survey was available

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online from 16.10.2023 to 24.1.2024. The questionnaire focused on closed items, supplemented by open questions. As it could not be assumed that participants had any knowledge of IVM, the survey offered at some point a brief, generally understandable technical introduction to the topic, citing the presentation of IVM on "Die-Debatte.org", a joint platform of "Wissenschaft im Dialog" and the Technical University of Braunschweig. In this introduction, a distinction was made between two possible options for producing IVM, namely option A with the use of calf serum and option B with the use of plant-based nutrient solutions. The open questions were analysed following the qualitative content analysis according to Mayring (2015). The study design was submitted to the responsible ethics committee ('Ethikkommission der Medizinischen Universität Wien') on August 31, 2023. Ethical approval was waived. IBM® SPSS Statistics version 29.0 was used for regression analyses. We considered p-values below 0.05 as statistically significant. To examine the effect on socio-demographic aspects and persons' attitudes towards the motivation to follow a vegan diet, binary regression analyses were conducted. We created a binary variable for the regression 0 = disagreement to make use of IVM; 1 = agreement to make use of IVM. The answer option "No information" was excluded. Participants' age and the following four attitude statements were inserted as continuous predictors in the regression: a) I eat vegan diet because I want to protect the environment and the climate, b) I eat vegan diet because I consider the slaughter of animals for food to be immoral, c) I eat vegan diet because I am disgusted by meat and d) I eat vegan for health reasons. Again, the answer option "No information" was excluded. The study does not claim to be representative; no conclusions are drawn as to the extent to which the answers are transferable to the vegan population in general.

Results

235 German-speaking vegans took part in the study (81.7% female; 16.6% male). The age of the respondents was between 18 and 67 years, with an average age of 36. A proportion of 46% have been vegan for more than five years, only 3.8% for less than a year and the rest for between one and five years. In summary, animal ethical considerations are clearly at the centre of the motives for a vegan diet, followed by environmental ethical considerations. The motive "disgust for meat" shows a diverse picture. The same applies to "health reasons" (see Figure 1).

Perception of IVM

Participants received a technical introduction and were subsequently asked to evaluate two IVM production options – option A: calf serum; option B: plant-based nutrient solution. There is rejection or scepticism toward both options, however, participants consistently preferred option B (see Figure 2). When asked whether they would regularly eat an IVM product, rejection is high regarding option A and somewhat lower for option B. Respondents were also asked if they would try IVM products (not shown in the figure due to space): For option A (calf serum), rejection is high: 82.6% strongly disagreed with trying it. Acceptance is higher for option B, with 44.9% expressing some level of agreement. Still, 31.2% strongly disagreed with trying in-vitro meat using a plant-based nutrient solution. When asked whether IVM is more ethically justifiable than "classic" meat, there was scepticism or disagreement with regard to option A (calf serum): 50.2% did not agree with this statement at all, for example. At the same time, a quarter of respondents tended to agree with this statement ('I completely agree'/'I agree'/'I somewhat agree'). The approval rate increases regarding option B (plant-based nutrient solution): For the majority of respondents at 73.5% ('I completely agree'/'I agree'/'I somewhat agree'), this version of meat production is more ethically justifiable than "classic" meat. 27% completely agree with this. The statement "I reject in-vitro meat on animal ethics grounds" also shows a clear differentiation: When calf serum is used, 70.1% completely agree with this statement, whereas when a plant-based nutrient solution is used, agreement or disagreement is largely evenly distributed.

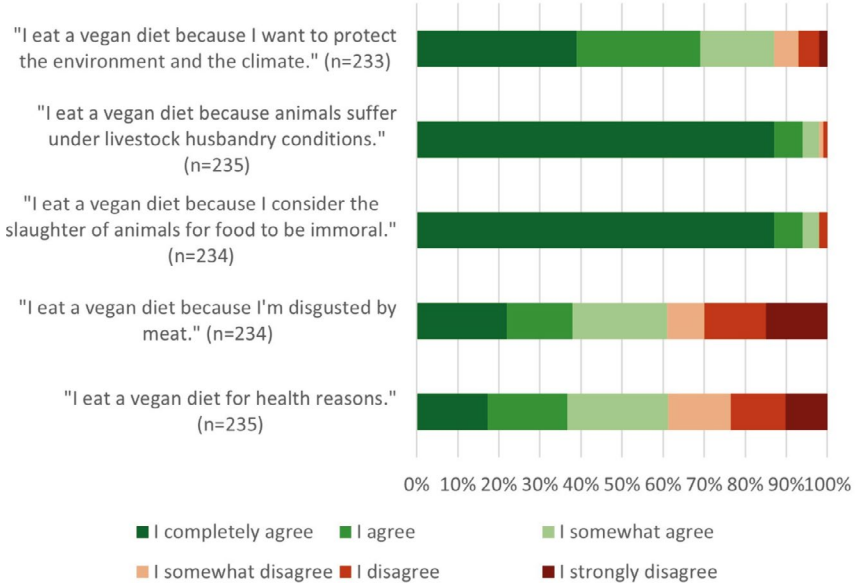


Figure 1. Participants' motives for a vegan diet

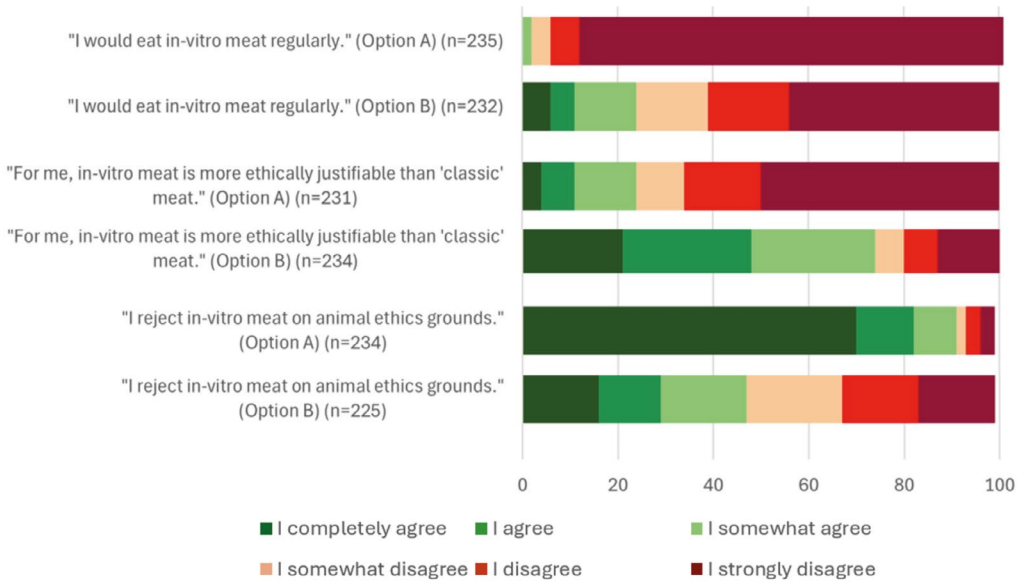


Figure 2. Assessment of IVM-products

What impacts that vegan persons would try IVM?

Binary regression analysis shows that participants' levels of disgust, gender, and the duration of a vegan diet impact whether they would try IVM or not. The analysis indicates that individuals who are less likely to express disgust towards meat are more likely to try IVM ($p<0.001$). Furthermore, female participants are more likely to disagree that they would try IVM compared to male participants ($p=0.049$). Participants who have been following a vegan diet for more than 5 years are less likely to agree that they would try IVM compared to those who have not yet been vegan for 5 years ($p=0.015$).

Reasoning for the assessment

The final question was open-ended and allowed participants to express their views on IVM in their own words. The most frequent arguments are explained in descending order: The participants most frequently addressed arguments relating to "animal rights". Most respondents not only reject the suffering and killing of animals for food production but also the use of animals for food production in any way. As the latter is the case with both options, IVM is classified as non-vegan and therefore rejected. Sample answers are as follows: "Animals are still abused to produce this meat, even with the plant-based nutrient solution. [...] So it's not vegan." Similarly: "I wouldn't eat it because it's still interfering with animals' lives without their consent." One response summarizes the rejection of IVM products in the sentence: "Being vegan means leaving animals alone." However, there are also some respondents who can imagine eating meat again. Exemplary animal ethical arguments in this context are as follows: "[I] Would only consume in vitro meat if [...] no further suffering is inflicted on the donor animal during the initiatory sample extraction (e.g. if comparable to taking blood from a dog at the veterinarian)." Or: "If animals do not have to be actively exploited for this purpose, I would be happy about authentic-tasting meat alternatives." Or: "I see no problem in removing muscle cells from a living animal. I even believe that this animal is particularly well cared for and can live freely."

Another key category indicates that many participants simply see "no need for IVM" regarding their own diet. In their view, there are sufficient alternatives. Exemplary answers include the following: "I find in-vitro meat completely pointless; there are 10000 other things you can eat that don't require the exploitation of non-human animals." Or: "I prefer natural food from vegetables, fruits, and grains etc." Some identified arguments surrounding the assessment of IVM can be summarized under the category "Better than the status quo". Although most participants would not eat IVM themselves, they point out that they see such products as a "lesser evil" and therefore an improvement on the current situation in which omnivores eat "classic" meat. Exemplary answers are as follows: "I wouldn't eat it, as I get along fine without eating meat. But I think it's a good alternative for the classic omni[vore; C.D.] who 'couldn't' (doesn't want to) do without meat." Or: "Not an option for me personally [...] But generally better than factory farming." Or: "Nevertheless, I think that any alternative to 'classic' meat can be a step in the right direction to reduce society's meat consumption (which in my opinion should be a goal of our society)."

Scepticism is evident with regard to the category "health". For example: "The health risks of in-vitro products [are] not known..." Or: "Without knowing it, I can well imagine that in-vitro meat will have health (...) disadvantages." "Ecological considerations" are also mentioned, pointing out that a final assessment of IVM depends not least on the actual life cycle assessment of these products. For example: "Is the impact on the environment less than with conventional meat production?" Some respondents state that they feel "disgust" by IVM, precisely because they expect a great similarity in taste to "classic" meat. Thereby, options A and B are viewed equally critically. Exemplary answers are as follows: "The version with 'plant-based nutrient solution' may be ethically much better, but I personally am disgusted by eating animal tissue – even if it was produced outside of an animal." Or: "For me, it [IVM; C.D.] is not an option because it disgusts me, and I don't want to eat meat." Finally, in their responses, the

interviewees also address considerations relating to the "naturalness/unnaturalness" of IVM – and here, too, scepticism prevails, with IVM being criticized as "unnatural": "[IVM is an; C.D.] unnatural food; better plant-based food than lab-grown meat."

Discussion

Meat missers and meat mislikers

The participants' motives for veganism can be clearly identified: At the centre are basic animal ethical convictions, followed by environmental and climate protection reasons. This result is consistent with other studies. (Mayrhofer et al. 2024; Dhont and Ioannidou 2024) Health considerations play comparatively only a minor role. As far as the motif "disgust for meat" is concerned in our survey, there is no uniform picture, quite the opposite. The present study underlines that vegans are not a homogeneous group in this context: Some are disgusted by meat – others miss the taste. So, there are "meat mislikers", but at the same time also "meat missers". This may explain why some vegans are suitable consumers of plant-based meat substitutes that aim to replicate the taste of 'real' meat as closely as possible, while others are less receptive and see no need for such products.

Perception of IVM

The answers to the open question in particular show that the group surveyed discusses and evaluates IVM primarily from an animal ethics perspective – other aspects such as health, taste, price, the socio-economic context of production, habit, ecological considerations or perceived "(un)naturalness" play a comparatively minor role. Generally, the survey results indicate that vegans in German-speaking countries are largely sceptical about IVM and tend not to be consumers. This is in line with other studies in this context (Heidmeier and Teuber 2022). They appear to be less willing to consume IVM than the general population, at least when the results are compared with similar studies (Weinrich et al. 2020) At the forefront of the profound rejection is the main motive for a vegan diet, namely the conviction that it is morally unjustifiable to use animals for the consumption of food, let alone to kill them. However, certain socio-demographic aspects do play a role: Male vegans show a higher willingness than female vegans to try these products. This is in line with other studies about IVM, showing that men are more receptive to it than women (Mancini and Antonioli 2019; Wilks and Phillips 2017). Further, our study underlines the importance of disgust and the duration of the vegan diet: Those less disgusted by meat are more open to try in-vitro products; and long-term vegans are less likely to try these products than persons who have recently gone vegan.

Generally, this study suggests that research on the acceptance or rejection of IVM should take different manufacturing processes into account. The results show that options A and B are evaluated quite differently. It can be assumed that these differences would also play a relevant role in the evaluation of other dietary groups such as omnivores or vegetarians. In the present context, it can be seen that IVM products that use calf serum are not judged any differently than "classic" meat from the point of view of the respondents: these products are rejected as immoral.

Although the option of using a plant-based nutrient solution is also viewed critically, respondents rate it much more positively from an animal ethics perspective – not only compared to the use of calf serum but also compared to the status quo of conventional meat production. There is even a small group of respondents who consider consuming these products, even if animal stem cells are the starting point of the manufacturing process. Answers to the open question indicate that the animal raw material (if obtained without suffering) is accepted by this small group in this case. However, there is a second possibility, namely that some respondents of this small group have misunderstood the technical

description: the word "plant-based" in the description of the nutrient solution could have led them to the erroneous assumption that animal material plays no role at all in the manufacturing process.

Judging food – with a view to your own plate or the plates of others?

The results of the present study show the following: precisely because food is increasingly understood not only as a question of personal preference ("What do I like?"; "What can I afford?", "What is healthy for me?"), but is increasingly being discussed as a moral issue, research on the acceptance or rejection of (novel) food should distinguish between personal dietary preferences and evaluations of societal food consumption. In other words: When judging food, do people look at their own plate – or at the plates of others?

This distinction reveals considerable differences in the assessment of IVM from a vegan perspective on basis of this study: With regard to their own diet, the vast majority of respondents rejects IVM on moral grounds; at the same time, however, most participants see IVM (with plant-based nutrient solution) as a better alternative to "traditional" meat production, i.e. a "lesser evil" compared to the status quo when it comes to the nutrition of society as a whole. Their assessment can therefore be summarized as follows: 'In-vitro meat? Not for me, but hopefully for the others.'

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AI-based nutrient estimation in apples using hyperspectral imaging

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Abstract

Accurate and timely assessment of plant nutritional and quality parameters is critical for precision agriculture and sustainable food production. Conventional laboratory-based analyses are typically destructive, time-consuming, and costly. This study proposes a non-destructive, data-driven framework for estimating key quality indicators in apples – specifically water content and soluble solid content (°Brix) – using near-infrared (NIR) hyperspectral imaging combined with machine learning. Hyperspectral data were acquired in the 400–1,000 nm spectral range using a push-broom imaging system with 342 contiguous bands. Spectral pre-processing, windowed feature extraction with Fast Fourier Transform (FFT) analysis, and Principal Component Analysis (PCA) were applied for dimensionality reduction. Linear regression models, evaluated through 10-fold cross-validation, achieved R^2 up to 0.88 and RMSE as low as 0.047. Cultivar-specific models for yellow and green apples yielded comparable results (R^2 = 0.87–0.88), confirming generalizability. The results demonstrate that spectral feature engineering combined with machine learning offers a cost-effective alternative to conventional laboratory analyses.

Keywords: precision agriculture, spectral feature engineering, dimensionality reduction, non-destructive sensing, machine learning regression

Introduction

The apple belongs to the genus *Malus* Miller within the subfamily Pomoidea (Maloideae) of the Rosaceae family. The cultivated apple (*Malus x domestica* (Suckow) Borkh.) originates from the Tien Shan Mountains in Central Asia. Wild *Malus* species are mainly found in temperate regions of the northern hemisphere, with China as its main center (Volk et al., 2021). Anatolia is among the genetic centers of the apple. Wild apple species *M. sylvestris* (L.) Mill., *M. florentine* (act.) Schneider, and *M. Trilobata* (Poir.) C.K. Schneider are widespread in Northeastern Anatolia and the Eastern Taurus Mountains (Phipps et al., 1990; Kurtto, 2009).

Agricultural yield is strongly dependent on the timely and accurate determination of nutritional properties. Currently, information on food composition is typically obtained through time-consuming and destructive laboratory analyses performed on sampled products. This reliance necessitates costly experimental methods and equipment, which do not allow for real-time assessment. As a result, critical decisions by producers – such as cultivation practices and seed selection are often based on delayed and limited information. The global demand for high-quality fruit production has intensified the need for rapid, non-destructive analytical methods capable of assessing internal quality parameters. In apples, key quality indicators such as soluble solid content (°Brix), water content, and firmness are traditionally measured through destructive laboratory procedures (Nicolai et al., 2007). These methods are slow, costly, and impractical for real-time quality control.

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Hyperspectral imaging (HSI) has emerged as a powerful alternative, capturing spatially resolved spectral information across hundreds of contiguous wavelength bands. HSI systems operating in the visible and near-infrared (Vis-NIR, 400–1,000 nm) range can detect absorption features associated with water (O–H overtone near 970 nm), sugars, and organic acids (ElMasry et al., 2012). When combined with machine learning, HSI enables pixel-level prediction of chemical properties across the entire sample surface.

Recent studies have demonstrated PLSR, SVR, and ANN for predicting fruit quality from hyperspectral data (Lu et al., 2020). However, reliance on raw spectral values may not fully exploit spectral information. Signal processing techniques such as windowed feature extraction, FFT analysis, and statistical moment computation can enrich the feature space (Ravikanth et al., 2017). The objective of this study is to develop a comprehensive spectral analysis pipeline for non-destructive estimation of water content in apples, integrating windowed feature extraction with Hanning apodization and Principal Component Analysis (PCA) to reduce dimension and combine linear regression with cross-validation.

Materials and methods

Sample preparation and image acquisition

Apple samples comprising two cultivar groups – yellow (Golden Delicious cv.) and green (Granny Smith cv.) were obtained from the Faculty of Agriculture, Eskisehir Osmangazi University. Six apples (three per cultivar) were used, with replicate acquisitions across multiple imaging sessions. A Near Infrared (NIR)-based operating system (Specim, Finland) within the 400–1000 nm wavelength range is used to allow the acquisition of spectral reflections from plants in the form of a three-dimensional data cube using the push-broom imaging technique. With a spectral resolution of 4 nm, the reflectance values corresponding to individual wavelengths with 342 contiguous spectral bands and a spatial resolution of 1,024 pixels per line make it feasible to distinguish characteristic markers of macronutrients. Since chemical-specific light reflectance provides deeper insight into features that may appear identical or similar in the visible spectrum, this camera based system enables more precise discrimination and tracking of such markers. Consequently, these spectral characteristics can be effectively correlated with key quality parameters such as soluble solid content, firmness, and moisture level.

Figure 1 shows the apple samples positioned on the hyperspectral scanning platform during image acquisition. It looks like a gray white image decomposed into 342 spectral bands. Figure 2 illustrates the spectral variation observed across the 400–1,000 nm range by displaying a single apple region at five representative wavelengths: 450 nm (blue), 550 nm (green), 700 nm (red), 850 nm (near-infrared), and 970 nm (water absorption). The pronounced contrast differences between bands reflect the wavelength-dependent reflectance properties of apple tissue and provide the basis for compositional estimation.

A custom developed GUI in Python programming environment is used to first mask and then segment the individual apples from the hyperspectral scene. Reflectance values of all pixels within each segmented region are exported as CSV files. A stratified random sampling strategy selected 15,000 representative pixels per experimental run to ensure computational tractability whilst preserving spectral diversity.

Feature extraction and modelling

Each 342-band spectrum was processed through a sliding window feature extraction procedure. The FFT of each segment is computed, and the top five frequency peak magnitudes areretained. Window sizes of 64 and 128 samples with overlap ratios of 50–75% are evaluated.

Feature matrices are standardized with PCA method with a 95% cumulative variance threshold. Linear regression models are evaluated using 10-fold cross-validation, reporting R^2 and RMSE. All computations used scikit-learn 1.4 in Python 3.11.

Table 1 summarizes the regression performance across seven experimental configurations. Configuration R3 (64-sample window, 60% overlap, combined dataset) achieved the best cross-validated R^2 of 0.874 (±0.006) and CV RMSE of 0.048.

Increasing overlap from 50% to 60% produced substantial improvement. Comparing R1 (47 PCA components, $R^2 = 0.70$) with R2 (191 components, $R^2 = 0.84$) shows that aggressive dimensionality reduction discards valuable information. Further increasing overlap to 75% (R5) yielded 470 features but did not improve performance (CV $R^2 = 0.85$), indicating diminishing returns from excessive overlap. Separate models for yellow (R4-Y) and green (R4-G) apples performed comparably to the combined model (R3). The green apple model achieved training $R^2 = 0.880$ and the yellow apple model the lowest CV RMSE = 0.047. Figure 3 and Figure 4 show the predicted versus observed scatter plots and residual distributions for yellow and green cultivar models, respectively.

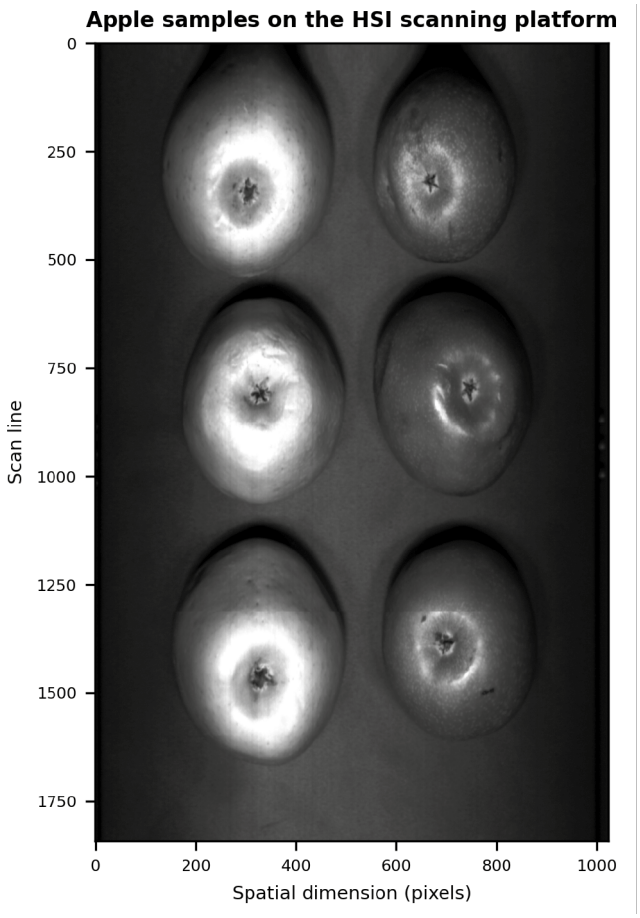


Figure 1. Apple samples (three yellow, three green) on the push-broom hyperspectral imaging platform during data acquisition. Image reconstructed from the 342-band data cube at visible wavelengths.

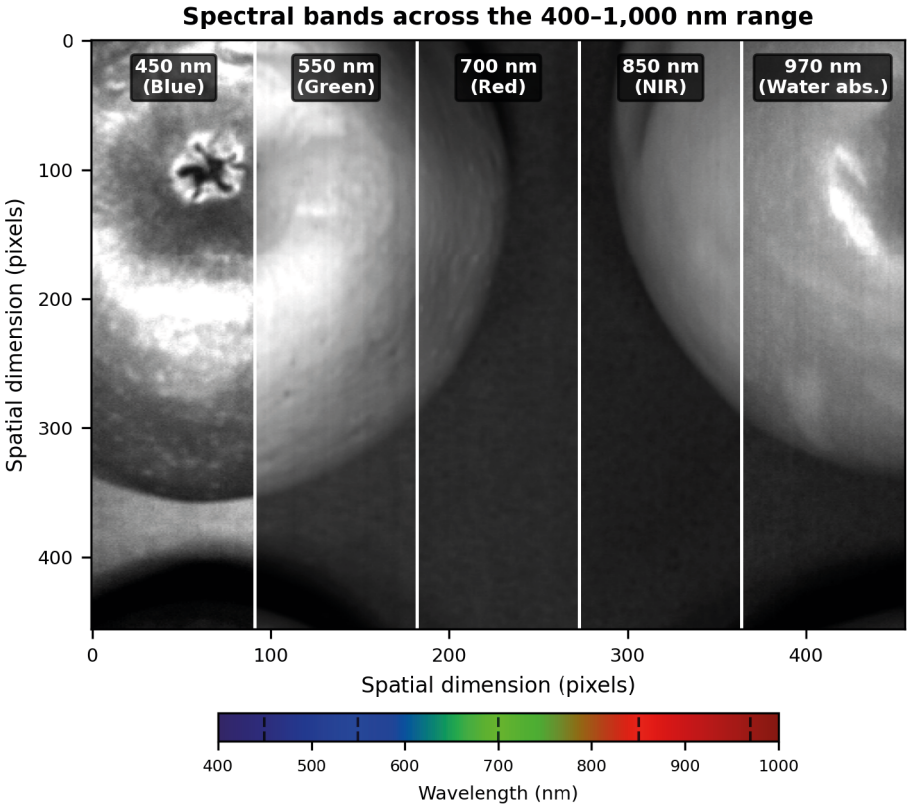


Figure 2. Hyperspectral image of a single apple divided into five vertical strips, each showing reflectance at a different wavelength. The colour bar indicates the position of each band within the 400–1,000 nm spectral range.

Table 1. Summary of linear regression performance across experimental configurations

Run	Dataset	Win.	Overlap	Feat.	PCA	Train R^2	CV R^2	CV RMSE
R1	Combined	64	50%	191	47	0.702	0.699±0.011	0.074±0.001
R2	Combined	64	50%	191	191	0.844	0.840±0.010	0.054±0.001
R3	Combined	64	60%	248	248	0.878	0.874±0.006	0.048±0.001
R4-Y	Yellow	64	60%	248	248	0.876	0.871±0.005	0.047±0.001
R4-G	Green	64	60%	248	248	0.880	0.876±0.008	0.048±0.001
R5	Combined	64	75%	470	263	0.857	0.852±0.007	0.053±0.001
R6	Yellow	128	75%	195	96	0.795	0.792±0.008	0.059±0.001
R7	Green	128	75%	195	98	0.809	0.806±0.010	0.060±0.001

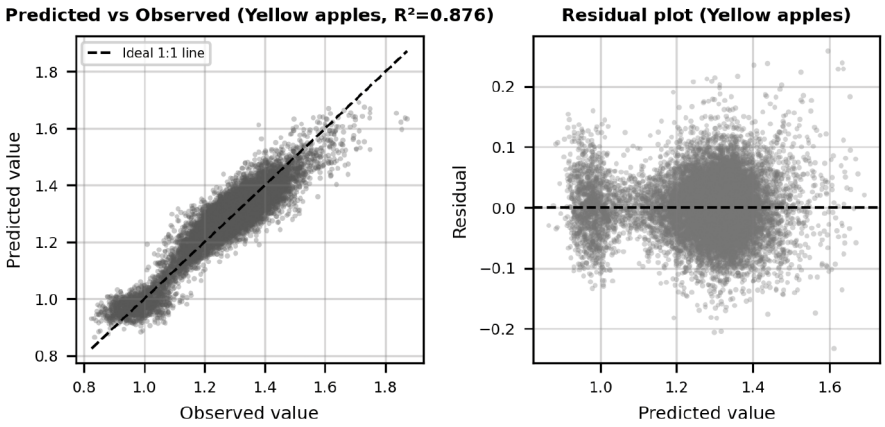


Figure 3. Predicted versus observed values (left) and residual plot (right) for the yellow apple cultivar model (R4-Y, $R^2 = 0.876$)

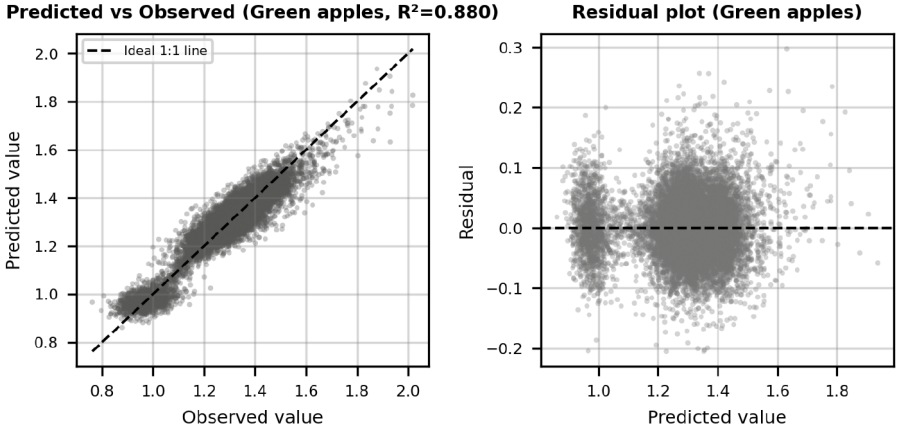


Figure 4. Predicted versus observed values (left) and residual plot (right) for the green apple cultivar model (R4-G, $R^2 = 0.880$)

Conclusions

Most studies in the literature do not present an integrated framework in which trained models are systematically supported by laboratory measurements. In the paper, a subset of samples were studied by utilizing the NIR hyperspectral data cube for a comparative and complementary machine learning methods for the determination of nutritional properties to ultimately establish a system capable of near real-time estimation. The study presented a spectral analysis pipeline for non-destructive water content estimation in apples and the key findings are summarized as follows:

1. Windowed feature extraction with Hanning apodization and FFT-derived descriptors enriches the spectral feature space compared to raw reflectance values.
2. A window size of 64 with 60% overlap yielded optimal performance (CV $R^2 = 0.87$, RMSE = 0.048).
3. Cultivar-specific models for yellow ($R^2 = 0.871$) and green apples ($R^2 = 0.876$) performed comparably to the combined model, confirming generalizability.

4. PCA at a 95% variance threshold compressed up to 470 dimensions to 248 components without sacrificing accuracy.

Future work will integrate laboratory-measured Brix and moisture values, and extend the framework to include SVR, random forests, and neural networks. The pipeline provides a foundation for deployment in mobile or drone-based platforms.

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Digital water management for climate-resilient wheat production: the water risks R&D project

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Abstract

In semi-arid regions such as Central Anatolia, climate change has intensified water scarcity stress, increasing the need for precision irrigation. This study presents the findings of the "Water Risks R&D Project" (2022-2023). It focused on water use optimization via sensor-based irrigation under saline conditions. The project site in Delice-Çerikli (Kırıkkale Province) receives about 400 mm precipitation, has C3S1 water quality, and regional irrigation efficiency remains around 50%.

Four plots were established in the 11.6 da project area: one for the farmer's sprinkler irrigation and three for project practices involving sprinkler irrigation, drip irrigation and rain-fed production, used to calibrate sensors and evaluate irrigation efficiency. Each plot was equipped with humidity (H), temperature (T), flow rate (F) and salinity (S) sensors placed at depths of 15, 45, 75, and 105 cm. Additionally, flow sensors were installed in the center of the field within the drip irrigation plot to measure and calibrate system water output. Sensor measurements were recorded at 5-minute intervals and monitored through a mobile application, enabling precise irrigation control through continuous soil moisture tracking.

The results showed up to 28% increase in wheat yield and 65% improvement in irrigation water use efficiency (IWUE). The IWUE attained values of up to 1.14 kg m^{-3}, accompanied by total water savings in the range of 53–65%. The water footprint of wheat production was determined as 1504 m^3 ton^{-1}, comprising 38% green water and 62% blue water, indicating dependence on irrigation. Moreover, wheat yield, with average 224 kg da^{-1} in the region, increased to 304–371 kg da^{-1} with drip irrigation.

Overall, the findings of this study demonstrate that digital water management and sensor-guided irrigation have a potential to significantly enhance water use efficiency and sustainability in semi-arid agriculture under climate stress.

Keywords: precision irrigation, water footprint, irrigation efficiency, digital agriculture, semi-arid regions

Introduction

Water scarcity has become one of the most critical constraints for agricultural production, particularly in semi-arid regions where climate change intensifies both drought frequency and evapotranspiration (World Bank, 2023). In Türkiye, where agriculture accounts for approximately 77% of total water withdrawals, improving irrigation efficiency is essential for sustaining both food production and water resources (Turkic Academy and OTS, 2024).

Central Anatolia is among the most vulnerable regions due to its low precipitation (approximately 400 mm annually) and high climate variability. Wheat production in this region is largely dependent

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on rainfall or supplemental irrigation, making it highly sensitive to climatic fluctuations (Capar et. al., 2022). Under these conditions, inefficient irrigation practices further exacerbate water stress and reduce agricultural productivity. Recent developments in digital agriculture, including sensor-based irrigation systems and real-time monitoring technologies, provide new opportunities for improving water use efficiency. These systems enable precise irrigation scheduling based on actual soil moisture conditions, reducing water losses and enhancing crop performance (Liao et. al., 2008; Lawston, et. al., 2017; Samreen, et. al., 2022; Kragh, et al., 2024). However, field-scale applications under real farming conditions remain limited.

This study evaluates the effectiveness of sensor-based irrigation systems in improving water use efficiency, yield, and sustainability through an integrated two-phase field experiment conducted within the Water Risks R&D Project.

Materials and methods

Experimental design and irrigation systems

The study was conducted in the Çerikli (Delice, Kırıkkale) region within the Kızılırmak Basin in Central Anatolia, Türkiye, under semi-arid conditions with approximately 400 mm annual precipitation. Two consecutive field experiments were carried out at different sites in Phase I (2022) and Phase II (2023) to evaluate irrigation performance and improve system design (Figure 1). In Phase I, a 40 da field was used to assess baseline irrigation performance under saline conditions, where loamy soils and high-salinity surface water (EC ≈ 14 mS cm^{-1}) represented typical regional constraints. The field was divided into six management units (M1–M6), and drip irrigation systems with different lateral spacings (0.28–0.70 m) were tested. In Phase II, a separate 11.6 da field with a more structured layout (P1–P7) was established to compare irrigation strategies, including farmer-managed and project-managed sprinkler irrigation, drip irrigation, and rainfed conditions. Soil characteristics were similar between phases, while irrigation water in Phase II was supplied from groundwater with lower salinity.

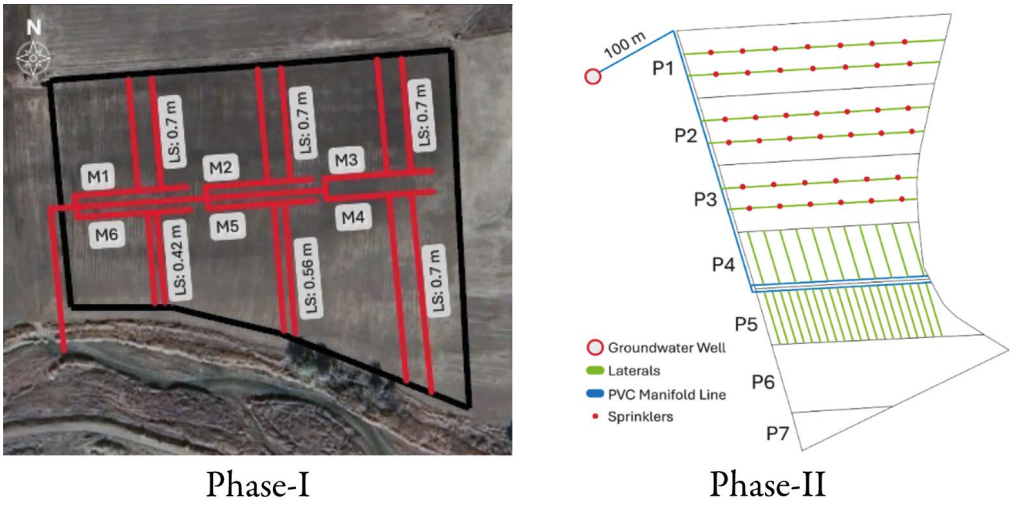


Figure 1. Layout of the management units

A sensor-based monitoring system was implemented in Phase II, including soil moisture, temperature, and salinity sensors installed at multiple depths and supported by flow measurements (Table 1). Sensor data were recorded at 5-minute intervals and used to guide irrigation scheduling (Capar, 2023). Wheat (*Triticum aestivum L., cv. Aliaga*) was cultivated under standard agronomic practices.

Performance indicators

Irrigation performance was evaluated using key indicators, including grain yield, irrigation water use efficiency (IWUE), and water footprint (WF). IWUE is defined as the ratio of crop yield to irrigation water applied (kg m^{-3}) (Eq. 1) (Zhang, 1999), while WF components are calculated based on green and blue crop water use relative to yield.

$$IWUE = Y/I \quad \text{Eq.1}$$

The green water footprint (m^3 t^{-1}) represents the volume of rainwater stored in the soil and consumed per ton of wheat, whereas the blue water footprint (m^3 t^{-1}) corresponds to irrigation water use from surface or groundwater sources (Eq. 1) (Hoekstra, 2011).

$$WF_{green} = CWU_{green}/Y \quad \text{Eq.2}$$

where CWU_{green} is green consumptive water use (m^3) and Y as yield (ton or kg) (Eq. 2) (Hoekstra, 2011).

$$WF_{blue} = CWF_{blue}/Y \quad \text{Eq.3}$$

where CWU_{blue} is blue consumptive water use (m^3) and Y as yield (ton or kg) (Eq. 3) (Hoekstra, 2011).

Table 1. Experimental treatments, plot areas, and characteristics of the installed soil moisture sensors

Plot No	Experimental treatment	Irrigation practice	Irrigation method	Plot area (da)	Sensor type	Sensor depth
P1	Farmer's Practice	Full Irrigation	Sprinkler	2.52	Soil Moisture Temperature Salinity	15 cm 45 cm 75 cm 105 cm
P2	Project	Full Irrigation	Sprinkler	2.17	Soil Moisture Temperature	
P3		Single Irrigation	Sprinkler	1.86		
P4		Full Irrigation	Drip: Wide Lateral	1.44	Soil Moisture Temperature Salinity Flow Rate	
P5		Full Irrigation	Drip: Narrow Lateral	1.55	Soil Moisture Temperature Flow Rate	
P6		Control	Rainfed	2.04	Soil Moisture Temperature Salinity	
P7		Sensor Calibration	Until Saturation		Soil Moisture Temperature	
Total				11.58		

This two-phase experimental design enabled both cross-comparison of irrigation methods under field conditions and the assessment of improvements achieved through system optimization and sensor-based irrigation management.

Results and Discussion

The results demonstrate that sensor-based irrigation significantly improves both yield and water efficiency compared to conventional practices. In Phase I, wheat yield values were already higher than regional averages due to improved irrigation configurations, providing a baseline for system performance under saline conditions. In Phase II, with the integration of sensor-based irrigation scheduling, yield increased more substantially from approximately 224 kg da^{-1} (regional average) to 304–371 kg da^{-1} under drip irrigation conditions, corresponding to an increase of up to 28–35%. Similarly, irrigation water use efficiency showed progressive improvement across the two phases. In Phase I, IWUE values improved compared to conventional practices, while in Phase II, sensor-based drip irrigation achieved values up to 1.14 kg m^{-3}, compared to approximately 0.35 kg m^{-3} under conventional systems, indicating more than a threefold increase in water productivity (Figure 2).

Water savings were more pronounced in Phase II, ranging between 53% and 65%, primarily due to improved irrigation scheduling and reduced over-irrigation through continuous soil moisture monitoring. WF analysis conducted in Phase II revealed a total value of 1504 m^3 ton^{-1}, consisting of 38% green water and 62% blue water, indicating an increasing dependence on irrigation under declining precipitation conditions (Figure 3).

Overall, the comparison of the two phases highlights a clear improvement in system performance, where Phase II achieved higher efficiency and more stable yields due to better calibration, optimized irrigation strategies, and enhanced use of sensor-based monitoring.

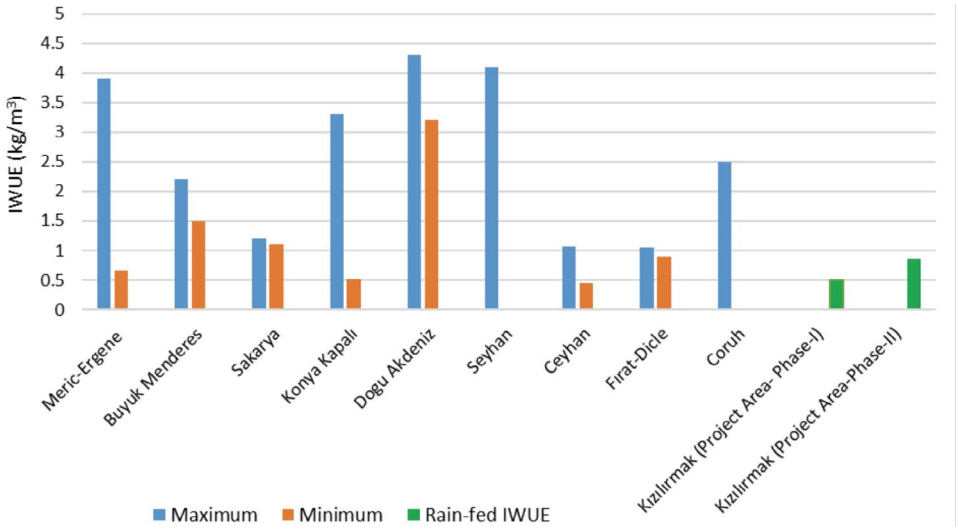


Figure 2. Water footprint of wheat in the project areas

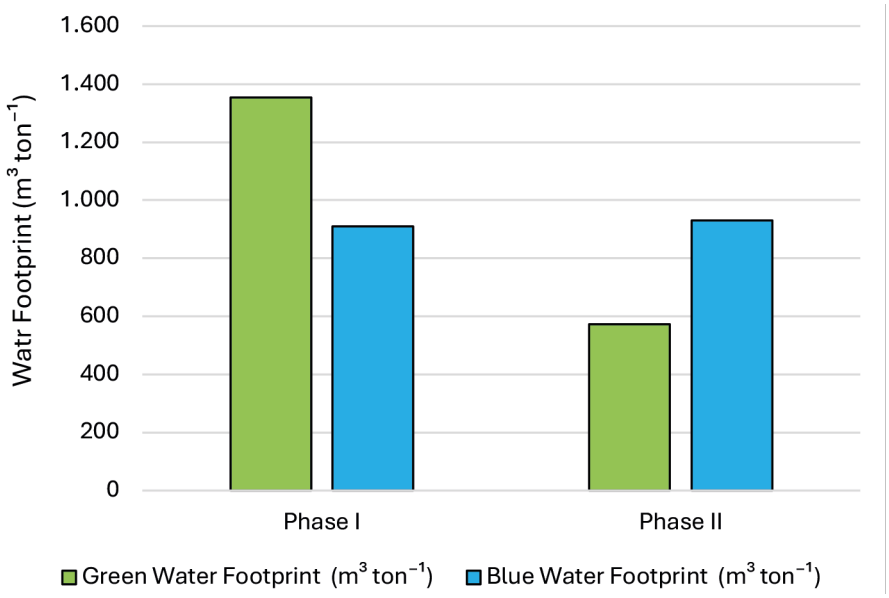


Figure 3. Water footprint of wheat in the project areas

Conclusions

The findings of this study demonstrate that digital water management and sensor-based irrigation systems can significantly improve water use efficiency and crop productivity in semi-arid regions. The integration of real-time monitoring technologies enables precise irrigation scheduling, leading to substantial water savings and increased yields. At the same time, the growing reliance on blue water highlights the need for adaptive strategies under changing climatic conditions.

Sensor-based irrigation systems provide a scalable and effective solution for sustainable agricultural water management. Their wider adoption can contribute to climate-resilient agriculture and support long-term water sustainability at both farm and basin scales. The water footprint analysis is useful for taking precautions during drought conditions.

Acknowledgement

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Commercial drone usage and research on drone usage by farmers

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Abstract

This study aims to examine the current state of commercial drone use in Kahramanmaras province and how farmers have adopted this technology. Drone technology is increasingly gaining importance in the agricultural sector, with advantages such as increased productivity and reduced costs. The study focuses on farmers' knowledge levels regarding drone use, application areas, and the challenges they face. The research was conducted in July 2024 in Kahramanmaras province through surveys and interviews with 20 farmers receiving drone services and 10 companies providing drone services. The data obtained reveal in detail the effects of drone technology on agricultural productivity, its adoption rate, and existing problems. Furthermore, the regional economic impacts of commercial drone use and its place in the agricultural sector are also evaluated. The results show that the use of drone technology in agriculture is increasing in Kahramanmaras province, and farmers are applying this technology in various ways. However, training and infrastructure investments are needed for wider adoption of the technology. The study makes recommendations to increase agricultural productivity and provide more support to farmers.

Keywords: drone technology, commercial use, agriculture, producer, Kahramanmaras

Introduction

Agricultural drones are tools with the potential to improve efficiency and precision, especially in agriculture. Xu et al. (2021) evaluate the application areas and future potential of agricultural drones, noting that the technology also presents various challenges. These challenges include technical problems, data management, and costs. Despite their vast potential, the adoption of drones in agriculture faces several challenges including regulatory restrictions, high initial costs, limited battery life, lack of skilled operators, and technical limitations in diverse environmental conditions (Satish et al. 2025). Gupta and Choudhury (2020), on the other hand, examine the general application areas of agricultural drones, highlighting the benefits of this technology for both small-scale farms and large agricultural enterprises. Through the use of drones enable farmers to monitor crops, assess plant health, and identify possible issues such as pests and diseases with a great accuracy and speed.

Technological advancements are leading to radical changes in the agricultural sector. In recent years, drone technology has attracted attention for its potential to increase efficiency and reduce costs in agricultural activities. Drones offer the possibility of managing agricultural processes more effectively through functions such as aerial data collection in agricultural areas, monitoring crops, and detecting diseases and pests. In this context, understanding the effects of drone technology on agricultural production and farmers at the regional level are important.

Research on the adoption of agricultural drone technology in Türkiye reveals that this technology is implemented at different levels throughout the country. Yılmaz and Tekin (2019) discuss the acceptance and application status of agricultural drone technology in Türkiye, while Acar and Koç (2021) evaluate the effects of this technology on precision agriculture practices in Türkiye. These studies comprehensively

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examine the levels of drone technology use by agricultural enterprises in Türkiye and the challenges they face.

The economic impacts of agricultural drones show that this technology can provide significant improvements in agricultural productivity. A study by Arslan and Kaya (2022) evaluates the economic impacts of agricultural drone technology in Türkiye and reveals the financial advantages provided by this technology. In addition, Yavuz and Çelik (2020) examine the main technical challenges encountered in the use of agricultural drones and strategies for overcoming these challenges, focusing on technical problems and solutions.

Research on the environmental impacts and social acceptance of agricultural drones evaluates the potential benefits and challenges of this technology. Liu and Yang (2021) examine the environmental impacts of drones in biological control, highlighting the potential of precision applications to reduce environmental damage. Kuru and Ege (2021) investigated the social acceptance of agricultural drones in Türkiye and how this technology was adopted in developing countries.

Kahramanmaras province is a region where agricultural production is important and various agricultural products are grown. However, there is no comprehensive information about the commercial use of drones in this region and the level of adoption of this technology by farmers. Research on the extent to which farmers have adopted drone technology, how this technology affects agricultural productivity, and the challenges they face is limited. In order to fill this gap, this study aims to investigate the commercial use of drones in Kahramanmaras province and the opinions of farmers regarding this technology.

Material and methods

This study is descriptive research examining the commercial use of drones in Kahramanmaras province and farmers' opinions on this technology. The research was conducted using a quantitative data collection method. Data collection through surveys aimed to measure farmers' knowledge levels regarding drone technology, frequency of use, application areas, and the challenges they face.

The research population consisted of farmers receiving drone services and companies providing drone services in Kahramanmaras province. For this purpose, 20 farmers receiving drone services and 10 companies providing drone services were randomly selected. Face-to-face surveys were conducted with the selected farmers and companies in July 2024.

Structured questionnaires were used to measure farmers' knowledge levels regarding drone technology, frequency of use, application areas, and the challenges they face. The questionnaires were designed to include multiple-choice, open-ended, and closed-ended questions. The content of the questionnaires was prepared in line with the literature review and expert opinions.

Farmers and companies were informed about how to complete the questionnaires and given sufficient time to complete them. It was checked whether any assistance was needed during the completion of the questionnaires. Data obtained from the surveys were evaluated using statistical analysis methods. Descriptive statistics, including frequency distributions, percentages, means, and standard deviations, were used in the analysis. The analyses were performed using SPSS statistical software.

Results

Data on farmers receiving drone services

The age range of the farmers varies between 34 and 60 years. The average age is 45.75 years, indicating that these farmers are in the middle-aged group. The wide age range reveals that agricultural experience is widespread among farmers of different age groups, and this group includes both young and old farmers (Table 1).

All of the farmers participating in the study were male. This indicates that the study was conducted only with male farmers and that gender may have influenced the research results. The education level of the farmers generally shows that they are high school and university graduates. The highest percentage belongs to high school graduates (60.0%). This reveals that individuals engaged in agricultural activities generally have a middle to high level of education (Table 2).

The majority of farmers have a middle-income level (90.0%). This shows that agricultural activities are generally carried out by middle-income farmers and that farmers with low or high incomes are proportionally small. A large portion of the farmers are insured under the Farmers' Social Security scheme (70.0%). Other types of social security, such as private insurance and pensions, are less common (15.0% each).

More than half of the farmers are members of both the Chamber of Agriculture and the Agricultural Credit Cooperative (50.0%). Membership in the Agricultural Credit Cooperative alone is 40.0%, while membership in the Chamber of Agriculture alone is lower at 10.0%. This shows that the majority of

Table 1. Socio-demographic characteristics of the farmers

Characteristics	Minimum	Maximum	Mean	Std. Deviation
Age (year)	34	60	45.75	7.993
Family size (person)	3	7	4.95	1.099
Agricultural experience (year)	9	45	21.90	9.619
Agricultural land (da)	9.7	55.0	27.48	114.174

Table 2. Education level of farmers

Education Level	Frequency	%
Literate	1	5.0
Primary school	2	10.0
Middle school	2	10.0
High School	12	60.0
Undergraduate	3	15.0
Total	20	100.0

farmers are members of both the Chamber of Agriculture and the Agricultural Credit Cooperative and benefit from agricultural support mechanisms. Half of the farmers have agricultural insurance (50.0%), while the other half do not (50.0%).

The crops grown by farmers are diverse. The most common crop patterns include maize, cotton, and wheat. Farmers generally grow more than one crop, such as maize, cotton, sunflower, and wheat.

While a large proportion of farmers (70.0%) have previously used agricultural technology, 30.0% have not. This indicates that agricultural technologies are widely used.

The vast majority of farmers (95.0%) use drones for agricultural spraying. This shows that drone technology is widely used in agricultural applications. Farmers mostly use insecticides and fungicides in drone spraying (95.0%). Herbicide use is less common (5.0%). Farmers use drone technology for a variety of crops. The most common applications are on corn and cotton. Farmers use drones for agricultural spraying on crops such as corn, cotton, wheat, and sunflower. Corn and cotton stand out as the most frequently sprayed crops.

The vast majority of farmers (80.0%) are unaware of drone usage. This indicates a lack of training and information. Farmers' sources of information are generally their social circles (20.0%). Most farmers use the DJI brand (55.0%). Other brands are less common. Farmers generally use drones 1 or 2 times a year. It is often used at a lower rate, and some farmers do not use it at all (Table 3).

The vast majority of farmers (95.0%) stated that drone use does not cause environmental damage. This shows that drone technology is environmentally friendly. All farmers are considering using drones for agricultural spraying in the future. This shows that drone technology will be widely used in the future. All farmers apply plant nutrition products with drones. This shows that drone technology is also used effectively in plant nutrition processes.

None of the farmers have received any training on drone use. This indicates a lack of training and the need for training programs in the future. A large majority of farmers (95.0%) stated that they take safety precautions when using drones. This shows that safety precautions are widely implemented.

Data on companies providing drone services

In Kahramanmaras province, a total of 10 drone companies provide services, with 5 in Pazarcik district, 2 in Türkoğlu district, and 3 in other districts (Dulkadiroglu, Elbistan, and Onikibubat districts).

Table 3. Drone usage frequency of farmers

Drone usage frequency	Frequency	%
No usage	2	10.0
Once a year	6	30.0
Twice a year	10	50.0
three times a year and more	2	10.0
Total	20	100.0

The vast majority of companies are sole proprietorships (70%). Limited and joint-stock companies are less represented. This indicates that commercial drone use is generally carried out by sole proprietorships. Most companies employ 2 or 3 employees. The generally low number of employees indicates that small-scale businesses offer drone services and larger teams are less common.

The most common duration for drone spraying is 4 years (50%). This indicates that drone-based agricultural spraying has been adopted over a certain period, and companies have gained significant experience during this time. All companies use the DJI Agras model. This indicates that DJI Agras is one of the dominant brands in the industry and that all survey participants prefer this brand.

Companies generally spray 500 hectares of land annually with drones (40%). The percentage of those spraying less than 500 hectares was found to be 30%, while the percentage of those spraying more than 500 hectares was also 30%. All companies charge 700 TL per hectare. This shows a standard pricing practice in the sector and no price variation. The most commonly used types of pesticides in spraying operations are insecticides and fungicides (90%). Herbicides are used less frequently (10%). All companies apply plant nutrition products with drones. This shows that drone technology is used not only in spraying but also in plant nutrition applications.

The most common technical problems in drone spraying are GPS signal problems (50%) and battery life issues (30%). Malfunctions in the spraying system are less common (20%). All companies use software provided by the drone manufacturer. This indicates that manufacturer software is the standard practice in the industry and other software is not widespread. The vast majority of companies perform wind and weather checks (80%). Pre-flight calibration is less common (20%).

All companies stated that agricultural spraying with drones is very economically advantageous. This highlights the cost-effectiveness of drone use.

The most anticipated innovations in drone spraying in the future include longer battery life and improved software and analysis tools (40%). More precise GPS systems are less prominent (20%).

The biggest challenges encountered in drone spraying are generally cited as legal regulations (40%), cost (30%), and lack of technical knowledge (30%). This shows that regulatory and financial obstacles in the sector are prominent. 60% of companies are considering receiving training or support on drone spraying. This indicates that there is a need for training in the sector and that technical knowledge gaps need to be addressed.

Conclusion

This study comprehensively examined the effects of drone use in agricultural spraying on farmers and commercial businesses. The study analysed the efficiency, economic advantages, challenges, and future expectations regarding the use of drones by both individual farmers and commercial agricultural enterprises. The findings are summarized below:

According to the study, the effects of drone use in agricultural spraying on farmers and commercial enterprises were comprehensively addressed. The average age of the farmers was 45-75 years, and the average agricultural experience was 21.90 years. They were generally high school graduates and had farmer's social security registration. The majority of farmers were in the middle-income bracket, and their relationships with agricultural organizations were generally in the form of membership in the Chamber of Agriculture and the Agricultural Credit Cooperative. A large portion (95%) of the farmers who follow agricultural technology use drones for agricultural spraying, and it was stated that this technology

provides speed, ease, and cost advantages. However, technical problems, especially GPS signal loss and battery life issues, can occur. Commercial agricultural enterprises also spray 500-800 hectares of land annually using DJI Agras brand drones and emphasize the efficiency and economic advantages of drone use. Challenges such as lack of training, legal regulations, and costs are also highlighted. Innovations such as longer battery life, precise GPS systems, and advanced software tools are expected in the future. Providing training and technical support is critical to overcoming these challenges and increasing the effective use of drone technology. Technological innovations are expected to increase efficiency by reducing existing problems. In conclusion, both individual farmers and commercial agricultural businesses benefit from the high efficiency and economic advantages provided by drone technology in agricultural spraying; however, overcoming challenges such as solving technical problems, providing training in the right methods, and properly regulating legal regulations are considered critical for the more effective use of drone technology. In the future, it is expected that the development of technological innovations like artificial intelligence (AI) and machine learning (ML) tools will reduce these challenges, and the use of agricultural drones will support the plant production process, accelerate the solution process, and increase efficiency. Also overcome economic problem, state government subsidies scheme, low-interest loans from banks, and farmer cooperatives society should play a significant role in adopting resources.

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How far are we from reliable AI animal welfare footprint assessment?

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Abstract

The Hedonic Track Custom GPT, developed by the Welfare Footprint Institute, automates the generation of draft Pain-Track analyses intended to describe the temporal organisation and relative intensity of negative affective states in farmed-animal scenarios. This study reports an exploratory specialist appraisal of the tool by 11 animal-welfare professionals from four countries, using standardised scenarios for tilapia, broiler chicken, and beef cattle. Specialists interacted with the Hedonic Track using GPT-5.2, following a standardised seven-step protocol, and then completed a study-specific structured questionnaire combining Likert-type items and open-ended responses. Temporal segmentation received unanimously positive ratings (11/11 respondents). The methodological sequence, objective clarity, method explanation and cumulative-pain concept were also positively rated by most respondents. By contrast, the scientific grounding of intensity attributions received clearly weaker ratings, and multiple respondents reported operational instability in the later workflow stages, especially during table generation and completion. The tool was consistently regarded as useful for teaching, preliminary analytical structuring and expert-supported welfare appraisal, but not as a stand-alone instrument for high-stakes assessment. Our findings identify specific priorities for refinement and provide an empirical basis for the cautious integration of generative AI into animal-welfare analysis.

Keywords: welfare footprint framework, pain-track, large language models, generative AI, pain intensity

Introduction

Farmed animals are exposed to cumulative welfare challenges throughout their productive lives, spanning housing, handling, transport, and slaughter. According to the Food and Agriculture Organization (FAO, 2024), aquaculture production reached 94.4 million tonnes of aquatic animals in 2022, surpassing capture fisheries for the first time. Alongside aquaculture, broiler chicken and beef cattle supply chains remain pillars of global food supply, each presenting distinct welfare problems (Emam *et al*., 2025; Nielsen *et al*., 2025; Riber and Wurtz, 2024).

The Welfare Footprint Framework (WFF), developed by the Welfare Footprint Institute, quantifies affective experiences as the time spent in negative and positive states of varying intensities, categorised as Excruciating, Disabling, Hurtful, and Annoying, through the Pain-Track and Pleasure-Track instruments (Alonso and Schuck-Paim, 2021, 2025). Using Large Language Models (LLMs) to assist in the construction of the proposed structured analyses may improve analytical speed and accessibility, but it also raises important questions regarding evidential grounding, hallucination risk, operational stability and the continuing need for expert validation (Gallifant *et al*., 2025; Shool *et al*., 2025).

The Hedonic Track Custom GPT was designed to generate step-by-step Pain-Track drafts for farmed animal species through a fixed seven-step sequence: (1) review of case information; (2) introduction; (3) methodology; (4) temporal segmentation; (5) intensity attribution; (6) table generation; and (7)

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discussion (Welfare Footprint Institute, 2026). The tool operates on GPT-5.2, as explicitly recommended by its developers. Despite its innovative architecture, no published specialist appraisal of the tool appears to have examined both its scientific plausibility and its operational performance. This study therefore aimed to characterise the current strengths, weaknesses and priority areas for refinement of the Hedonic Track Custom GPT through an exploratory expert evaluation.

Methods

The study was approved by the Research Ethics Committee of the Federal University of Paraná (CEP/UFPR), under protocol No. 55445522.6.0000.0102. To ensure consistency across evaluations, three standardised case vignettes were prepared for Nile tilapia, broiler chickens and beef cattle. The scenarios were drafted with AI assistance and subsequently reviewed by the authors for internal consistency, plausibility, and cross-species comparability before use: Nile tilapia (54 h pre-slaughter and slaughter), broiler chickens (17 h pre-slaughter handling and slaughter), and beef cattle (24 h transport and slaughter). Each scenario incorporated objective parameters, numerical values, and measurable conditions.

A convenience database of approximately 125 animal-welfare professionals from multiple countries was assembled. Invitations were distributed by email and social media to researchers, veterinarians, animal scientists and other professionals with recognised experience relevant to the focal species or to animal-welfare assessment. Participants received a standardised script containing the scenario for their chosen species and were instructed to paste it into the Hedonic Track's initial interaction field. They subsequently interacted with the tool sequentially through all seven methodological steps using GPT-5.2. Some respondents later reported uncertainty about how to initiate the workflow, and this issue was considered in the interpretation of operational difficulties.

After using the tool, specialists completed a 25–30-minute questionnaire combining a five-point Likert-scale and open-ended questions on usability, scientific appraisal, and overall evaluation. With only 11 participants, analysis was descriptive and exploratory, using thematic grouping of qualitative responses. Results are anonymized and not intended for population-level inference.

Results

Of the 125 invited professionals, 11 (8.8%) completed the evaluation. Because participation was voluntary and completion required a full interaction with the tool followed by a 25–30 minutes questionnaire, the resulting dataset is best interpreted as an exploratory specialist sample rather than a representative panel. The sample comprised researchers, university lecturers, consultants, and animal welfare specialists affiliated with universities, non-governmental organisations, and private consultancies in Brazil (seven), Canada (two), the Netherlands (one), and one additional European respondent working across Spain and the United Kingdom. Thematic distribution included six evaluators in fish production, two in poultry production, two in cattle production, and one specialist covering multiple species. Academic backgrounds included Veterinary Medicine, Animal Science, Oceanography, and Fisheries Engineering, with the majority holding doctoral degrees or in the final stages of doctoral training.

Temporal segmentation of pain episodes was the most consistently well-rated feature, receiving positive ratings from all 11 respondents. Explanation of methods, description and duration of segments, consistency of assigned intensities, the cumulative-pain concept, and the introductory framing each received positive ratings from 10/11 respondents. In open-ended comments, the tool was repeatedly valued for its didactic clarity, chronological organisation and usefulness in structuring preliminary welfare analyses (Figure 1). In such qualitative comments, the tool was described as providing a clear, accessible, and technically appropriate language that guided users through a recognisable analytical

sequence. Respondents particularly valued the system's ability to decompose complex episodes of suffering into successive interpretable chronological phases, which may be regarded as the conceptual core of the Pain-Track approach. Several evaluators noted substantial didactic potential, describing the tool as useful for teaching, initial welfare assessment structuring, and the identification of critical welfare points in management protocols.

System problems were commonly reported, with operational instabilities concentrated in the later stages of the workflow. Three respondents explicitly reported freezing at Step 5 or Step 6, two described repeated numerical inconsistency across executions of the same case, one reported wrong scenario routing, and one reported failure to generate figures. Disclosure of the tool's AI-draft status at the end of the workflow was inconsistent: only 5/11 respondents reported a clear final declaration, whereas 2/11 reported only partial disclosure and 4/11 reported none. Additional comments referred to mixed-language outputs and uncertainty about how to initiate the interaction (Table 1). The most recurrent pattern involved a combination of insufficiently clear initial instructions and system freezing at Step 6, which prevented the automatic completion of the Pain-Track and cumulative pain tables. Explicit error messages, language mixing in outputs, inconsistency between repeated executions of the same case, and the inability to generate figures (with the system outputting Python code instead) were among the specific failures described. At least some non-completions in the study may be attributable to operational difficulties: several invitees communicated informally that they would not complete the questionnaire due to difficulties operating the tool, although these cases are outside the formal database.

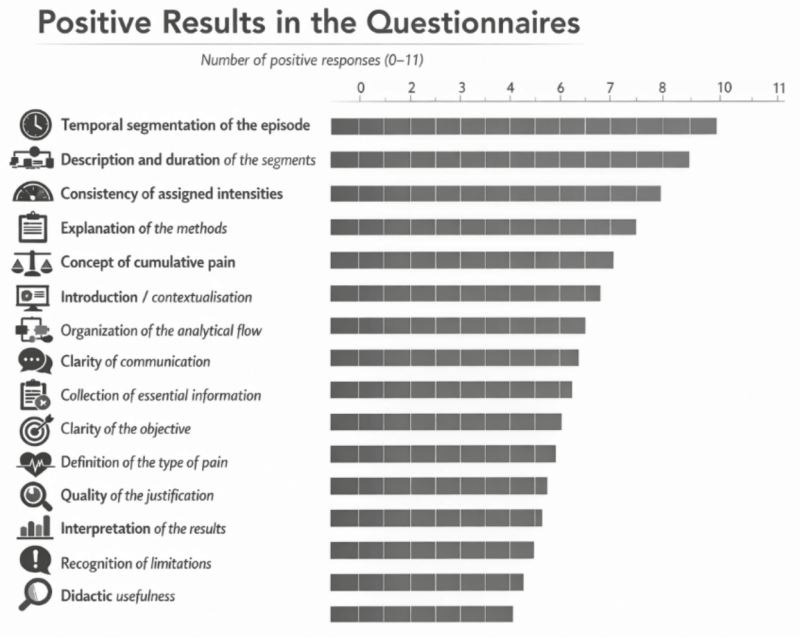


Figure 1. Positive ratings for each evaluation criterion, ordered by frequency, according to responses from 11 participants in the period between October, 2025 and February, 2026.

Table 1. Operational problems explicitly reported during use of the Hedonic Track (GPT-5.2), with frequency of mention, according to responses from 11 participants in the period between October, 2025 and February, 2026.

Operational problem	n/N	Illustrative manifestation	Practical impact
Unclear onboarding and initial instructions	2/11	Users reported uncertainty about how to start the workflow, including whether the full scenario should be pasted at once or whether the tool would progressively request information.	Increased trial-and-error at the outset and may have contributed to early user friction and non-completion.
Late-stage workflow instability (Steps 5–6)	3/11	The system stopped at Step 5 or Step 6, sometimes requesting consultation of stored instructions or external authorisation, and in some cases required repeated attempts or manual prompting to continue.	Prevented smooth completion of the standard workflow and reduced confidence in operational reliability.
Failure or instability in final table generation	2/11	Respondents reported problems generating the Pain-Track and cumulative pain tables or being unable to obtain a scientifically satisfactory explanation of cumulative values.	Compromised delivery of one of the tool's central outputs and weakened confidence in the quantitative stage.
Explicit technical error message	1/11	One respondent reported the message "Error talking to App" associated with the tool's memory query.	Interrupted workflow continuity and exposed backend fragility to the user.
Figure-generation failure	1/11	Instead of returning the expected figures, the system returned Python code.	Reduced interpretability and practical usefulness of the final output.
Inconsistency across repeated executions	1/11	Slightly different pain assessments were reported across repeated runs of the same case.	Weakened confidence in reproducibility and stability of outputs.
Language inconsistency / mixed-language output	2/11	Parts of the workflow or questionnaire appeared in Portuguese and English, or pain labels remained in English.	Undermined standardisation and may create confusion, especially for less experienced users.
Wrong scenario routing	1/11	A respondent expecting the cattle scenario was shown a piglet castration case.	Indicates failure in scenario routing or configuration and raises concern about case fidelity.

Note: Frequencies refer to explicit mentions in the completed respondent questionnaires and should therefore be interpreted as conservative minima. Additional informal reports from invitees who did not complete the questionnaire suggest that operational difficulties may have been more frequent than captured in the formal dataset.

The clearest scientific weakness identified by respondents concerned the grounding of pain-intensity attributions and, especially, the opaque conversion of qualitative categories into numerical values. This was reflected both in lower ratings and in open-ended comments questioning how category boundaries were defined, how percentages were assigned, and which species-specific indicators supported the transition from descriptive reasoning to cumulative quantification. This concern manifested consistently across species and scenarios: evaluators recognised the general logic of the tool but regarded the stage at which qualitative categories were translated into specific percentages and cumulative pain indices as considerably more fragile. Only 4/11 respondents rated the scientific grounding of pain characteristics positively (scores 4–5), whereas concerns about missing, outdated, incorrect or insufficiently specific references recurred across multiple responses. Comments indicated that the transition from descriptive

reasoning to quantitative output was opaque, with insufficient clarity about which indicators supported transitions between intensity levels (Table 2). Additional concerns included the quality and currency of references, the risk of hallucinated citations, and the tendency to underestimate psychological dimensions of suffering.

Despite its limitations, the tool shows strong practical potential if validated by experts. It was seen as useful for teaching, research support, and preliminary welfare screening. Key improvements include stronger scientific grounding, clearer citations, explicit uncertainty, and revising the logic for converting qualitative data into numbers. Additional suggestions included the creation of a stage for manual specialist intervention before final table generation, implementation of self-analysis of input data, development of training materials for users, and linguistic standardisation of outputs.

Discussion

The results of this evaluation point to a clear asymmetry in the current performance of the Hedonic Track: the tool functions well as a reasoning organiser and didactic scaffold but has not yet demonstrated that it can quantify animal suffering with sufficient scientific rigour. This asymmetry is not unusual in the LLM validation literature, where fluent and plausible textual outputs are poor proxies for technical validity (Gallifant *et al*., 2025; Shool *et al*., 2025). The unanimous positive rating for temporal segmentation is particularly meaningful, as it touches the conceptual core of the Pain-Track proposal: if the tool were not able to reconstruct the temporal trajectory of suffering, its fundamental promise would be undermined. The fact that this element was widely praised suggests the system possesses a functional methodological basis for temporal description.

The main weakness was not the timing of episodes, but how qualitative assessments were converted into numerical values. Respondents questioned how categories, percentages, and cumulative scores were defined from uneven evidence. Since cumulative pain indices can influence decisions and standards,

Table 2. Principal technical and scientific limitations identified by 11 participants in the period between October, 2025 and February, 2026.

Identified limitation	Nature of the problem
Insufficient grounding of intensity assignments	Justifications based on general principles rather than species-specific evidence; boundary between adjacent categories poorly demarcated
Insufficient, imprecise, or outdated references	Missing references in Results and Discussion; some citations incorrect or hallucinated; limited critical use of sources
Opaque conversion of categories to numerical values	Respondents unable to understand how qualitative categories were transformed into percentages; one evaluator reported the system stated values were assigned "to give values"
Unclear criteria for qualitative categories	Categories not sufficiently calibrated or operationalised; internal logic of the analysis difficult to follow
Insufficient treatment of uncertainty	System did not always signal clearly where evidence is weak or absent; risk of overconfident reading of fragile estimates
Psychological suffering underestimated	Psychological components sometimes neglected; scope excessively centred on physical pain
Superficial connection with literature in discussion	Discussion weakly connected to or insufficiently developed from available scientific knowledge

unclear methods risk producing convincing but weak conclusions. This reflects TRIPOD-LLM guidance, which requires transparency and human oversight in high-stakes LLM applications (Gallifant et al., 2025).

Evaluators had to complete seven AI-interaction steps before a 25–30-minute survey, and operational difficulties likely reduced participation. With only 11 respondents, results are exploratory rather than representative. Low completion reflects not just survey fatigue but usability issues, introducing specific participation biases. Still, detailed qualitative responses add valuable depth to the data despite this limitation (Hochberg and Eakin, 2024; Torrejón-Guirado *et al*., 2024). Another issue with direct practical implications concerns disclosure. The final reminder that outputs should be treated as AI-generated drafts requiring human validation was not consistently perceived by respondents. In a workflow aimed at potentially sensitive welfare judgements, this caveat should be explicit both before analytical generation begins and again at the end of the final output.

Conclusions

The Hedonic Track Custom GPT (GPT-5.2) showed a coherent analytical structure, strong temporal-segmentation performance, and clear didactic value. In this exploratory specialist appraisal, however, the tool was perceived as more robust for structuring reasoning than for transparently and reproducibly quantifying cumulative welfare burden. Priority areas for refinement include the evidential grounding of intensity attributions, the transparency of qualitative-to-quantitative conversion, workflow stability in later stages, and explicit end-of-workflow disclosure that outputs remain AI-generated drafts requiring expert human validation. At present, the tool is best regarded as an expert-reviewed drafting aid rather than as a stand-alone welfare assessment instrument.

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Potential roles for AI in accelerating advancements for animal-free food protein production systems

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Abstract

Alternative protein production systems are under development to supply food of animal origin or its analogues without the need to raise and kill animals. As they are disruptively novel, their successful establishment depends on breakthroughs across diverse fields of knowledge. Using the case of culture-medium ingredients for animal cell cultivation, this paper discusses the role of artificial intelligence in accelerating knowledge generation for the development of animal-free food protein production systems. The discussion is grounded in a project in which the identification of potential animal-free medium ingredients yielded a substantially larger number of candidates than initially anticipated. The resources of interest involve the up-cycling residues of established agricultural products in Brazil, with an initial focus on organic cocoa production by family farmers. As the project progressed, it became evident that selecting optimal combinations of animal-free ingredients to meet cellular nutritional and functional requirements, based on their chemical and molecular composition, would benefit from AI-assisted analytical tools. Among the technical key bottlenecks for animal-free protein production, other supplies may also require substitution, as some of the available options are animal-sourced, such as scaffolds, enzymes, coatings and immunoassays; they are also likely to benefit from AI use. Beyond cell-cultivation, additional areas related to the success of animal-free systems are also likely to benefit from AI-based research, such as the development of more efficient, use-specific and cheaper bioreactors, logistics for production chain organisation, final product composition and presentation, outreach materials for information and education, market studies and marketing strategies. As the whole new food production chains and supplies for them are in their initial phases of development, it is likely that multiple opportunities exist to replicate and expand the benefits which AI-based tools can offer for animal-free protein production.

Keywords: cellular agriculture, culture medium optimization, agricultural by-products, predictive modeling

Introduction

For the cultivation of animal cells, basal media are supplemented with complex additives, among which animal-derived serum remains widely used. Such supplements provide macromolecules, carrier proteins, trace elements, adhesion factors, low-molecular-weight nutrients, hormones, and growth factors essential for cell proliferation and maintenance). Fetal bovine serum (FBS) is the most used supplement and is often regarded as a universal additive for enriching basal media (van der Valk and Gstraunthaler, 2017).

However, the use of FBS is increasingly questioned due to ethical, technical, and economic limitations (Chelladurai *et al.*, 2021). It is the serum fraction of blood obtained via cardiac puncture of foetuses removed from slaughtered pregnant cows (Lee *et al.*, 2022). It is estimated that approximately two million bovine foetuses are used annually to produce around 800,000 litres of FBS (Brindley *et al.*,

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2012). In addition to the serious ethical concerns, its use significantly increases production costs and imposes barriers to the standardisation of culture protocols. The supply of FBS is characterised by unpredictable shortages and continuously rising prices. Its composition is undefined and highly variable between batches, brands, seasons, and geographical origins, thereby compromising reproducibility (van der Valk and Gstraunthaler, 2017; Fang *et al.*, 2017; Chelladurai *et al.*, 2021). Furthermore, FBS may be contaminated with endotoxins, prion proteins, microorganisms, immunoglobulins, and viruses, posing significant biosafety risks (van der Valk and Gstraunthaler, 2017; Toohey-Kurth *et al.*, 2017; Chelladurai *et al.*, 2021; GFI, 2022). From an economic perspective, recent findings indicate that replacing FBS can reduce culture medium costs by up to 73% for certain cell types (Schenzle *et al.*, 2025).

In this context, several challenges remain for the large-scale commercialisation of cultivated meat, many of which are directly related to the formulation and performance of culture media (O'Neill *et al.*, 2020; Negulescu *et al.*, 2023). Culture media are estimated to account for between 55% and 90% of total production costs (Romero and Boyle, 2023), making them one of the primary economic bottlenecks in the production chain. Although cell culture media have been widely used and optimised over decades, they were not originally designed to meet the specific requirements of cultivated meat. Efficient industrial-scale production demands food-grade media with low-cost formulations, free from animal-derived components, capable of supporting cell proliferation and differentiation, ensuring satisfactory sensory qualities, and complying with regulatory requirements (O'Neill *et al.*, 2020). Therefore, strategies aimed at replacing traditional components with more accessible, sustainable, and well-defined alternatives are essential.

Plant hydrolysates, for instance, represent promising sources of nutrients and bioactive compounds with the potential to replace costly animal-derived ingredients commonly used in culture media, thereby contributing to both economic feasibility and process sustainability (Ho *et al.*, 2021; Hubalek *et al.*, 2022). This potential is illustrated in the study by Fleibam *et al.* (2024), which demonstrates that protein extracts and plant hydrolysates derived from soybean and peanut can serve as inputs for cultivated meat production, as they exhibit protein contents comparable to FBS and are particularly rich in leucine and proline. In this scenario, Brazil holds a strategic advantage due to its well-established agribusiness sector and extensive plant biodiversity (GFI, 2022).

Brazil is the most biodiverse country in the world, with more than 44,000 catalogued plant species (Brasil, 2025), and in 2023 it was the second-largest global exporter of agricultural products (CNA, 2025). It is the world's leading producer of sugarcane, soybean, coffee, and citrus, and ranks among the largest producers of many other crops (FAO, 2025). Additionally, Brazil plays a significant role in fruit production to meet both domestic and international market demands, with the North and Northeast regions being particularly prominent (IBGE, 2023; Brasil, 2024). As a result of this high production volume, large quantities of by-products are generated, making their responsible management increasingly important (Campos-Vega *et al.*, 2020). The use of residues and by-products in cellular agriculture has been increasingly explored in scientific literature (e.g. Charteris and Le Coutre, 2025).

Considering the above, Brazil demonstrates strong agricultural potential alongside a wide availability of agro-industrial residues and by-products with high nutritional and functional value. However, the challenge lies in utilising these resources strategically and effectively. For these inputs to be considered viable alternatives in culture media formulation, detailed information on their identification and composition is essential. Even with such data, the range of possible uses of isolated components from each by-product is vast, generating a combinatorial explosion of potential formulations that may produce synergistic effects among individual compounds. Directly testing all these possibilities in cell systems is unfeasible. Therefore, selecting the most promising formulations becomes a critical decision point.

In this regard, artificial intelligence (AI) tools have shown great promise in accelerating the development of complex and customised formulations. An example is the Giuseppe platform, developed by NotCo, which aims to revolutionise food formulation through molecular-level analysis.

Similarly to how Giuseppe identifies plant-based molecular equivalents to those found in animal-derived foods, our proposal is to develop an AI-based tool capable of identifying plant-derived inputs with the potential to replace costly or animal-derived ingredients currently used in basal media supplementation. This approach aims to reduce reliance on random trial-and-error strategies and enable more precise and efficient experimentation. Initially, the database will be composed of information on fruits widely produced in Brazil and by-products from the brewing industry, with gradual expansion to include additional ingredients. The revalorisation of residues will reduce costs, minimise dependence on imports, and add value to local production chains, while also generating positive social impacts by creating new income opportunities for producers. By leveraging Brazilian biodiversity, this project also strengthens the country's position as a leader in innovation in food biotechnology and cultivated meat production.

Approach

This study will be conducted in interdependent stages, including: (1) the selection of promising plant sources, particularly parts such as seeds and leaves, as well as the collection of plant-based agro-industrial residues and by-products, followed by the production of hydrolysates; (2) the physicochemical characterisation of the obtained compounds, with emphasis on the quantification of amino acids and potential bioactive components; (3) the application of computational tools to identify and select the most promising combinations of ingredients; and (4) the functional evaluation of these combinations through in vitro assays using the animal cells of interest (Figure 1).

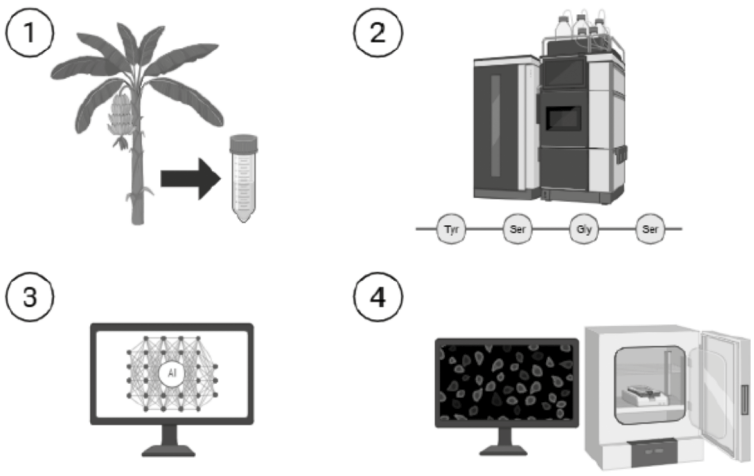


Figure 1. Methodological stages of the study: (1) Collection and processing of plant materials, residues, and plant-based by-products to obtain hydrolysates; (2) Characterisation of the compounds, including the quantification of amino acids and bioactive compounds; (3) Data analysis using artificial intelligence to identify the most promising combinations; (4) In vitro evaluation of the viability and proliferation rate of bovine and porcine cells exposed to the hydrolysed materials, with the progressive withdrawal of FBS.

Anticipated outcomes

FBS contains a wide range of compounds that support cellular development and proliferation (Brunner *et al*., 2009) (Figure 2). However, the optimisation of serum-free culture media, as well as media devoid of any animal-derived components, based solely on trial-and-error approaches, is unsustainable and impractical in the short term. Albumin and transferrin play essential roles in cell culture by supporting cell viability, growth, and metabolism, yet they are typically sourced from animal-derived serum or produced recombinantly, significantly contributing to the high cost of serum-free media (GFI, 2021). Therefore, identifying alternative and cost-effective strategies to replace their functionality remains a key challenge in cellular agriculture.

In this context, Giuseppe, an AI platform developed by NotCo, analyses food matrices and can improve analogues of animal-derived products using exclusively plant-based ingredients by identifying combinations that reproduce flavour, texture, functionality, and nutritional value. To achieve this, it employs a database containing hundreds of thousands of plant-based ingredients and advanced algorithms that propose efficient formulations, reducing time, cost, and risk in product development (NotCo, 2025). This example highlights the potential of data-driven tools to support the identification of alternative functional compounds and their combinations while reducing reliance on trial-and-error experimentation.

As a starting point, this work proposes the use of cocoa by-products as a source for the identification of functional compounds to support cell culture, given their availability within established agro-industrial chains and their underexplored biochemical composition. The approach focuses on the characterisation of amino acid profiles, as amino acid composition and availability are critical factors influencing cellular growth, metabolism, and protein synthesis. Comparative analysis of amino acid profiles from plant-derived sources is used to prioritise candidates with potential to support cell culture performance. Although initially centred on cocoa-derived materials, the approach can be expanded to other plant biomasses, enabling the development of a broader pipeline for ingredient screening. AI-based tools can be incorporated to support candidate-input selection, while the use of agro-industrial by-products aligns with circular economy principles and supports the development of more sustainable and cost-effective strategies for serum-free media formulation.

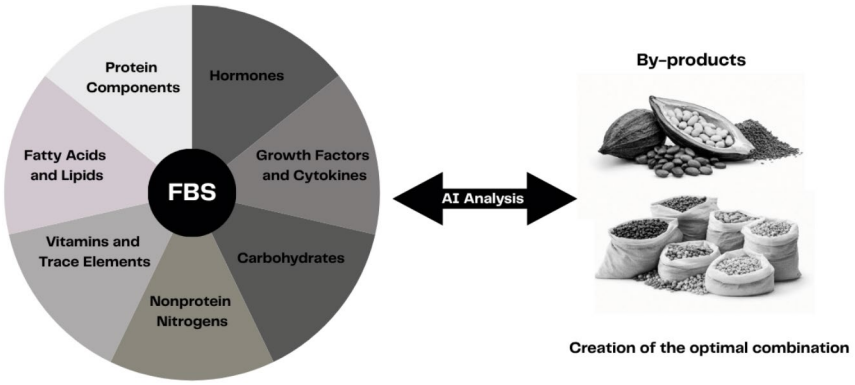


Figure 2. Schematic representation of the complexity of FBS composition and the proposed strategy for identifying plant-based alternatives.

Conclusion

The replacement of FBS is essential to enable large-scale production of cultivated meat. The use of artificial intelligence tools to accelerate plant and other animal-free inputs by predicting best combinations shows great potential to optimise culture media formulation, reducing costs, time, and reliance on empirical approaches. This is one example of the many biotechnological challenges which may be aided by artificial intelligence. In this context, the integration of AI in the search for sustainability, technological innovation, and ethical principles stands out as a promising pathway for the development of more responsible and efficient solutions.

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Section 2.
AI governance ethics and regulatory frameworks

Context-sensitive AI ethics in agrifood systems: the importance of regional premise conditions

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Abstract

Artificial intelligence (AI) and digital technologies are transforming agrifood systems and have become increasingly important topics in agrifood ethics. While these technologies can enhance efficiency, traceability, and climate responsiveness, they also redistribute risks, benefits, and responsibilities among farms, fisheries, digital platforms, consumers, ecosystems, and supply chains. This paper introduces a context-sensitive framework for agrifood AI ethics. Instead of treating agriculture as a uniform domain for general AI ethics principles, it argues that principles such as transparency, fairness, accountability, privacy, and sustainability must be specified considering the concrete conditions in which AI is implemented. The central argument is that regional conditions are not merely empirical background factors. To clarify their normative role, this paper proposes the concept of regional premise conditions: social, ecological, institutional, and epistemic conditions that shape whether AI-ethics principles can be meaningfully specified and justified agrifood settings. These conditions determine which ethical issues become salient, which safeguards are feasible, and who has legitimate authority over data, knowledge, risks, and benefits. Rather than fixed universal thresholds, these conditions operate as context-specific justification for assessing whether transparency, fairness, accountability, sustainability, and data governance can be meaningfully realised in each agrifood AI deployment. Focusing on Asia-Pacific agrifood systems as a diagnostic field rather than as a homogeneous regional unit, the paper identifies five regional premise conditions. First, rapid urbanisation and platform-mediated logistics shift ethical concerns beyond production to include access, pricing, food waste, labour, and accountability throughout the supply chain. Second, the prominence of fisheries and aquaculture foregrounds issues related to coastal communities, aquatic animal welfare, ecosystem management, and the visibility of environmental impacts. Third, the prevalence of smallholder, family-based, and land-scarce farming highlights the importance of practicality, affordability, dependency, and equitable distribution of benefits for responsible innovation. Fourth, persistent digital divides and limited monitoring capacity hinder affected actors from participating in decision-making, understanding automated outputs, or contesting harmful decisions. Fifth, Indigenous data sovereignty, local knowledge, and community authority raise critical questions about data control, the legitimacy of knowledge, and the processes by which explanations and decisions are validated.

Keywords: digital agriculture, responsible innovation, regional premise conditions, data sovereignty, smallholder farming

Introduction

Artificial intelligence (AI) is increasingly regarded as a transformative technology within agriculture and food systems. Its applications now encompass farm-level decision support, animal monitoring, aquaculture surveillance, logistics optimisation, and food-system platforms. Policy and innovation narratives frequently highlight promises of enhanced productivity, resource efficiency, traceability, and climate-smart food systems. However, social-scientific research on digital agriculture demonstrates that these technologies do not merely introduce new tools to an existing sector. Instead, they fundamentally

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reorganise relationships among farmers, fishers, aquaculture producers, platform firms, retailers, logistics workers, public agencies, consumers, non-human animals, and ecological systems (Klerkx et al., 2019; Rose and Chilvers, 2018; Ryan, 2023).

A primary challenge is that agrifood systems are characterised by significant ethical complexity and regional heterogeneity. Farms, fisheries, and food-distribution networks function not only as production sites but also as sources of livelihood, locations of ecological stewardship, nodes within global and local supply chains, sites of human and non-human labour, and culturally significant foodscapes. Even technically accurate AI systems may raise ethical concerns if they increase dependence on proprietary platforms, favour large-scale, data-rich producers, transfer data-derived value away from farmers or coastal communities, marginalise local and Indigenous knowledge, or obscure ecological harms. AI is ethically distinctive in agrifood systems because it can transform existing inequalities through prediction, classification, automated recommendation, platform optimisation, risk scoring, and data-driven value extraction. These processes can shift decision-making authority away from farmers, fishers, workers, and communities; fragment responsibility among developers, platforms, retailers, and public agencies; and render ecological, welfare, labour, or community impacts invisible when they fall outside measurable model outputs. This risk may be described as operational invisibility, or phantomisation: the process by which certain actors, harms, forms of work, welfare concerns, or knowledge systems become operationally invisible because they are not captured by the system's data, metrics, or optimisation targets.

This paper therefore treats the Asia-Pacific as a diagnostic field rather than a homogeneous regional unit. The region makes visible several globally relevant but locally configured pressures: urbanisation, platform-mediated food distribution, fisheries and aquaculture, smallholder and family-based production, uneven digital infrastructure, and contested local, customary, or Indigenous authority over data. To make this diagnostic use concrete, the paper refers to three cases: AI-based advisory systems for smallholder farmers in India, AI-assisted review within electronic monitoring systems in Pacific tuna fisheries, and data-driven platformisation of small-scale aquaculture in Indonesia. These cases are illustrative rather than representative; they show how regional configurations alter the ethical meaning of transparency, fairness, accountability, sustainability, and data governance.

Regional premise conditions and method

Regional premise conditions are not simply local background variables. In this paper, they refer to social, ecological, institutional, and epistemic conditions that shape three dimensions of ethical justification. First, they determine ethical salience: which harms, benefits, and responsibilities become visible as ethical issues. Second, they determine governance feasibility: whether safeguards such as explanation, audit, participation, contestation, and redress can realistically be implemented. Third, they determine normative authority: who has legitimate standing to define problems, control data, validate knowledge, distribute benefits, and decide whether an AI application should be adopted, redesigned, postponed, or rejected.

The concept builds on responsible innovation, situated AI ethics, and data justice, but gives context a specific justificatory role: it asks not only how agrifood AI can be adapted to local settings, but whether the conditions for responsible deployment are present at all (Mager et al., 2025; Rose and Chilvers, 2018; Taylor, 2017). This paper is an integrative conceptual review, bringing together literature on global AI ethics, digital agriculture, Asia-Pacific agrifood systems, and Indigenous data governance. The five premise conditions were selected because each is recurrent in Asia-Pacific agrifood systems, changes the practical meaning of core AI-ethics principles, and affects deployment justification rather than only post-deployment governance. Other issues, including gendered labour, migrant work, land

tenure, corporate concentration, food safety, climate vulnerability, and state surveillance, are treated as cross-cutting concerns that may appear through, and intensify, the five selected premise conditions.

Translating AI-ethics principles into agrifood thresholds

Research on digital agriculture underscores the need to account for regional differences. Klerkx et al. (2019) explains that digital agriculture involves more than just farm technologies; it also affects value chains, policy, and food systems. Bronson (2019) shows that data systems can benefit large-scale crop farmers while leaving out others. Ryan (2023) outlines how agricultural AI affects areas like sustainability, privacy, justice, fairness, transparency, autonomy, responsibility, animal welfare, and solidarity.

The unique nature of agrifood systems is important. While many AI fields focus on individuals, agrifood ethics often involve groups or relationships, such as farm households, cooperatives, fishing communities, networks, herds, ponds, ecosystems, watersheds, or regions. Because of this, agrifood AI ethics go beyond privacy, accuracy, or explainability. They must also consider which food system is being improved, whose work and knowledge are affected, which animals and ecosystems are included or excluded, and whether the system supports livelihoods, the environment, and cultural traditions.

This means that agrifood AI ethics should consider political and economic factors, not just procedures. The main issue is not only whether AI systems are clear or accurate, but also whose goals they support – farmers, cooperatives, companies, retailers, consumers, public agencies, animals, or ecosystems. If we ignore ownership, contracts, data value, and market power, ethical discussions may become little more than words attached to systems that take resources without giving back.

The Asia-Pacific context makes this relational structure especially visible. Rapid urbanisation, aquatic food systems, smallholder and land-scarce farming, platform-mediated logistics, and uneven digital access show that agrifood AI ethics cannot be confined to precision farming. Food-delivery and logistics platforms, for example, shape food access, prices, working conditions, waste, and environmental impacts. Likewise, fisheries and aquaculture shift attention from terrestrial production to coastal communities, marine ecosystems, and aquatic animal welfare (FAO, 2024). An AI system that improves productivity in aquaculture may still be ethically deficient if it weakens community control, narrows welfare to measurable indicators, or externalises ecosystem risks.

Smallholders and land-limited farming bring a third change. Here, the main ethical issue is not just whether a system is accurate or new, but whether it is affordable, easy to use, can be managed together, and fits with local ways of living. A crop recommendation system trained mostly on large farms may not work well for smallholders, but the bigger issue is that the social and institutional support needed for fair use and sharing of benefits may not exist.

Digital gaps and limited monitoring capabilities create another challenge. Transparency should be more than just sharing information. It should include clear explanations, use of local languages, trusted go-betweens, public or cooperative audits, and ways to raise complaints. Accountability should be more than just naming who is responsible, especially if farmers, fishers, workers, or consumers do not have the means to question automated decisions or platform choices.

Finally, Indigenous data sovereignty should be distinguished from broader issues of local knowledge and community authority. Agrifood data can involve land, livelihoods, ecological knowledge, and community power, and may therefore include collective rights and responsibilities across generations. Because of this, responsible agrifood AI should address not only privacy and consent but also collective

benefit, control, responsibility, and ethics, as described in Indigenous data governance research (Carroll et al., 2020).

These thresholds can be clarified through three diagnostic cases. First, AI-based advisory systems for smallholder farmers in India show that transparency cannot be reduced to the availability of technical documentation or model outputs. If a system recommends a crop variety, pesticide use, irrigation schedule, or market decision, affected farmers must be able to understand the recommendation in locally usable forms, compare it with experiential and community knowledge, and contest harmful advice through trusted institutions such as extension services, cooperatives, or public grievance mechanisms (High et al., 2026).

Second, AI-assisted review within electronic monitoring systems in Pacific tuna fisheries shows that sustainability and accountability depend on what the system makes visible and who has authority over the resulting data. Cameras, sensors, and AI-assisted review may improve the visibility of catch, bycatch, compliance, and ecological impacts, but responsible deployment requires human verification, data security, fair cost distribution, and legitimate authority for Pacific Island states, national fisheries agencies, and relevant regional governance bodies over fisheries data and its use (Brown et al., 2021).

Third, data-driven digital platforms in Indonesian small-scale aquaculture show that digital systems may reorganise production rather than merely support it. Smart feeding, water-quality monitoring, credit, input supply, and market access can improve productivity, but they may also create platform dependency, shift risks to farmers, and privilege measurable indicators such as feed efficiency or growth rates while making aquatic welfare, water pollution, debt, and bargaining power less visible (Kruk et al., 2025).

Normative implications

The proposed framework has three main implications. First, it treats context as part of ethical justification without reducing AI ethics to relativism. Principles such as transparency, fairness, accountability, and sustainability remain relevant across contexts; what varies is what must be true for these principles to be satisfied in practice. A system cannot be called transparent merely because technical documentation exists, fair merely because formal access is provided, or sustainable merely because productivity improves. These claims must be justified in relation to the social, institutional, ecological, and epistemic conditions of the agrifood system in which AI is deployed. This addresses a key weakness in AI ethics: while principles such as fairness, transparency, and accountability are widely supported, they do not specify how to assign responsibility, resolve value conflicts, or ensure the right institutions are in place for implementation (Jobin et al., 2019; Mittelstadt, 2019).

Second, the framework separates ethical deployment from ethical preparation and distinguishes three possible responses when regional premise conditions are not met. Redesign is appropriate when the problem lies in system-level features, such as inaccessible explanations, poorly adapted interfaces, unrepresentative training data, or the absence of appeal mechanisms. Delayed deployment is appropriate when the AI system may be defensible in principle, but institutional supports such as extension services, cooperative data management, audit capacity, local-language explanation, digital skills, legal remedies, or ecological monitoring are not yet in place. Rejection is appropriate when the proposed AI system depends on non-consensual data extraction, structurally transfers risks to vulnerable actors, undermines legitimate community authority, or makes ecological, welfare, labour, or community harms unaccountable. The diagnostic cases illustrate how these responses differ. In Indian AI advisory systems, redesign may be required when explanations are not locally understandable, training data do not reflect smallholder conditions, or appeal mechanisms are absent. Delayed deployment may be appropriate where extension services, cooperative data governance, or legal remedies are not yet available. In Pacific fisheries

monitoring, delayed deployment or institutional redesign may be required if AI-assisted monitoring expands data collection without secure data governance, human verification, and legitimate authority for Pacific Island states. In Indonesian aquaculture platforms, rejection may become appropriate where data-driven optimisation depends on non-consensual data extraction, platform lock-in, or the systematic invisibility of water-quality, welfare, debt, and livelihood harms.

Third, these justification tests are not automatic bans. They identify cases in which technology providers, public officials, and users bear a stronger burden of justification. Such judgments should not be made solely by technology providers. They should be assessed through public, cooperative, or community-based review processes that include producers, fishers, workers, consumers, and relevant experts in ecology, animal welfare, data governance, and local knowledge.

Agrifood AI should only be called responsible when those affected can understand and challenge its results, data management shares control and benefits, ecological and welfare impacts are clear, accountability covers the whole supply chain, and it is still possible to redesign, delay, or reject the technology.

Conclusion

The Asia-Pacific example is important, not because it follows a single path of agrifood development, but because it highlights several challenges that reveal the limits of general AI ethics. These include rapid urbanisation, platform-based logistics, aquatic food systems, smallholder and land-scarce farming, digital divides, and unresolved questions about data authority. The central claim is not that AI ethics principles vary by region, but that their satisfaction depends on regional premise conditions. In agrifood AI, a system should not be described as responsible simply because it is accurate, efficient, or formally transparent. It must also be embedded in conditions that make explanation usable, contestation possible, accountability enforceable, benefits shareable, ecological and welfare harms visible, and data governance legitimate. Where these conditions are absent, responsible agrifood AI may require redesign, delayed deployment, or rejection rather than adoption under the label of ethical AI.

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Distinctive aspects of agricultural artificial intelligence: what makes it special, and why it requires unique governance

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Abstract

This work advances the claim that Agricultural Artificial Intelligence (AgAI) constitutes a distinct category of dynamic, world-altering technology that demands governance frameworks tailored to its unique material, social, and epistemic characteristics. AgAI systems differ fundamentally from other artificial intelligence domains because they are materially embedded within living environments, context-sensitive to hyperlocal ecological and cultural conditions, and entangled with social systems such as labor, land stewardship, and community traditions. I develop a taxonomy of AgAI (private, public, and security-facing systems) to clarify how varying deployment contexts generate distinct ethical and regulatory challenges. I demonstrate that analogies to existing governance models, particularly those for pharmaceuticals and genetically modified organisms (GMOs), are insufficient for AgAI because these models presuppose environmental stability and static product behavior. In contrast, AgAI systems co-evolve with the environments they inhabit, continuously reshaping ecological and social conditions. I argue that legitimate AgAI governance must be materially reflexive, epistemically pluralistic, and participatory. Such governance should integrate Traditional Ecological Knowledge (TEK) and local expertise alongside scientific and regulatory oversight to ensure that the situated knowledge of affected communities is recognized as epistemically authoritative. I conclude by identifying five characteristics of appropriate AgAI governance: (1) hybrid participatory governance structures; (2) contextual, Curated Information Frameworks (CIFs) (LaRosa 2025) for differentiated transparency; (3) hyperlocal performance benchmarks with post-deployment monitoring; (4) legal protections for TEK and local knowledge; and (5) agroecological and cultural impact assessments. These recommendations position AgAI as a paradigmatic case for reimagining the governance of dynamic, materially entangled AI systems, and for advancing just, context-sensitive approaches to technological oversight in agricultural deployment scenarios.

Keywords: agricultural AI, governance, ethics, curated information framework

Introduction

Agricultural Artificial Intelligence (AgAI) constitutes a distinct class of dynamic, world-altering technology that cannot be adequately governed through existing regulatory analogies. Unlike other autonomous systems, AgAI is not merely informational or operational: it is materially embedded, hyperlocal, and socially entangled. It acts within living systems, modifies the ecological and cultural landscapes it occupies, and co-evolves with those environments over time. Because of this dynamic and situated nature, AgAI demands new forms of governance that are materially reflexive, epistemically pluralistic, and participatory. The central claim of this chapter is that governance of AgAI cannot simply be modeled after that of pharmaceuticals, genetically modified organisms (GMOs), or even autonomous vehicles. Each of these analogies presupposes environmental stability and centralized oversight that fail to capture AgAI's constitutive entanglement with living, evolving, and socially situated systems. I therefore develop three core approaches to dynamic AgAI systems:

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1. A taxonomy of AgAI systems (private, public, and security-facing) that clarifies the differing ethical and regulatory requirements across deployment contexts.
2. An analysis of three key features of AgAI (materiality, context-sensitivity, and social entanglement) that explain why governance must differ from prior models.
3. A normative argument for pluralistic and participatory governance, grounded in epistemic justice, Traditional Ecological Knowledge (TEK), and Curated Information Frameworks (CIFs) as instruments for equitable transparency and oversight.

Together, these arguments position AgAI as both a test case and a proving ground for developing governance models suited to dynamic, materially embedded AI systems more broadly.

Taxonomy of Agricultural AI

To understand why AgAI requires unique governance, the chapter first constructs a taxonomy distinguishing private, public, and security-facing AgAI systems. Each category is defined not by ownership, but by the scope and nature of its effects – that is, by the degree to which the system's outputs impact consenting or non-consenting others, and by the systemic risks that follow from its deployment.

1. **Private AgAI** operates in bounded, consent-based environments. Examples include handheld soil sensors or autonomous greenhouse bots. Their effects are largely confined to individual users, and the ethical focus centers on informed consent, user education, and data autonomy. Governance at this level resembles consumer-protection models but benefits from lightweight Curated Information Frameworks (CIFs) to ensure users understand system limits and data practices.
2. **Public AgAI** encompasses systems whose outputs or data practices spill into shared environments, such as pesticide-spraying drones or autonomous harvesters. These systems interact with non-consenting publics, laborers, and ecologies. They raise questions of accountability, transparency, and democratic legitimacy, as their impacts on soil health, labor markets, or biodiversity extend beyond their owners. For such systems, governance must integrate participatory oversight and role-sensitive transparency frameworks to respect the rights of those affected.
3. **Security-Facing AgAI** refers to systems embedded within or managing critical infrastructure – for instance, AI-driven irrigation systems, predictive pest outbreak models, or agricultural supply chain logistics. These systems carry national or regional security implications. Here, transparency must be inversely structured: information sharing should be restricted by clearance levels to prevent epistemic or material vulnerabilities. Governance requires a hybrid model balancing secrecy and accountability, recognizing that excessive disclosure may itself constitute a form of risk.

The three defining features of AgAI

There are three constitutive features that distinguish AgAI from other AI systems and that explain why analogical governance models fail: materiality, context-sensitivity, and entanglement.

Materiality

AgAI systems are materially embedded in the environments they act upon. They operate directly on land, crops, water, and ecosystems – altering soil microbiomes, pest populations, and local climates. Unlike virtual AI systems, AgAI transforms the very conditions that define its operation. Its effects are not simply the result of algorithmic decision-making but of recursive ecological interaction. Materiality thus produces a governance paradox: because AgAI reshapes its environment, both the system's context and the system itself evolve. This complicates conventional risk assessment and post-deployment monitoring, which assume a stable context of evaluation. A pesticide-optimization AI, for instance, does not just select doses; it redefines the ecological balance and future risk profile of the environment. Governance

must therefore be materially reflexive: it must anticipate not only how the system operates, but how it transforms its own regulatory context.

Context-Sensitivity

AgAI performance is radically context-dependent. Systems trained in one soil, climate, or cultural setting may fail – or produce ethically different outcomes – in another. A robotic harvester designed for California's orchards cannot be assumed to function appropriately in Kenyan highlands without adjustment to local labor norms, terrain, and ecological variables. This context-sensitivity challenges centralized or universal standards. Regulatory fragmentation, such as that which is already present in U.S. agricultural oversight, is magnified when systems require local calibration. Governance frameworks must therefore be capable of hyperlocal adaptation and continuous feedback, drawing on local expertise to interpret how AI interacts with specific ecological and social conditions.

Entanglement

Finally, AgAI is deeply socially entangled. It operates within and transforms social relations of labor, land tenure, and ecological stewardship. For example, automated weeding systems such as WeLASER alter not only environmental outcomes but labor economies, potentially displacing vulnerable migrant workers. Similarly, data-driven yield prediction tools reconfigure economic dependencies between smallholders, insurers, and commodity markets. Entanglement blurs the boundary between public and private domains. It demands governance that accounts for relational responsibilities – between developers, deployers, and the communities whose livelihoods are affected. Additionally, because AgAI is co-constituted with human and non-human actors, its failures are collective, not isolated. Accountability cannot be limited to developers or end-users; it must encompass the entire sociotechnical biome (LaRosa and Osoba 2019). Together, these three features make dynamic AgAI ontologically distinct from other forms of AI, and reveal why one-size-fits-all regulatory structures fail. Governance must therefore be plural, iterative, and responsive to the evolving interrelations between the addressed system, its environment, and society.

Failures of analogy: why prior governance models fall short

To demonstrate the inadequacy of existing regulatory models, the chapter analyzes two prominent analogies – pharmaceutical regulation and GMO oversight – and explains why neither transfers with full success over to AgAI.

Pharmaceutical analogy

London and Danks (2018) have proposed that autonomous vehicle regulation could follow the pharmaceutical model: staged testing, controlled deployment, and post-market surveillance. While this analogy accounts for uncertainty, it presumes a stable operating context – a "patient body" that remains largely constant. AgAI, by contrast, alters the ecological and social body it operates in. Its context is not only uncertain, but co-evolving. The pharmaceutical model's surveillance mechanisms, designed to detect discrete failures, cannot capture distributed or emergent harms such as soil degradation, biodiversity loss, or long-term labor displacement. Governance must therefore extend beyond static post-market monitoring to continuous, participatory oversight grounded in ecological reflexivity.

GMO Analogy

GMO regulation, by contrast, addresses environmental risk and public exposure but is product-based rather than process-based. It assumes that once a genetic modification is approved, its behavior is fixed. AgAI, however, learns, adapts, and changes post-deployment. It cannot be treated as a single, finished intervention. Moreover, GMO regulation is technocratically centralized, often excluding farmers and Indigenous communities from decision-making. Applying this model to AgAI would reproduce epistemic injustice by sidelining those with critical local and traditional knowledge necessary for contextual calibration and ethical deployment. Both analogies fail because AgAI's defining characteristics (materiality, context-sensitivity, and entanglement) violate the epistemic and institutional assumptions on which the aforementioned models rest. The pharmaceutical model overemphasizes technical validation; the GMO model overemphasizes static risk. AgAI requires governance that is adaptive, participatory, and epistemically plural.

Toward materially reflexive and epistemically just governance

Recognizing these failures, we ought to set normative principles for AgAI governance grounded in epistemic justice, pluralism, and participatory reflexivity. Drawing on Fricker's (2007) epistemic framework, I argue that the exclusion of farmers, Indigenous peoples, and local stewards from governance constitutes both testimonial and hermeneutical injustice: their knowledge is dismissed as anecdotal or illegible within technocratic paradigms. To counter this, just governance must recognize Traditional Ecological Knowledge (TEK) and local expertise as epistemically authoritative. These knowledge systems provide context-sensitive insights into soil, microclimate, and ecological interaction that scientific models often overlook. Integrating these forms of knowledge not only improves system performance but fulfills the moral requirement of recognizing marginalized knowers as legitimate contributors to public inquiry (for more discussion on TEK, see Whyte (2013) and Noll and Murdock (2020)). Curated Information Frameworks (CIFs) per LaRosa (2025) become essential instruments here. CIFs operationalize role-specific transparency: they distribute information to stakeholders based on epistemic need and responsibility, avoiding both opacity and overload. Within AgAI governance, CIFs can enable hybrid accountability by ensuring that each actor, whether they be farmworkers, regulators, developers, or policymakers, receives intelligible, actionable information appropriate to their role and context.

The five characteristics of appropriate AgAI governance

There are five key features that contribute to appropriate governance of AgAI and, by extension, the governance of other dynamic, materially embedded AI systems:

1. **Hybrid Participatory Governance:** combine centralized regulatory oversight with local participatory mechanisms, ensuring affected communities have a voice in the design, deployment, and ongoing assessment of AgAI systems;
2. **Contextual curated information frameworks (CIFs) (LaRosa 2025):** employ tiered, role-specific information sharing to balance transparency with intelligibility and security, enabling responsible communication across diverse stakeholders;
3. **Hyperlocal performance benchmarks and post-deployment monitoring:** establish adaptive, community-sensitive and astute evaluation standards responsive to local, well-defined ecological and social conditions, recognizing that system performance varies across sites and evolves over time;
4. **Legal protections for traditional and local knowledge:** recognize TEK and local expertise as protected epistemic resources, safeguarding them from appropriation and integrating them into formal governance processes;
5. **Agroecological and cultural impact assessments:** require pre- and post-deployment assessments that include social, cultural, and ecological dimensions, not merely technical or economic metrics.

Conclusion

Agricultural AI is not merely another domain of AI application, but a paradigmatic case requiring a rethinking of how governance functions in dynamic, entangled systems. Through its taxonomy, analysis of core features, and critique of regulatory analogies, we uncover that AgAI's distinctive dynamic nature (its ability to transform both environment and society) renders conventional oversight methods insufficient. Appropriate governance ought to be envisioned as an ongoing, participatory process rather than accomplished through a fixed institutional design. Governance must be capable of learning, adapting, and co-evolving with the systems it regulates. In this respect, AgAI serves as a model for reimagining AI governance in other materially and socially complex contexts where the boundaries between technology, ecology, and society are inseparable.

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Study on ethical embedding mechanisms and practices in China's smart agriculture policies

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Abstract

Smart agriculture has become a core strategy for China's agricultural modernization and rural revitalization; however, the application of technology has given rise to ethical tensions such as imbalanced data rights, insufficient technological inclusivity, and industrial value conflicts. This study takes central and local smart agriculture policy texts from 2015 to 2025 as the research object, and systematically examines the ethical logic of policy evolution by comprehensively employing content analysis and multi-case study methods. It proposes a four-dimensional collaborative theoretical framework of ethical embedding, comprising "value guidance, structural adaptation, scenario nesting, and risk underpinning." By analyzing typical practices of intelligent agricultural machinery financial leasing in Zhejiang, the feasibility of the mechanism was verified. The study found that current ethical embedding still faces challenges such as ambiguous data property rights, insufficient technological adaptability, weak rigidity in interest linkage, and an incomplete regulatory system. Future efforts need to optimize the mechanism from four dimensions: legal system construction, technological supply, organizational restructuring, and governance improvement, to promote smart agriculture in achieving dual values of efficiency and fairness.

Keywords: smart agriculture, policy design, ethical embedding mechanism

Introduction

With the deep penetration of artificial intelligence and digital technologies, the global agri-food system is undergoing an unprecedented paradigm shift. In recent years, China has intensively introduced policies that prioritize smart agriculture as a key development area and a core domain for AI integration. However, behind technological empowerment lie latent ethical tensions: smallholder farmers face dilemmas such as the erosion of data rights and interests, imbalance of algorithmic power, and the technology accessibility gap, rendering the coordination between public and smallholder interests increasingly salient. Existing studies have mostly focused on the technical and economic values of smart agriculture, but lack systematic investigation into the institutional regulatory mechanisms for ethical conflicts, particularly the pathways of ethical embedding in policy design. Taking relevant policy texts from 2015 to 2025 as the research object and incorporating practical cases from Zhejiang Province, this study explores how China's smart agriculture policies respond to ethical tensions, the ethical embedding mechanisms formed therein, and their optimization pathways.

Analysis of the development process of China's smart agriculture policies and their ethical tensions

Policy development process

Based on differences in policy objectives and ethical orientations, the evolution of China's smart agriculture policies can be divided into three phases: The Pilot Exploration Phase (2015–2017): centered

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on "Internet +" agriculture (SC, 2015), this phase focused on localized trials of Internet of Things (IoT) technologies and the construction of rural "triple network integration" infrastructure. Policies concentrated on verifying technological feasibility and did not substantially address ethical governance issues. The Standardization and Promotion Phase (2018–2023): marked by the "Digital Rural and Agricultural Development Plan (2019–2025)" (MARA et al., 2019), this phase promoted large-scale technology application and full-chain integration. It first incorporated "guiding smallholder farmers to integrate into modern agriculture" as a policy principle; however, ethical governance provisions remained fragmented and lacked systematic design (Zhang et al., 2023). The Comprehensive Maturity Phase (2024–2025): policies shifted toward a multi-oriented approach encompassing "technological empowerment, public services, and rights protection", with ethical governance emerging as an explicit core focus. The National Smart Agriculture Action Plan (2024–2028) (MARA, 2024) explicitly identifies driving the development of smallholder farmers as an important goal.

The core manifestation and generative logic of ethical tensions

The ethical tensions in smart agriculture are concentrated in three dimensions. First, conflicts over data rights and interests. Institutional gaps persist in defining agricultural data property rights. Tech companies expropriate smallholder farmers' production data without compensation by virtue of their technological advantages to form monopolies, leaving smallholders excluded from sharing data value-added benefits. Second, an inclusivity gap in technology application. Mainstream smart technologies are tailored for large-scale farming, which is fundamentally misaligned with the fragmented smallholder farming reality in China. Smallholders face insurmountable barriers to technology adoption due to financial and skill constraints, while the disproportionate concentration of public resources on large-scale operators further exacerbates rural income disparities. Third, conflicts in industrial value objectives. Market profit-seeking motives stand in opposition to the public value of agriculture. Some regions blindly construct smart agricultural parks while neglecting smallholders' livelihood security. The underlying generative logic of these tensions lies in the inherent contradiction between technological rationality and value rationality, the structural adaptation dilemma of "a large country with smallholder farmers", and the phased absence of policy ethical governance mechanisms.

Policy responsiveness and existing ethical governance foundation

As ethical tensions become explicit, China's policy value orientation has undergone a profound transformation: establishing underlying value guidance centered on "people" and promoting common prosperity; emphasizing the enhancement of smallholder farmers' digital capabilities and interest protection, incorporating "the number of smallholder farmers driven" into project evaluation indicators (MARA, 2024); and initially establishing an agricultural data security governance framework, laying the foundation for the improvement of ethical mechanisms. However, existing governance still faces issues such as a large number of principled clauses, insufficient constraint-oriented details, and inadequate junction between top-level design and grassroots implementation.

Theoretical framework of ethical embedment mechanisms in the design of China's smart agriculture policies

China's current smart agriculture policies have established a four-dimensional collaborative ethical embedding system characterized by 'value leadership – structural adaptation – scenario embedding – risk bottoming out'. Through systematic institutional design, this system converts ethical principles for balancing diverse interests into operational governance tools.

Value leadership serves as the top-level logic of ethical embedding. It delineates technical ethical boundaries through three orientations: people-oriented (Wu et al., 2025), holistic agricultural synergistic development, and shared construction and inclusive equality. Policy objectives include safeguarding smallholder livelihoods, coordinating the three major benefits, and ensuring inclusive smallholder returns, using policy value rationality to calibrate technical instrumental rationality. Structural adaptation functions as the implementation carrier. It enhances smallholders' bargaining power and technical access levels through organizational means, such as the linkage mechanism between new business entities and small farmers, the agricultural social service system, and the intermediary role of cooperatives. While upholding the foundational status of household management, it balances efficiency and fairness.

Scenario embedding transforms abstract ethical principles into concrete technical standards and service norms. By facilitating the decentralization of digital public services, the research and development of low-cost intelligent equipment, and the establishment of benefit-sharing rules across the entire industrial chain, it enables ethical requirements to be operationalized throughout all stages of technology application. Risk bottoming out constructs a closed-loop system of 'pre-event prevention – mid-event supervision – post-event punishment'. It provides institutional safeguards for smallholder rights through property rights separation of data, technical ethical review, and accountability tracing systems. In summary, the four mechanisms form a complete top-down operational closed loop. Their collaborative essence lies in achieving dynamic balance among national institutional rationality, market technical rationality, and smallholder operational interests. Ultimately, this drives a virtuous cycle of technological benevolence, industrial value increment, and smallholder income growth.

Practical analysis of the mechanism for embedding policy ethics in China's smart agriculture

Based on the four-dimensional ethical embedding mechanism of 'value guidance – structural adaptation – scenario embedding – risk bottoming out' proposed in the preceding text, this paper selects typical cases from Zhejiang Province, one of the first national smart agriculture leading areas, to analyze the implementation pathways of ethical principles, and to demonstrate the operational logic, implementation effectiveness, and practical shortcomings of policy-based ethical embedding mechanisms.

Case: Zhejiang's financial leasing of intelligent agricultural machinery solves technology access difficulties

Zhejiang Province has adopted financial innovation as a core tool for ethical embedding. Targeting the pain points of small-scale farmers and new agricultural entities, who cannot afford or utilize intelligent agricultural machinery, Zhejiang has achieved precise alignment between financial capital, small-farmer interests, and public interests through financial leasing. It has explored a distinctive ethical embedding pathway characterized by 'legal safeguards + fiscal guidance + financial empowerment + service integration,' thereby constructing an integrated intelligent agricultural machinery promotion model. Specific measures include: first, improving legal safeguards, where the newly revised "Regulations of Zhejiang Province on Promoting Agricultural Mechanization" explicitly encourages agricultural machinery financial leasing and streamlines procedures, providing a legal basis (SCZPPC, 2025); second, strengthening fiscal guidance by offering special interest subsidies and risk compensation for this business to leverage the lever effect of fiscal funds; third, promoting financial product innovation by shifting from traditional credit to equipment support models, thereby empowering rural revitalization (Li, 2024); and fourth, innovate the linkage mechanism of 'leasing + socialized services', establish agricultural service centers, and provide services such as land management on behalf and crop cultivation on behalf to meet the diverse production needs of different farmers (Zhu et al., 2024).

The practices in Zhejiang Province have accurately addressed the core pain points of small-scale farmers, such as high technical barriers and financing difficulties, achieving a win-win outcome for multiple parties: the financial leasing model has significantly reduced the technical usage barriers for small farmers; fiscal funds have leveraged public resource utilization efficiency; simultaneously, financial resources have been deeply integrated with pro-agricultural benefits, effectively guiding technological dividends to flow to small-scale farmers. Ultimately, this has achieved an organic unity of industrial development and increased income for small farmers.

Realistic challenges faced in implementing the mechanism for embedding ethical considerations in China's smart agriculture policies

At present, the ethical embedding mechanisms in China's smart agriculture policies still face several practical challenges in their implementation.

First, the delineation of data property rights remains ambiguous, with a lack of effective protection for smallholder farmers' rights and interests. Agricultural data lacks support from high-level legislation, and there are no clear implementation standards for the boundaries and ownership of three categories of data: smallholder production data, corporate commercial data, and government public data (He et al., 2026). Enterprises mostly obtain data usage rights through standard form clauses, leaving smallholders with little negotiating power and control. Mechanisms for data value assessment and benefit distribution have not yet been established; value-added benefits are primarily captured by platform enterprises, making it difficult for smallholders to share in the data dividends.

Second, the supply of technology is poorly adapted to smallholder needs, and the cost barriers to application remain high. Mainstream technology research and development tends to favor large-scale farming scenarios, resulting in a severe shortage of low-cost, easy-to-operate equipment suitable for hilly and mountainous areas and smallholder farming. The costs of purchasing and maintaining smart equipment far exceed the affordability of smallholder farmers, and targeted financial support is insufficient. Meanwhile, smallholders generally possess low levels of digital literacy (Cui, 2022), and the lack of well-established routine practical training systems further exacerbates the "digital divide".

Third, organizational intermediaries for farmer linkage are underdeveloped, and the rigidity of benefit-sharing mechanisms is weak. Most new types of agricultural business entities are relatively weak and have limited capacity to benefit smallholders, while some cooperatives suffer from "insider control" and "hollowing out" issues. Benefit-sharing often remains at the level of simple procurement and short-term orders, lacking robust mechanisms for risk-sharing and mutual benefit. Enterprises hold the power over pricing and technology, leaving smallholders with weak bargaining power and low contractual security. The agricultural social service system is incomplete, with low coverage of village-level service stations and insufficient supply of high-end technical services.

Fourth, the allocation of institutional and operational resources is unbalanced, and the ethical regulatory system is incomplete. Public resource allocation exhibits a "Matthew effect," whereby financial and technological resources are primarily channeled to large-scale entities and industrial parks, while inclusive support for smallholder farmers remains limited. Ethical reviews lack unified standards and enforcement systems, often becoming mere formalities, and dynamic oversight of high-risk algorithms and data collection projects is inadequate. Cross-departmental coordination mechanisms have not yet taken shape, and grassroots regulatory capacity is weak. Inadequate dynamic regulation of high-risk algorithms and data collection projects raises the question of who should be held responsible for farmers' economic losses resulting from poorly managed or erroneous decisions made by artificial intelligence systems (Dara et al., 2022).

Optimization pathways for ethical embedment mechanisms in China's smart agriculture policies

To address the current practical shortcomings, China's policy ethics embedding mechanism for smart agriculture can be systematically optimized from four dimensions:

First, consolidate the foundation of the rule of law and establish a rigid data property rights governance system. Accelerate the improvement of regulations for the protection of agricultural data rights and interests, establish a 'three-rights separation' property rights framework, and clarify the ownership, control rights, and revenue rights of smallholder production data. Establish a standardized data collection compliance mechanism, enforce exclusive authorization, and prohibit illegal collection. Establish a market-oriented mechanism for evaluating data value and distributing returns, explore the 'data equity + return dividend' model, and ensure that the added-value returns from data are fed back to small-scale farmers.

Second, optimize technological supply and build an inclusive and universally beneficial technological support system. Adjust the orientation of technological research and development, taking adaptation to smallholder farming scenarios as a prerequisite for R&D, and focus on developing low-cost, easy-to-operate intelligent equipment and lightweight digital applications. Strengthen financial empowerment by promoting Zhejiang's intelligent agricultural machinery financial leasing model, developing low-interest long-term financial products tailored for smallholders, and increasing the proportion of technological subsidies. Improve the digital literacy training system to enhance smallholders' capabilities through 'field classrooms' combined with on-site guidance.

Third, reshape industrial organization and improve close-knit interest-linking mechanisms. Cultivate and strengthen new types of operating entities, and use the effectiveness of supporting agriculture and leading farmers as a prerequisite for project approval and financial subsidies. Promote standardized contractual linkages, enforce the 'protected-price purchase + profit return + risk sharing' mechanism, and introduce performance guarantee insurance. Improve the three-tiered county-village-social service network to achieve full coverage of village-level service stations.

Fourth, improve the governance system and establish a full-chain closed-loop supervision system. Set up a hierarchical and full-process ethical review mechanism, form a cross-disciplinary review committee, and utilize blockchain technology to achieve end-to-end supervision. Improve the judicial protection mechanism for small-scale farmers' rights and interests, and explore public interest litigation and relief systems in the agricultural sector.

Conclusion

The following conclusions are drawn through the study of this paper: first, the value orientation of China's smart agriculture policies has shifted from 'priority to technical efficiency' to 'a balanced emphasis on efficiency and equity,' with ethical governance transitioning from implicit demands to explicit institutional constraints. Second, a four-dimensional collaborative mechanism for ethical embedding – encompassing 'value leadership, structural adaptation, scenario integration, and risk mitigation' – has been established, providing an institutional framework to balance the interests of small-scale farmers and the public good. Third, the financial empowerment implementation path explored by the pilot experimental region of Zhejiang Province has validated the feasibility of localized mechanisms. Fourth, current ethical embedding still faces four major challenges: data property rights, technological supply, organizational connectivity, and institutional operation, which require systematic improvement across the dimensions of law, technology, organization, and regulation.

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From seeds to sequences: legal and ethical challenges for plant genetic resources in the digital era

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Abstract

Plant genetic resources (PGR) are the biological foundation of agriculture and food security, yet their legal status has become increasingly fragmented across overlapping regimes of sovereignty, market regulation, and intellectual property. The rapid development of genome editing techniques and digital sequence information (DSI), together with artificial intelligence-assisted breeding, is accelerating the "dematerialization" of PGR: genetic information can now be accessed and used without the need for physical material. This development challenges the effectiveness of existing access and benefit-sharing (ABS) frameworks under the Convention on Biological Diversity, the Nagoya Protocol, and the FAO International Treaty on Plant Genetic Resources for Food and Agriculture, while raising ethical questions concerning equity, biodiversity, and the rights of farmers and Indigenous communities.

This paper examines how the convergence of digitalization, AI-assisted breeding, and new genomic techniques is reshaping the governance of plant genetic resources in Europe and globally. It analyses tensions between international ABS obligations, EU regulation of plant reproductive material, and the growing overlap between breeders' rights and biotechnology patents. It argues that the transition from seeds to sequences exposes the limits of legal models still centred on physical access to genetic resources, while creating new forms of control over data, traits, and innovation pathways.

The contribution defends the need for a more coherent and equitable governance model capable of ensuring access to germplasm for research and innovation while safeguarding biodiversity, farmers' rights, and global justice. By situating genome editing and agricultural digitalization within broader debates on sustainability, the paper highlights how legal design will shape future agri-food systems.

Keywords: plant genetic resources, digital sequence information, access and benefit-sharing, breeders' rights, biotechnology patents, biodiversity governance

Introduction

Plant genetic resources (PGR) are the biological foundation of global agriculture and food systems. They provide the raw material for plant breeding, contribute to food security, and embody long-standing agricultural practices and cultural knowledge. In the twenty-first century, however, PGR are undergoing a profound transformation. Digital technologies – particularly big data analytics, artificial intelligence (AI), and genome editing – are reshaping how these resources are accessed, conserved, and used. The integration of genomic data analysis and digital breeding tools is accelerating the "dematerialization" of PGR: genetic information can now be digitized, stored, and circulated as sequences, increasingly detached from physical biological material.

This shift challenges established governance frameworks. International law has traditionally regulated PGR through overlapping regimes: the Convention on Biological Diversity (CBD), the Nagoya Protocol

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on Access and Benefit-Sharing (ABS), and the FAO International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). These instruments sought to reconcile sovereign rights over biological resources with the need for access to germplasm for research and breeding. At the same time, the European Union (EU) has developed a dense regulatory framework for the marketing of plant reproductive material (PRM), while intellectual property (IP) regimes – patents and plant breeders' rights – have expanded to cover innovations derived from plant genomes.

The emergence of digital sequence information (DSI) and new genomic techniques (NGT) exposes the fragility of this legal architecture. How should benefit-sharing operate when only genetic data, rather than physical material, is exchanged? To what extent can IP regimes be reconciled with farmers' rights and biodiversity conservation? Who controls the infrastructures and knowledge systems that support digital breeding? These questions point to the need for renewed analysis at the intersection of law, ethics, and technology. This paper argues that PGR governance is at a critical crossroads. By tracing the transition "from seeds to sequences", it analyses how sovereignty, market regulation, and innovation regimes interact – and often collide – in the digital era. It examines the risks of fragmentation, concentration of power, and inequity, while identifying the normative conditions for more coherent and just frameworks.

2. Plant genetic resources: biological unity, legal fragmentation

Plant genetic resources constitute the biological basis of food security, climate resilience, and agricultural innovation. They include traditional landraces maintained by farming communities, ex situ germplasm conserved in gene banks, and wild relatives that provide traits essential for adaptation (Esquinas-Alcázar, 2005; Maxted et al., 2020). Beyond their biological dimension, seeds also embody cultural memory, local knowledge, and social practices of conservation and exchange. Yet, while PGR form a unified biological continuum, their legal status is fragmented. They are governed through overlapping and sometimes contradictory regimes of sovereignty, market regulation, and innovation. This plurality reflects not only legal design, but also broader sociotechnical choices concerning standardization, access, and control (Jasanoff, 2016).

From PGR to PRM: when life becomes a legal category

A central distinction is that between plant genetic resources (PGR) and plant reproductive material (PRM). PGR refers to biological diversity in seeds, tissues, and genetic material, whereas PRM is a legal category used in EU law to regulate the production and marketing of propagating material. This transformation of PGR into PRM illustrates how law reframes biological life into technical and economic units, privileging standardization, traceability, and market circulation. EU regulation in this field has historically favoured uniformity, stability, and certification. Although recent reform proposals introduce categories such as conservation varieties and heterogeneous material, the system remains largely oriented towards formal market integration and regulatory control (European Commission, 2023; Louwaars, 2021).

Sovereignty regimes and the rise of ABS

The CBD marked a decisive shift from the idea of genetic resources as the "common heritage of humankind" to the principle of state sovereignty over biological resources. Access to such resources now requires prior informed consent and the establishment of benefit-sharing arrangements. The Nagoya Protocol reinforced this contractual logic, while the ITPGRFA introduced a partially different model through its Multilateral System (MLS), which facilitates access to a defined set of crops and combines it with standardized conditions and a collective benefit-sharing mechanism (Halewood et al., 2018).

This architecture, however, faces significant limitations. ABS regimes presuppose that access and benefit-sharing can be linked through identifiable transactions. In plant breeding, by contrast, innovation often relies on cumulative, long-term, and highly diffuse genetic contributions. DSI intensifies this difficulty: when genomes are accessed through digital databases, the material origin of PGR becomes harder to trace and the territorial logic of sovereignty is weakened (Sirakaya, 2019).

Market regimes: seeds as commodities

Within the EU, once PGR enter formal markets, they are treated as PRM and become subject to certification, registration, and phytosanitary requirements. These rules seek to ensure quality, safety, and traceability, but they also reinforce a preference for uniform and stable varieties. As a result, more diverse or community-based seed systems often remain structurally disadvantaged. This is not only a technical effect. Legal requirements contribute to the consolidation of agricultural models centred on standardization and market competitiveness, while more plural seed systems struggle to fit within the dominant regulatory template (Dedeurwaerdere, 2019; Louwaars, 2021).

Innovation regimes and the expansion of intellectual property

A third layer of governance is provided by intellectual property. Plant breeders' rights protect varieties that meet the criteria of distinctness, uniformity, and stability, while patents may extend to biotechnological inventions, including traits and processes. Genome editing has made the interaction between these regimes more complex, particularly where patented techniques or traits become embedded in new plant varieties (Blakeney, 2019; Custers & Dima, 2022). Although IP rights are commonly justified as incentives for innovation, they may also restrict access to germplasm and increase barriers for public breeders, farmers, and smaller actors. The growing overlap between breeders' rights and patents raises questions not only of legal coordination, but also of fairness and concentration of control.

Fragmentation, power, and inequity

The coexistence of sovereignty-based ABS rules, EU PRM regulation, and overlapping IP regimes produces legal incoherence and uneven distributive effects. A single genetic resource may simultaneously be subject to benefit-sharing obligations, market-entry requirements, and multiple layers of proprietary claims. Navigating this landscape requires technical, legal, and financial capacities that are unevenly distributed. Large corporations are therefore better positioned to manage complexity and accumulate advantages across seeds, traits, patents, and data infrastructures, while farmers, Indigenous communities, and many public researchers face structural disadvantages (Clapp, 2018; Clapp, 2025). The fragmentation of PGR governance is thus not simply a legal puzzle. It is also a political question about who can innovate, who benefits from innovation, and who is excluded from its rewards.

Precision Agriculture, AI, and Genome Editing

The rise of precision agriculture illustrates how digitalization, big data, and AI are transforming agri-food systems. Digital tools can optimize the use of inputs, improve monitoring, and support decision-making through data-intensive forms of crop management (Rose & Chilvers, 2018). In parallel, genome editing techniques such as CRISPR have expanded the possibilities of targeted intervention in plant genomes, enabling the development of varieties with improved agronomic traits (Zhang et al., 2018). Taken together, these developments are often framed as part of a broader transition towards data-driven agriculture. AI-assisted breeding can accelerate the identification of desirable traits, reduce breeding cycles, and intensify the reliance on sequence-based knowledge. This reinforces the dematerialization of PGR by shifting attention from physical germplasm to informational and computational forms of access.

Governance and legal tensions

The integration of AI and genome editing into agriculture challenges existing regulatory frameworks. At the international level, edited crops may derive from genetic material that falls within CBD or Nagoya obligations, yet their digital development weakens the link between material origin and subsequent innovation (Sirakaya, 2019). Within the EU, the legal status of NGT remains contested, and current debates on regulatory reform reveal tensions between innovation policy, biodiversity protection, and farmers' rights (Escajedo San-Epifanio et al., 2023; Nawaz & Kandlikar, 2021). At the same time, seed law continues to privilege formal categories of PRM, raising questions about how heterogeneous, community-bred, or digitally developed varieties fit into the regulatory framework. Intellectual property adds another layer of complexity: while breeders' rights allow further breeding under certain conditions, patents on traits or editing techniques may limit access and increase licensing costs (Custers & Dima, 2022).

Power dynamics and sustainability

These transformations are also shaping the political economy of agriculture. Digital breeding, genome editing, and data-driven farming may expand scientific and productive capacities, but they can also reinforce dependence on proprietary technologies and concentrated market structures. The concentration of control over seeds, data, and agri-food infrastructures in a small number of corporate actors raises broader questions about sustainability, access, and distributive justice (Clapp, 2025). The problem is therefore not only whether these technologies work, but how they are embedded in legal and institutional structures. Their trajectories will shape who controls innovation, how benefits are distributed, and whether sustainability is defined in inclusive or exclusionary terms.

International governance of plant genetic resources

The governance of plant genetic resources has evolved through a complex set of international, regional, and national regimes. While PGR were once discussed in terms of common heritage, they are now regulated through fragmented arrangements combining sovereignty, market integration, and innovation policy. This fragmentation is not merely technical. It has direct consequences for access to biodiversity, conservation responsibilities, and the distribution of benefits from scientific and technological development.

From commons to contracts

The CBD and the Nagoya Protocol institutionalized a sovereignty-based model in which access to genetic resources depends on state authorization and benefit-sharing arrangements. By contrast, the ITPGRFA's Multilateral System reflects a more collective logic, especially in relation to food and agriculture, where interdependence among countries and breeding systems is particularly strong (Halewood et al., 2018). The distinction matters because these two models embody different conceptions of justice. Bilateral ABS mechanisms are essentially contractual: benefits are tied to specific transactions. The MLS, by contrast, is closer to a distributive model, in which benefits are pooled and redirected to conservation and sustainable use. DSI has made this contrast sharper, since sequence-based access fits poorly within legal models designed around the transfer of physical material (Sirakaya, 2019).

The European PRM framework

At EU level, PGR are mainly governed through the PRM regime. This framework is concerned with the regulation of varieties and propagating material in the internal market, and it has historically prioritized

uniformity, certification, and traceability. While this system serves important regulatory purposes, it also creates structural tension between biodiversity conservation and seed commodification. The 2023 reform proposal acknowledges some of these tensions by opening space for conservation varieties and heterogeneous material (European Commission, 2023). Even so, the overall framework remains anchored in a model of regulated market circulation rather than in support for plural and community-based seed systems.

Breeders' rights, patents, and legal overlap

Breeders' rights and patents together create a dense field of claims over plant innovation. Breeders' rights are designed specifically for plant varieties and include limited exceptions, such as the breeder's exemption. Patents, by contrast, may extend to particular traits, sequences, or techniques and can therefore restrict access more broadly (Blakeney, 2019; Custers & Dima, 2022). The result is a layered form of legal protection that may constrain research, increase dependency on licensing, and favour actors with the capacity to manage complex proprietary environments. In practice, this overlap contributes to concentration and may undermine the openness historically associated with plant breeding.

Ethical and social challenges

The transformation of PGR in the digital era raises ethical questions that go beyond legal coordination. Seeds are not merely agricultural inputs. They are also carriers of cultural memory, social practice, and ecological interdependence. Therefore, their governance implicates issues of justice, recognition, and responsibility.

Justice and Benefit-Sharing

The original promise of ABS was fairness. Yet bilateral contractual models have often struggled to deliver meaningful benefit-sharing in plant breeding, where causal chains are diffuse and benefits emerge over long time horizons. For this reason, distributive approaches based on pooled mechanisms appear normatively more adequate in the context of PGR and DSI (Halewood et al., 2018).

Farmers' Rights and Indigenous Communities

Ethical analysis of PGR governance must also consider those who have historically conserved, reproduced, and transmitted agricultural biodiversity. Farmers' rights remain central in this regard, especially insofar as they concern seed saving, exchange, and participation in decision-making. These rights are not merely ancillary to innovation policy; they express a claim that those who sustain agrobiodiversity should not be excluded from the legal and institutional arrangements that determine its future use.

Indigenous communities raise further questions of recognition, consent, and the relationship between genetic resources and knowledge systems. Their claims cannot be reduced to access to biological material alone, since plant genetic resources may be embedded in wider systems of ecological knowledge, cultural practice, and collective responsibility. In this sense, PGR governance raises questions not only of distribution, but also of recognition and participation.

These issues are addressed here not simply as examples of data-driven inequality, but as claims grounded in historical contribution, consent, and recognition. In both cases, formal legal inclusion does not automatically resolve underlying asymmetries of power. The following subsection therefore considers how digitalization adds a further layer to these asymmetries by shifting control from material access to informational infrastructures.

Power, Data, and Inequality

Digitalization adds a new layer to old inequalities. If genetic resources become accessible mainly through data infrastructures controlled by a small number of actors, then the governance of biodiversity risks shifting from questions of material access to questions of informational enclosure. The concentration of data, patents, and seed markets in large corporate actors underscores the distributive dimension of technological change (Clapp, 2018; Clapp, 2025). The central ethical question is therefore not simply whether innovation should be promoted, but under what conditions and for whose benefit.

Towards Coherent and Equitable Governance

The fragmentation of PGR governance reveals a deeper tension between competing legal and normative logics. Sovereignty regimes emphasize national control and contractual exchange; market regimes prioritize uniformity and circulation; innovation regimes protect private investment and proprietary claims. Taken together, these regimes construct a legal architecture that is difficult to reconcile internally and uneven in its effects.

A more coherent framework requires, first, adapting ABS to the realities of DSI through mechanisms capable of addressing non-material access. Second, it requires PRM regulation to accommodate diversity more effectively and to avoid treating informal or community-based seed systems as marginal exceptions. Third, it requires rebalancing the relationship between breeders' rights and patents in order to preserve access to germplasm and avoid excessive enclosure.

This is not merely a technical task. It is also a normative one. The legal treatment of PGR expresses choices about what kind of agriculture is to be supported, how biodiversity is to be valued, and whether innovation will remain compatible with equity, conservation, and plural forms of knowledge (Jasanoff, 2016).

Conclusion

The trajectory of plant genetic resources in the digital era reveals more than a technical transformation. It exposes a point of tension where competing visions of agriculture, innovation, and justice collide. The digitalization of genomes and the rise of AI intensify existing fragmentation by weakening legal models centred on material access and by strengthening new forms of control over data, traits, and breeding pathways.

The implications are substantial. Contract-based ABS mechanisms struggle to capture the cumulative and distributed character of plant breeding. Market regimes continue to favour standardization over diversity. Intellectual property regimes increasingly generate overlapping rights that may restrict access and reinforce concentration.

Yet the future governance of PGR is not predetermined by digitalization, market integration, or intellectual property expansion. Precisely because plant genetic resources sit at the intersection of biodiversity, food security, technological innovation, and justice, they remain a field in which legal and institutional choices are still open. A more coherent and equitable legal framework can still be built – one that preserves access to germplasm, ensures fair benefit-sharing in the context of DSI, and protects biodiversity together with the rights of those who have historically sustained it. Whether seeds are governed primarily as strategic assets, market goods, or shared foundations of food systems will shape the future of agriculture in decisive ways.

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Who owns the carbon? Ethical dimensions of hazelnut-based agroforestry systems

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Abstract

Hazelnut-based agroforestry systems contribute to climate mitigation through perennial tree cover, soil carbon sequestration, and long-term land stewardship. In Türkiye, where hazelnut orchards are central to rural livelihoods and landscapes, these systems are increasingly integrated into voluntary carbon market frameworks. This development raises a fundamental ethical question: who owns the carbon sequestered through sustained farmer stewardship of land and trees? This paper examines the ethical dimensions of carbon ownership and farmer agency in hazelnut-centred agroforestry systems, with particular attention to digital measurement, reporting, and verification (MRV) mechanisms. Although carbon credits are treated as abstract, tradable assets, their generation is inseparable from site-specific management practices, labour, and farmers' ecological knowledge. Yet contemporary carbon accounting frameworks rely heavily on expert-driven and digitally mediated systems that risk marginalising farmers' decision-making roles. Adopting an ethical and political ecology perspective, the study addresses three questions: (i) can carbon sequestered in hazelnut agroforestry systems be ethically separated from land tenure and farmer stewardship; (ii) do digital MRV systems empower farmers as co-owners of carbon value or reduce them to passive data providers; and (iii) how can distributive justice be ensured in carbon governance frameworks applied to smallholder-dominated perennial systems? Drawing on hazelnut-based agroforestry practices in Türkiye, the paper argues that carbon markets risk reproducing power asymmetries unless farmer agency is explicitly recognised. It proposes an ethical reframing of agroforestry carbon governance that positions farmers as co-owners and long-term stewards of carbon value. Complementary high-value crops such as truffles are discussed as economic co-benefits supporting land conservation and farmer participation, aligning carbon markets with environmental integrity and social justice.

Keywords: smallholder stewardship, voluntary offset markets, political ecology, digital verification, benefit-sharing

Introduction

Carbon markets have emerged as a central instrument in global climate governance, channelling private capital towards activities that reduce or remove greenhouse gas emissions (Streck, 2020). In the agricultural sector, agroforestry systems are increasingly recognised as significant carbon sinks, capable of sequestering substantial volumes of carbon in both above-ground biomass and soil organic matter (Granata *et al.*, 2020; Pacchiarelli *et al.*, 2022). Hazelnut orchards (*Corylus avellana* L.) represent a particularly notable case: managed predominantly by smallholders in Türkiye's Black Sea region, these perennial systems combine ecological permanence with deep cultural and economic significance for rural communities.

The legal classification of hazelnut as an 'agricultural product' under Turkish law obscures its ecological function as a woody perennial within agroforestry systems. This classificatory mismatch has direct

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consequences for carbon rights allocation, as agroforestry-based carbon sequestration falls between agricultural and forestry governance frameworks – a gap that Türkiye's Climate Law No. 7552 (Republic of Türkiye, 2025) does not address.

Yet the incorporation of agroforestry carbon into market-based mechanisms raises profound ethical questions that remain insufficiently addressed in both academic literature and policy design. The dominant framing of carbon credits as fungible, tradable commodities tend to abstract sequestered carbon from the social relations, labour, and ecological knowledge through which it is produced (Fairhead *et al.*, 2012). When carbon is detached from the land tenure arrangements and stewardship practices that generate it, the conditions are created for what has been termed 'green grabbing' – the appropriation of environmental value by actors far removed from the site of ecological production (Fairhead *et al.*, 2012).

This tension is compounded by the rapid digitisation of carbon accounting. Digital MRV systems, typically relying on satellite remote sensing, artificial intelligence and machine learning algorithms, and centralised data platforms, promise greater accuracy and scalability in quantifying carbon stocks and fluxes. However, they simultaneously risk transforming farmers from active ecological stewards into passive data subjects whose land and practices are rendered legible to external markets without their meaningful participation in governance or value distribution (Rotz *et al.*, 2019; Canfield and Ntambirweki, 2024).

The present paper addresses this gap by examining the ethical dimensions of carbon ownership and farmer agency in hazelnut-based agroforestry systems. Drawing on political ecology and agricultural ethics, it asks whether carbon governance frameworks can be designed to recognise farmers as co-owners of the carbon value they help create, rather than as mere implementers of externally prescribed practices. The analysis is situated in Türkiye's hazelnut sector, where cooperative structures and long-standing land stewardship traditions offer both a concrete empirical context and a normative horizon for more equitable carbon governance. Adopting a conceptual analysis approach grounded in ethical theory and political ecology, the paper synthesises existing scholarship to develop a normative framework for evaluating carbon governance in smallholder agroforestry contexts.

Ethical and conceptual framework

Carbon as embedded value

This paper adopts a conceptual and normative analytical approach, drawing on ethical theory and political ecology to examine carbon governance. The ethical analysis presented here departs from the premise that carbon sequestered in agroforestry systems is not a free-standing commodity but an *embedded value* – inseparable from the land, labour, and knowledge systems that produce it. This position draws on Thompson's (2015; 2017) stewardship ethic, which holds that agricultural land carries obligations that extend beyond market exchange, encompassing ecological care, intergenerational responsibility, and community well-being. From this perspective, treating sequestered carbon as a detachable asset to be traded on global markets represents a category error: it conflates a relational good with a transactional one. Hackfort and Haas (2025) reinforce this argument by demonstrating how soil carbon markets are increasingly shaped by agribusiness accumulation strategies that decouple carbon value from the farming practices that generate it.

Political ecology provides a complementary lens. Corbera and Brown (2010) have demonstrated that carbon offset schemes systematically disadvantage rural communities because the structural conditions required to access carbon markets – capital, technical expertise, legal capacity, and market connectivity

– are precisely those that smallholders lack. The result is a pattern in which carbon value flows upward through intermediary chains while the costs of land management, monitoring compliance, and ecological maintenance remain with farming households.

Distributive justice and benefit-sharing

The question of who should benefit from carbon transactions has been examined extensively in the context of forest-based programmes. Luttrell *et al.* (2013) identify six competing rationales for benefit distribution – based on emission reductions, costs incurred, legal rights, poverty alleviation, stewardship, and facilitation – each yielding different equity outcomes. McDermott *et al.* (2013) propose a three-dimensional equity framework encompassing distributive, procedural, and contextual dimensions. These frameworks, developed primarily for REDD+ and payment for ecosystem services (PES) schemes, have yet to be applied systematically to temperate agroforestry contexts. The present paper contributes to filling this gap by extending distributive justice analysis to hazelnut-based carbon systems.

Digital MRV and epistemic justice

A further ethical dimension concerns the epistemological implications of digital MRV. Satellite-based monitoring and algorithmic carbon estimation create what Rotz *et al.* (2019) characterise as a 'politics of digital agricultural technologies', in which data ownership, algorithmic opacity, and platform governance become sites of power. When carbon verification depends entirely on remote sensing and machine learning models, farmers' experiential knowledge of soil conditions, phenological cycles, and management effects is rendered invisible or redundant. Ruder and Wittman (2025) argue that achieving data justice in agriculture requires not merely better data governance policies but structural changes, including new legal frameworks, novel governance institutions, and meaningful capacity building for farming communities. Canfield and Ntambirweki (2024) extend this argument to African smallholders, showing that the emphasis on personal data privacy obscures collective risks and power asymmetries embedded in agricultural datafication.

Carbon ownership in hazelnut agroforestry systems

The hazelnut orchard as a carbon system

Hazelnut orchards constitute long-lived perennial systems with significant carbon sequestration capacity. Pacchiarelli *et al.* (2022) report that mature hazelnut orchards in central Italy store between 0.6 and 3.3 Mg C/ha in tree biomass, with soil organic carbon levels exceeding those of adjacent grasslands in orchards older than 35 years. Granata *et al.* (2020) estimate annual CO_2 sequestration at approximately 58.8 Mg CO_2/ha in established Italian hazelnut orchards. In Türkiye's Black Sea region, where hazelnut cultivation has been practised for centuries under diverse management regimes, these figures suggest a substantial but largely unquantified carbon stock maintained through continuous farmer stewardship.

Crucially, this carbon is not the product of a single intervention or technology. It accumulates through decades of management decisions: planting and replanting cycles, pruning regimes, soil conservation practices, and the maintenance of associated vegetation. The carbon stock in a hazelnut orchard is therefore co-produced by ecological processes and human labour – a fact that standard carbon accounting methodologies, which attribute sequestration to biophysical parameters alone, tend to obscure.

Tenure, cooperatives, and the carbon rights gap

In Türkiye, hazelnut production is overwhelmingly smallholder-based, with average farm sizes of approximately two hectares. Land tenure is typically private and fragmented, and marketing is organised through cooperative structures, historically including Fiskobirlik (the Hazelnut Agricultural Sales Cooperatives Union) and regional cooperatives such as those in Giresun and Ordu. Carbon rights, however, remain legally undefined: Turkish law, including the Forest Law (No. 6831) and the Agricultural Law (No. 5488), does not recognise sequestered carbon as a distinct property right, nor do existing cooperative mandates extend to carbon market participation. This creates a governance vacuum in which external intermediaries – project developers, certification bodies, and international buyers – can claim carbon value without meaningful farmer consent or participation. Mantey *et al.* (2026) document analogous governance challenges in Kenyan smallholder carbon projects, where digital tools intended to enhance transparency instead reinforced intermediary control over carbon revenues.

The tenure–carbon relationship in this context echoes findings from forest carbon programmes. Larson (2011) and Corbera *et al.* (2011) have shown that where carbon rights are not explicitly linked to land tenure and use rights, carbon programmes tend to reinforce existing power hierarchies rather than redistribute value to land stewards. In hazelnut agroforestry, the risk is that digital MRV systems will quantify carbon stocks across thousands of smallholder parcels, generating tradable credits whose value accrues primarily to platform operators and certification intermediaries rather than to the farming households whose stewardship produced the sequestration.

Reframing carbon governance: farmers as co-owners

The analysis presented above suggests that ethical carbon governance in hazelnut agroforestry requires a fundamental reframing: from carbon as an extractable commodity to carbon as an embedded value co-owned by the farming communities whose stewardship sustains it. This reframing has three practical implications.

First, carbon rights must be formally linked to land tenure and stewardship practices. Legal recognition of farmer carbon rights, whether through national legislation or cooperative bylaws, is a precondition for equitable market participation. Without such recognition, voluntary carbon markets will replicate the patterns of value extraction documented in forest carbon programmes (Fairhead *et al.*, 2012; Streck, 2020).

Second, digital MRV systems must be designed as participatory tools rather than extractive surveillance mechanisms. While digital MRV systems offer genuine advantages in terms of measurement accuracy, cost reduction, and scalability that can benefit smallholders, these benefits can only be realised when farmers are positioned as active participants rather than passive subjects of data extraction. This entails not merely making data accessible to farmers, but ensuring that farmers participate in the design, calibration, and governance of monitoring systems. Farmer-held ecological knowledge – of soil variability, microclimate, phenological timing, and management effects – should complement remote sensing data rather than be displaced by it (Ruder and Wittman, 2025).

Third, benefit-sharing mechanisms must reflect the full spectrum of contributions that farmers make to carbon sequestration. Drawing on Luttrell *et al.* (2013) and McDermott *et al.* (2013), we argue that stewardship-based and cost-based rationales should take precedence over efficiency-based allocation in smallholder agroforestry contexts, ensuring that the households bearing the costs and risks of long-term land management receive a proportionate share of carbon revenues.

Complementary value chains and long-term conservation

An additional dimension of equitable carbon governance concerns the economic viability of sustained land stewardship. High-value complementary crops, particularly truffles (*Tuber* spp.), offer a compelling model. Truffle cultivation in agroforestry settings requires the maintenance of mature tree systems and undisturbed soils – precisely the conditions that maximise long-term carbon storage (Reyna and García-Barreda, 2014; Bruhn *et al.*, 2013). Moreover, truffles are ectomycorrhizal fungi whose below-ground networks enhance soil carbon retention by slowing organic matter decomposition (Clemmensen *et al.*, 2013; Averill *et al.*, 2014), effectively linking tree, fungus, and soil into a single carbon-storing holobiont – a framing that reinforces the embedded-value argument advanced above. By generating direct economic returns from land conservation, truffle production can reduce farmers' dependence on carbon credit revenues and strengthen their bargaining position within carbon markets. This approach treats complementary value chains not as carbon accounting mechanisms but as structural supports for the kind of long-term stewardship on which genuine carbon permanence depends, thereby strengthening farmer agency and reducing the risk of carbon value extraction by external intermediaries.

Conclusion

This paper has argued that the ethical governance of carbon in hazelnut-based agroforestry systems requires explicit recognition of farmer agency, formal linkage of carbon rights to land tenure and stewardship, participatory design of digital MRV systems, and benefit-sharing mechanisms grounded in distributive justice. The dominant model of carbon commodification, in which sequestered carbon is abstracted from the social and ecological relations that produce it, risks reproducing the power asymmetries and value extraction patterns documented in forest carbon programmes.

The hazelnut agroforestry systems of Türkiye offer both a cautionary case and a constructive horizon. With centuries of smallholder stewardship, established cooperative institutions, and significant but unquantified carbon stocks, these systems represent an opportunity to develop carbon governance models that centre farmer agency and distributional equity. Achieving this will require legal innovation, participatory technology design, and a willingness to subordinate market efficiency to ethical principles – principles rooted in the recognition that the farmers who tend the soil and trees are not merely service providers to carbon markets but co-owners of the value their labour sustains.

Future research should investigate the legal frameworks required to formalise farmer carbon rights in Türkiye, evaluate participatory MRV models that integrate local ecological knowledge with satellite-based monitoring, and assess the economic potential of complementary value chains – including truffle cultivation – as mechanisms for strengthening farmer autonomy within carbon governance frameworks.

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Epistemic injustice and legitimacy in AI-enabled agricultural governance

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Abstract

Artificial intelligence (AI), connected machinery, farm-management platforms and data-sharing infrastructures are increasingly shaping agricultural decision-making. They do not only improve technical capacity; they reorganise who controls agricultural data, whose knowledge is treated as credible evidence and how authority is exercised across farms, platforms, markets and public administration. I argue that justice and legitimacy in digital agriculture cannot be assessed only through efficiency, innovation or narrow AI-safety concerns. They require attention to the epistemic conditions under which farmers are recognised, or not recognised, as knowers within data-driven governance.

I build on literature on digital agriculture, data justice, platform power, epistemic injustice and democratic legitimacy to develop a normative framework for AI and data governance in agriculture. The framework integrates distributive justice, procedural justice and input-throughput-output legitimacy, but it treats epistemic injustice as the central analytical mechanism linking them. Farmers may be positioned as data sources while their situated expertise is discounted in contractual data arrangements, algorithmic compliance systems and participatory forums. This produces both testimonial injustice, when farmer knowledge is treated as less credible than standardised data outputs, and hermeneutical injustice, when governance categories and indicators fail to make local experience intelligible.

Using recent European Union developments, including agricultural data-space initiatives, the Data Governance Act, the Data Act and AI regulation, I show how data control, algorithmic authority and formal participation become legitimacy problems when affected actors lack usable access, contestability and institutional standing. I extend existing arguments about platformisation and data justice by shifting the analytical focus from data access alone to the epistemic status of farmer knowledge within governance. Responsible governance therefore requires enforceable data-access and portability rights, anti-lock-in and interoperability measures, auditable and contestable algorithmic systems and participatory institutions that treat farmers as knowledge-holders rather than merely data providers.

Keywords: data politics, farmer autonomy, platformisation, contestability, participation

Introduction

Digital agriculture has moved from farm-level optimisation towards broader forms of data-driven governance. Artificial intelligence (AI), precision tools, connected machinery, platform services, satellite monitoring and farm-management systems increasingly mediate decisions about production, compliance, risk, sustainability and market coordination. Precision tools, connected machinery, platform services, satellite monitoring and farm-management systems increasingly mediate decisions about production, compliance, risk, sustainability and market coordination. The transformation is therefore not merely technical. It changes the institutional conditions under which agricultural knowledge is produced, validated and acted upon.

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I argue that the governance of AI and agricultural data should be evaluated through a justice-and-legitimacy framework in which epistemic injustice is the central analytical mechanism. Existing literature has shown that digital agriculture can intensify platform power, data enclosure and uneven relations between farmers, agribusinesses and public authorities (Bronson and Knezevic, 2016; Carolan, 2020; Klerkx et al., 2019). I build on this work, and on data justice scholarship (Taylor, 2017), by asking not only who controls data or receives benefits, but whose knowledge counts when data-driven systems define agricultural problems, classify performance and justify decisions.

The paper addresses the following research question: how should justice and legitimacy be understood in the governance of AI and data use in agriculture when farmers are increasingly governed through digital infrastructures? I answer by developing a normative framework and applying it to three governance problems: data control, algorithmic authority and participation. The contribution is conceptual and normative. I extend existing debates by showing that epistemic injustice is not an additional ethical concern beside distribution and procedure; it is the mechanism through which distributive inequalities, procedural exclusions and legitimacy deficits are reproduced.

Justice, legitimacy and epistemic injustice

Distributive justice asks who benefits from digitalisation and who bears its costs. In digital agriculture, this includes access to farm-generated data, control over secondary data uses, exposure to surveillance and the capacity to switch providers or challenge platform dependency. A Rawlsian concern with the distribution of rights, opportunities and institutional advantages is therefore relevant, but insufficient on its own (Rawls, 2009). What is distributed is not only economic value. It is also practical agency: the ability to understand, interpret and contest decisions made through data.

Procedural justice concerns voice, accountability, reason-giving and fair participation in decision-making. Democratic theories of inclusion show that formal access can coexist with exclusion when participation is structured in ways that leave affected groups unable to shape rules or challenge dominant standards (Fraser, 2010; Young, 2000). In digital agriculture, this matters when data-sharing terms are set through standard-form contracts, when algorithmic monitoring systems define compliance categories and when consultation is framed as participation without real influence.

I depart from approaches that treat epistemic justice as a secondary matter of communication or inclusion. Following Fricker (2007), epistemic injustice concerns wrongs done to people in their capacity as knowers. Testimonial injustice occurs when a speaker receives a credibility deficit; hermeneutical injustice occurs when collective interpretive resources are structured so that some experiences are difficult to make intelligible. In AI-enabled agricultural governance, these wrongs become institutional when algorithmic outputs, platform indicators or administrative categories are treated as authoritative while farmers‘ contextual knowledge is downgraded as anecdotal, self-interested or merely supplementary.

Legitimacy links these justice concerns to institutional assessment. I use Schmidt‘s distinction between input, throughput and output legitimacy (Schmidt, 2013). Input legitimacy concerns participation and representation; throughput legitimacy concerns the quality, transparency, accountability and openness of governance processes; output legitimacy concerns effectiveness and public value. Epistemic justice cuts across all three. Participation is hollow if farmers are not treated as credible knowers. Governance processes are distorted if evidence is filtered through credibility hierarchies. Effectiveness is fragile if systems ignore the situated knowledge needed to diagnose failure and revise rules.

Governance challenges

The first challenge is data control. European policy increasingly seeks to expand data sharing while improving trust and control for data-generating actors. The Common European Agricultural Data Space aims to support secure and trusted data access and reuse in agriculture (European Commission, 2024). The EU Code of Conduct on Agricultural Data Sharing by Contractual Agreement places farmers at the centre of agricultural data governance, but its voluntary status limits its capacity to address unequal bargaining power (European Commission, 2018; Ryan et al., 2024). The Data Act introduces binding rules on fair access to and use of data, including data generated by connected products (European Union, 2023). Yet agriculture remains marked by sector-specific dependencies on machinery firms, software providers, insurers, input suppliers and buyers. Data control is therefore not simply a question of ownership; it is a condition of intelligibility and contestability.

The second challenge is algorithmic authority. Algorithmic systems increasingly support farm-management advice, sustainability metrics, credit and insurance assessments and public compliance monitoring. In the Common Agricultural Policy, remote sensing, satellite imagery and algorithmic classification are used to assess compliance, creating what van der Velden et al. (2025) describe as governance by satellite. Such systems may improve administrative capacity, but they can also privilege what is measurable and machine-readable. The governance problem is not only opacity or error. It is the institutional elevation of algorithmic outputs as default evidence, especially where farmers lack accessible reasons, review procedures or recognised avenues for contextual counter-evidence.

The third challenge is participation. EU data-governance initiatives emphasise multi-stakeholder involvement, trust and intermediaries (European Commission, 2022, 2024a). I align with the view that participation is essential, but I extend it by insisting that participation must include epistemic recognition. Farmers are not only affected stakeholders or data suppliers. They hold situated knowledge about local conditions, uncertainty, seasonal variation, practical constraints and the unintended effects of digital classification. If this knowledge is treated only as feedback after standards have been set, participation remains procedural rather than substantive.

Implications for responsible governance

The framework supports four implications. First, distributive justice requires enforceable data-access and portability rights, implemented in agriculturally usable formats. Farmers need practical access not only to raw data, but also to the interpretive materials required to understand how data are generated, combined and used. Anti-lock-in measures, interoperability rules and limits on unfair contractual terms are therefore justice requirements, not merely market-efficiency tools.

Second, throughput legitimacy requires accountable and governable data arrangements. Voluntary codes can support trust, but they cannot by themselves correct structural asymmetries where farmers depend on proprietary infrastructures and standard-form contracts. Governance should allocate responsibilities clearly across providers, deployers, intermediaries and public authorities, and should include accessible complaint and dispute-resolution pathways.

Third, contestability should be treated as an epistemic safeguard. Where algorithmic systems shape subsidy eligibility, compliance assessments, sustainability metrics or market access, affected farmers should receive reasons that are intelligible in context, be able to challenge classifications and have counter-evidence taken seriously. Transparency alone is inadequate if disclosures are unusable or if institutional procedures continue to treat farmer testimony as less credible than automated outputs.

Fourth, input legitimacy requires participation with capacity. Farmer organisations, cooperatives and smaller actors need resources and institutional standing to shape standards, indicators, interoperability requirements and oversight procedures. This moves participation beyond consultation and makes epistemic inclusion part of the governance architecture.

Conclusion

AI and data use in agriculture should be governed as socio-political infrastructure. They allocate control over data, structure credibility and organise decision power through platforms, contracts and algorithmic monitoring. European regulatory developments provide important starting points, but they do not automatically secure justice or legitimacy in agriculture-specific settings.

I have argued that epistemic injustice is the central mechanism through which digital agricultural governance can become unjust and illegitimate. When farmers are treated as data providers but not as credible knowledge-holders, distributive and procedural safeguards remain incomplete. Responsible governance must therefore combine enforceable data rights, anti-lock-in protections, auditable and contestable algorithmic systems and participatory institutions that recognise farmer expertise as evidence. This shift strengthens the normative basis for governing AI and data in agriculture: legitimacy depends not only on better outputs, but on whose knowledge is allowed to count in producing them.

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Section 3.
Livestock, blue foods and aquaculture in the digital age

An ethical taxonomy of genome edited animals

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Abstract

Genome editing in animals is advancing rapidly, yet its regulatory and ethical status remains unsettled. Current debates oscillate between treating genome edited animals as genetically modified organisms subject to stringent regulation, or as products of advanced breeding that should fall under existing frameworks. In this article, we examine the view that GE should be ethically evaluated in the same way as traditional breeding and argue that the arguments do not hold up. Although genome editing is a more precise and efficient technology offering better control over results, this does not mean that there are no moral stakes beyond welfare. The emergence of this powerful new technology requires a rethink of our moral obligations in creating new animal breeds. To address these responsibilities, we develop a sketch for an ethical taxonomy of applications of genome editing based on Van Eenennaam's (2023) classification of altered trait categories in New Genomic Techniques. This taxonomy provides a framework for casebycase ethical assessment and supports more responsible research trajectories for GE in animal husbandry.

Keywords: CRISPR, New Genomic Techniques, animal welfare, animal integrity

Introduction

Scientific advances in genome editing (GE) of animals are progressing rapidly, but the ethical debate lags behind and the regulation of the applications differ widely across the world and remains unsettled in many jurisdictions. Much of the recent technological momentum stems from advances in CRISPR-Cas-system, the dominating kind of New Genomic Techniques (NGTs), as GE and similar technologies are called in the EU. Many hold that since this is an emerging technology, often described as disruptive, it should be treated according to established GMO regulations (Ahmad et al, 2023; Kurenbach et al, 2021; Gelinsky and Hilbeck 2018), whereas others argue that production animals altered by this technology should be treated according to standards accepted for established breeding methods (Van Eenennaam, 2025). Hence, we ask two questions: Should GE of animals be subjected to additional ethical treatment beyond that of breeding? If yes, what is at morally stake in different applications of this technology in animal husbandry?

Between GM and breeding

GE enables more targeted, precise and efficient changes in animal genotypes and phenotypes than both traditional breeding and standard genetic modification (GM). Although GE can involve crossing species barriers, targeted changes within the species are often described as one of its major advantages. Because this distinguishes GE from GM, ethically, socially and in some regulatory systems, this paper will only discuss GE applications within the species. To see how the GE discussion differs from the GM controversies, we will take a quick look at the normative GM debates.

Public and scholarly debates on traditional GM have largely centered on three themes: risks to human health and the environment, questions of naturalness, and the implications of patenting. Traditional breeding, by contrast, has seldom been scrutinized on these grounds, although concrete applications

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have occasionally been criticized for moral reasons, as we will see below. In discussions about the moral acceptability of GM, breeding has functioned as a comparative benchmark: either justifying special concerns regarding applications of gene technologies in general or justifying that the technology as such is unproblematic. This has been the case in GM risk assessments. Here, two opposing positions dominate: one argues for evaluating GM organisms according to the principle of substantial equivalence with established varieties, while the other supports precautionary approaches due to alleged scientific uncertainty or ignorance, respectively (Levidow *et al.*, 2007). Similarly, appeals to naturalness have regularly been invoked to argue both that GM is merely "breeding with better tools" and therefore natural (Borlaug, 2000), or to argue that GM is problematic because it represents yet another step in the human interference in evolutionary processes, instrumentalizing living nature (Verhoog, 2003). The patent debate follows the same pattern: patents are either framed as evidence that GM differs fundamentally from breeding, or seen as an extension of existing intellectual property rights over plants and animal varieties. To simplify our discussion, we bracket the patent issue in the following.

The GM dispute is not settled and has real-world political and economic consequences in form of technology-specific regulation, demanding risk assessment procedures and public skepticism. The emergence of GE seems to provide a way out of this quagmire. GE promises to deliver greater precision, speed and efficiency in improving agricultural products without going beyond the well-established practices and accompanying regulations of traditional breeding. Because GE is widely regarded as more targeted and controlled than conventional breeding, and because it does not involve crossing species barriers (however defined), it is often assumed that GE products should be evaluated on the same ethical terms as those issuing from selective breeding. From this perspective, one might conclude that GE raises no ethical issues beyond those that are raised in the general animal ethics literature. This conclusion, we argue, does not capture the ethical challenge adequately.

GE as breeding

Equating genome editing with breeding is based on the assumption is that since GE does not involve integration of species-foreign genetic material, it should be treated similarly with traditional breeding. This claim is not convincing without further argument. GE and breeding differ in several ways, and while some of them suggest that GE may be more acceptable than breeding, others point in the opposite direction.

Arguments in support of the view that GE is *more* acceptable begin from the observation that both GE and breeding involve deliberate human intervention in animal reproduction to change traits in a way mainly beneficial for humans. If the only difference between them is technical, and these interventions are already considered morally acceptable in breeding, then there seems to be no reason to reject using GE. In addition, GE is generally understood to be more precise and controllable than breeding: it allows targeted, predictable genomic changes, whereas breeding alters many phenotypic traits at the same time, often beyond the intended changes. On this basis, it is reasonable to conclude that GE is safer and should not be subjected to stricter scrutiny than breeding. Other considerations also support this position. In plant breeding, mutagenesis – creating mutations in the genome by exposure to chemicals or radiation – is considered a well-established method with a history of safe use. Since GE is doing the same thing in a more targeted way, this provides further support for the similar treatment conclusion. Indeed, it may even suggest that GE should be subjected to *less* scrutiny.

There are, however, two technology-based considerations that point in the opposite direction, namely that GE may be less acceptable than traditional breeding. First, GE is more efficient and the path from intervention to commercial products is much shorter. This increases the theoretical risk that there

are some negative or unintended consequences that will not be discovered in the development phase. Second, GE as technology lacks a history of safe use comparable to that of traditional breeding. Even if there is, arguably, a history of safe use with mutagenesis in plants we cannot determine that this is valid for GE animals, given the technical differences in the intervention. Although the matter may be discussed, this paper will accept the assumption that there are no specific technological reasons for distinguishing between breeding and GE in ethical and regulatory assessments.

The case for ethical assessments

One may think that since traditional breeding is already socially and politically accepted, and we assume no principled distinctions between breeding and GE, there is no reason for extra ethical scrutiny of this new technology. What we need is a case-by-case assessment of the altered characteristics. However, even if something is socially and politically accepted, it does not follow that it should be morally accepted. There are numerous cases of traditional breeding affecting companion and production animals negatively, showing that ethical discussions in these cases have come too late and have had insufficient impact. The emergence of a new and arguably more precise technology making possible early interventions in the R&D trajectory and better control over the results, implies a duty to rethink the moral obligations in creating new animal breeds. The argument is not that this technology is more powerful and hence, riskier, but that this technology gives us better control and therefore enables the prevention of future cases of integrity loss and animal suffering due to deliberate changes to their phenotypic traits.

This argument is supported by the moral principle "ought implies can" (Kant, 1998: A548/B576). When there is better control over the breeding process, it is also possible to demand more precise assessments of the process and results. In traditional breeding, this has not been achievable and cannot be demanded. Since there is agreement that GE is more precise and controllable than breeding, it follows that it is possible to exert better control of it – and therefore we have a duty to exercise such control. This is not an argument against the principle that assessments should be technology-neutral, but a recognition that the characteristics of specific technologies determine the frames for assessments. The locus of assessment will be the particular variety, and hence we adhere to a case-by-case evaluation, but the technology employed enables different kinds of assessments at different stages in the respective processes.

NGT categories

As a first step towards fulfilling this moral obligation, we will develop the outline for an ethical taxonomy, based on a review of research on genome editing in animals. "Taxonomy" is a concept drawn from biology where it refers to the classification of species. Hare (1997) developed an ethical taxonomy, which was a classification of ethical theories. What we do here is something different, namely, to use an existing classification of different types of genome-editing of animals and discuss what is morally at stake in each of them. In some of these cases, the same intervention could have been achieved by traditional breeding, and in these cases, we assume that the same ethical issues would have applied.

The structure will be based on Van Eenennaam's (2023) classification of altered trait categories of what she, in accordance with EU standards, calls NGTs as her work was done on behalf of the European Food Safety Authority (EFSA). The categories she identifies is based in av review of 195 publications, most of them using CRISPR. Although the number of published interventions would be significantly higher today, it is unlikely that it would involve other kinds of trait categories, which means that this is a sufficient basis for an ethical categorization. Her review excludes all biomedical applications, but includes animals that are not strictly speaking production animals, such as ornamental fish (Van Eenennaam 2023).

The study identifies the following categories, indicating the frequency of these traits: "meat and fibre yield (31%), reproduction (22%), biotic stress (16%), production of hypoallergenic products (8%), multiple traits (7%), colour (6%), product quality (5%), abiotic stress (2%), and other (5%)" (Van Eenennaam 2023: 5).

Ethical taxonomy

For each of these categories one may give an analysis of what is at stake ethically in terms of animal welfare, animal integrity, human-animal relationships and environmental impact. These four themes are derived from the usual topics of animal ethics as conceived in consequentialist, deontological and virtue ethical thinking, with the addition of environmental concerns. The latter is based on the significant environmental impact of animal husbandry. This will provide a tool for specific ethical assessments in each case, enabling early interventions in the research trajectories to ensure an ethically justifiable use of the technology on animals. Due to restricted space, we will only give examples from the first two categories of issues that are relevant in a case-by-case analysis based on this structure.

Meat and fibre yield

Enhanced growth has been a common goal in traditional breeding, and it is predictable that this will be important also in GE applications. The two commercially approved Japanese GE fish varieties have this trait. All four ethical concerns are relevant. First, we know from traditional breeding that increased meat yield is closely correlated with reduced welfare. One example is chicken, where the highly efficient contemporary "broiler" varieties have a number of serious welfare issues directly caused by the increased growth speed and meat yield (Bessei, 2006). Second, increased meat yield will, in some cases, affect negatively the animals' integrity, understood as the ability to exercise species-typical behaviour. This is exemplified in animals bred for highly industrialized food production, such as broilers and salmon. Third, as this trait is linked to industrialized food production, optimizing animals for such food production systems may affect the relationship between humans and animals negatively, at least according to a virtue ethical approach. It is decisive that this intervention is merely motivated by human interests and will not improve the conditions for the animals in any conceivable way. Fourth, faster growth and increased slaughter weight increases efficiency in production and optimizes resource use, and the environmental impact will be positive.

Reproduction

This is a wide category with different kinds of alterations, so we focus on the ethically most challenging area, namely the production of single-sex offspring, where egg producing hens and dairy cows are typical examples (Van Eenennaam 2023). Welfare issues may be relevant here. The killing of newly born animals, an institutionalized practice for egg-laying chicken (Coppola *et al*. 2024), is supposed to be painless, but this may be contested. If so, avoiding the production of male offspring and guaranteeing no suffering, is a preferrable solution from a welfare perspective. A similar case is male dairy calves, which are surplus animals and may suffer welfare deprivation or early killing (Schultze *et al*. 2023). The reason for these problems in the first place is the efficiency demands in modern farming, and one can argue that the moral issue lies there and not in the culling practices, Discussing the ethics of GE in this wider context will demand a different perspective from the one we take in this article. Creating single-sex offspring does not affect the integrity issue in itself. Again, this seems to belong to the discussion of modern farming systems, and the alternatives, such as large-scale systematic culling of male chicks is morally worse from an integrity perspective. In the GE solution, there will be no animal whose integrity may be affected by the technology. As in the case above, GE use will affect human-animal relations from a virtue ethical perspective. A reasonable perspective will be that the current practices and a GE-created single-sex variety

of egg-laying chicks or dairy cattle are both expressive of a distorted relationship between humans and animals, meaning that this solution is part of a deflection from the real moral issues (Diamond 2003). From an environmental perspective, this technology would be better than the current practices as the production of "waste", unwanted animals, would be reduced.

Conclusion

Many countries choose to exempt genome editing from biotechnology regulation, arguing that this biotechnological approach is in practice an improved variety of existing breeding and should be treated similarly. Accepting that, we argue there are normative reasons for an ethical assessment of GE animals since traditional breeding has resulted in many well-known cases of morally problematic products, and the improved control over the production process provided by the GE technology gives a strong moral imperative for using the tool in a morally acceptable way. This must be done according to a case-by-case approach, and we have suggested that this should be structured as an ethical taxonomy according to the kind of trait and four ethical categories particularly relevant for animal husbandry.

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GPS tracking technology for companion animals: risks and challenges for human-animal relationships

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Abstract

Smart trackers, most commonly 'smart' GPS-collars with app-based dashboards for companion animals, continuously map their location, activity, territory, sleep and much more. Tracking devices are typically framed as tools for responsible caretaking, but this framing is not neutral. We offer an explorative inventory of potential risks and impacts on human-animal relationships. We argue that companion animal surveillance is more than a technologically boosted way of caring. We see it as a socio-technical practice that reconfigures human-companion animal relationships. We do so by examining the framing of tracking as responsible care and its potential role in the normalisation of surveillance and behavioural control, the datafication of animal life and the possible consequences of leaving these practices to commercialisation without ethical scrutiny. Companion animal tracking falls between regulatory regimes: neither wildlife protection ethics nor consumer privacy adequately covers it. By presenting what is at stake in using smart trackers, we propose to put this topic on the agenda of animal ethics.

Keywords: datafication, technological mediation, biopolitics, animal ethics, wearables

Introduction

Until recently, whenever cats would leave the house, they would embark on journeys we humans had no way of knowing about. Carers only got hints of cats' mysterious outdoor adventures in the shape of the occasional dead mouse or particularly muddy paws. Today, however, you can 'check in on the secret lives of your pets' with smart trackers (Enabot 2026). Smart trackers, most commonly "smart" GPS-collars with app-based dashboards for companion animals such as dogs or cats, continuously map their location, activity, territory, sleep and much more. Carers can now 'watch' their beloved companion animals in real time when they are out of sight as well as be assisted in their responsibilities in the care of their animal: where should and shouldn't my animal go? What is a healthy amount of sleep and movement? Is their heart rate normal? How can I find my animal if he or she escapes or is lost? Almost acting as a personal coach, these smart trackers are more than happy to assist you in every decision and interaction with your animal. Tracking your animal, marketing of these devices tells us, is a demonstration of care and love.

Tracking devices are typically framed as tools for responsible caretaking: continuous traceability promises safety (Tractive 2026). Health monitoring allows for early detection of potential diseases (Tractive 2026). Additionally, they are marketed to give insight into things animals cannot tell humans themselves, allowing for a better understanding of their animal: 'discover their favourite spots' (Tractive 2026). This framing is not neutral. Built into framing is the suggestion that non-tracked relationships are somehow deficient: that there will always be something missing, whether in safety or in intimacy, that technology could 'solve'. With the surge of smart monitoring wearables in human and nonhuman lives, from smart watches to wolf trackers, the (ethical) question is no longer merely whether these devices work, but how they impact the relationships and (non)human life worlds they enter. Companion animal tracking escapes both the regulation wildlife tracking is subjected to, as well as the ethical scrutiny (consumer) surveillance of humans receives.

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Increasingly, such devices are equipped with intervention options such as virtual fences or (anti)-barking mechanisms (such as collars that vibrate or give sound signals when barking is detected). The availability of these control features is normatively meaningful: does the availability of a feature mean that it is recommended, responsible or expected to use it? This is a concerning development, especially with the gamified experience such devices offer: ranking your companion animal, earning badges, reaching goals, 'scoring' wellness and activity, adding 'friends' and encouraging intervention options. Are these devices framing companion animals as game characters? And how concerning is the lack of ethical scrutiny over commercial tracking devices? In what ways does it change the way we see and interact with our companion animals? And how does it change their perception of the world?

In this paper, we offer a first explorative inventory of potential risks and impacts on human-animal relationships. We argue that companion animal surveillance is more than a technologically boosted way of caring. Instead, we see it as a socio-technical practice that reconfigures human-companion animal relationships. This technology and associated practice introduce normative forms of surveillance, datafication, technological mediation and (biopolitical) control to human-companion animal relationships in ways that carry the potential to fundamentally change the ways we care for and live together with companion animals.

We bring together insights from surveillance studies, wildlife ethics, science and technology studies and philosophy of technology to explore what ethical issues arise from this particular tracking practice. We do so by examining the framing of tracking as responsible care and its potential role in the normalisation of surveillance and behavioural control, the datafication of animal life and the possible consequences of leaving these practices to commercialisation without ethical scrutiny. We reference wildlife tracking because this practice offers the most developed (ethical) thought on animal tracking due to its long-established application practices in wildlife research, such as with GPS collars, camera traps or drones.

Responsible caring

The marketing of 'smart' GPS-collars typically frames 'care' in a way that creates normative pressure. Marketing frames tracking as an act of love and responsible caretaking, but this framing isn't neutral. It shapes what counts as good care. For instance: 'Safety that never sleeps', 'Always know where your dog is', 'Health Alerts: Be alerted if there are changes in your dog's health patterns that you should be aware of', 'Set up Virtual Fences to keep them safe' (Halo Collar 2026, Tractive 2026). Non-technologically enhanced relationships almost become backwards: why should you and your companion animal have to settle for anything less? This creates a potential normative shift: will not using a tracker eventually look like negligence, the way not microchipping already does? Chipping companion animals became the norm in returning lost animals; will smart tracking eventually become the new standard? Because the framing is one of care and love, opting out becomes morally suspicious, even though animals cannot consent to being tracked in the first place. The benign appearance of these devices is precisely what allows them to escape scrutiny.

In addition to the norm changing potential of such devices, the technology also reconfigures what intimacy with a companion animal means. Marketing narratives promise insights into the parts of their life animals cannot tell: 'Know every detail of your cat's day,' 'Discover the places they love most,' 'Check in on the secret lives of your pets!' (Enabot 2026, Tractive 2026). The knowledge provided by tracking technology becomes instrumental to individual relationships. The way to understand and know your companion animal even better is by using this technology. Promising to reveal the 'secret lives of your pets' assumes a deficit in non-technological relationships: there will always be missing information. The same logic applies to health monitoring: non-technologically enhanced attentiveness is assumed to fall short. Rather than scientifically instrumental tracking, as in wildlife research where the focus is on

gathering data for knowledge or preservation, there is an intimacy-instrumental tracking: that repositions technology as the most effective way to knowing and caring for one's animal.

Normalising surveillance and behavioural control

Tracking technology for companion animals is designed for continuous wear and use. Promotional texts even emphasize the importance of continuous use as it ensures that analyses and predictions are correct (Tractive 2026). This form of dataveillance, a continuous and systematic gathering of information about individuals for intervention or managing them (Clarke 1988, 499) is under increasing scrutiny when humans are subjected to it, but in the context of animals it remains underexplored.

In addition to continuous observation, smart GPS-collars for companion animals actively promote intervention options by means of safety measures. The most prominent is the virtual fence function, which allows carers to set up virtual boundaries that dictate where animals 'shouldn't go' (Tractive). Available intervention options range from 'escape alerts' to 'sound, vibration or static feedback' to keep animals from leaving a 'safe zone' (Halo Collar 2026. Remote audio features allow carers to 'talk' to their animals at a distance. There are training options using vibrations and/or sounds to dis- or encourage behaviours (Weenect 2026, Enabot 2026). The technology does not only permit observation. The technology invites and normalises (behavioural) intervention. Features such as virtual fence, training options or (anti)bark detection reconfigures this close connection in human-companion animal relationships to behavioural control management: what behaviour is desirable? What behaviour needs adjusting? How far should my animal go? Moreover, the availability of these behaviour training options normalises its use. However, it raises the question whether technologically guided training is preferable over non-technological training, and how the two (should) coexist.

Wildlife tracking is the closest comparable case. The application of tracking technology in wildlife research assumes a certain distance in the researcher-animal relationship. The goal is to avoid disruption of 'natural behaviour' and smart tracking technologies allow researchers to observe animals from a distance. This protects the animals and their life worlds from damaging intervention or disruption. In companion animal tracking, there is no assumed distance in the application of this technology. On the contrary: the premise of this relationship is based on fostering mutual connection. This raises the ethical question of what kind of relationship is being enacted: one of mutual connection, or one of continuous observation and optimized management? There is a structural power asymmetry in the practice of companion animal tracking. A carer who uses a tracking device subjects their animal to surveillance. There are limited options for opting out. Losing a collar outside allows for temporary untraceability, but animals cannot consent or interpret their own data and have very limited means of resistance.

The tracker dashboard: a partial and normative portrait

Smart trackers translate animals into quantitative data points. Trackers translate a selection of aspects of an animal's life that are quantifiable (sleep, activity, physiological indicators) into metrics. This process involves the following ethical concerns:

Only measurable information is included in the smart monitoring. What aspects of animal life gets tracked (distance, activity minutes, sleeping, heartrate, barking, etc.) and translated into 'wellness reports' and 'health reports' imply what information is relevant to gain insight into an animal's life. There are potentially relevant aspects that are left out because they resist concrete measurements: inter- or intraspecies interactions, playing activities, hunting activities. Moreover, the animal experience consists of many unmeasurable aspects that such devices cannot capture: is an animal more or less interactive with their carer? What is the condition of their fur? What do they smell as they navigate the world? The

digital representation of animals trackers produce are partial and biased towards quantifiable features, yet marketing texts typically fail to mention this, giving the impression that the apps information creates a comprehensive picture of an animal's life.

'Smart' trackers use AI to interpret data and produce (health) reports, comparisons and predictions. It is not possible for carers to get meaningful insight into how and based on what information these are produced: this is known as the 'black box problem'. Yet, the generated information holds normative assumptions concerning health and behaviour. Datasets might be inadequate with regards to specific breeds, a-typical behaviours, individual variation or different personalities, potentially resulting in biased outcomes. Attributing epistemic authority to such devices may be problematic as it is unclear how reliable output is.

Carers could become overly dependent on the generated wellness and health statistics in the app, risking skill erosion and objectification of animals, or 'quantifying' an animal, as previously argued in the precision livestock farming-context (Bos et al. 2018). Overvaluing data-based information over embodied, experiential information might lead to carers becoming less adept at interpreting how their animal is doing based on interaction: how does their fur feel? What is the look in their eyes? How do they respond to touch? Are they less interested in attention? The shift to objectification may work against marketing promises that give the impression that the technology gives insight into animals' condition that relational, embodied attentiveness cannot.

The commerical logic of tracking: animalus economicus

The use of tracking technology in wildlife research is embedded in a research context, subject to institutional regulations of the field. There are protocols and ethical approvals that ensure its use is safe enough and that proposed results justify potential harm (Kays et al. 2015). There are peer reviews and peer control; ethically approved data management plans usually protect generated data. Tracking devices for companion animals are, instead, commercialised and there are no shared ethical standards for this type of tracking yet. This is a significant difference that has practical consequences that run through all the dimensions of the practice.

The combination of commercial incentive and quantification leads to a risk of overcommercialization and becoming a pawn to market forces: a smart collar can only do half the job. Smart feed trays that connect to the app could potentially provide an appropriate personalized amount of preselected and specially produced food based on sleep and activity data. Smart cat flaps can enforce a curfew. If the app detects a potential health problem, why not automatically recommend medication? If carers adopt this technologically enhanced care practice, to what extent do external forces become responsible for the wellbeing of your companion animal? The question of which functionalities are desirable or ethical is currently being answered by the market and there is no ethical structure in place to question or guide that.

The development and use of smart trackers against a commercial backdrop creates further ethical concerns: who ensures that data remains safe? In addition to the vast amount of data trackers generate through use, devices ask of users to provide personal data: name, picture, date of birth, breed, carer name, address, etc. All information that is valuable to (other) (commercial) parties.

Design of such apps typically encourages full integration of the smart technology into human-companion relationships: there is a feature for every (inter)action. Users are led to believe their 'set up' is not complete if features are left unused: 'complete your profile and set up a virtual fence' (Tractive 2026). This emphasis on feature use, app interaction and comparative accomplishments may alter how carers view their animal. There is much to do in tracking apps: there are activity goals to set, badges to earn,

wellness and activity reports to read, comparative analyses to ponder ('Your cat sleeps 80% more than the average of his breed'), rankings to keep an eye on, achievements to share via social media, and more. Well-aimed confetti popper animations assist in properly celebrating new badges, cashing in on the dopamine hit such features provide for the human users. This gamification risks turning the companion animal into a proxy for scoring points, reframing good care as maximum app engagement. Can you 'win' at performing animal care, and does 'winning' mean full points, streaks and maximum use of the app features? And who exactly 'wins' here, the carer or the companion animal?

Changing relationships

Companion animal tracking technology may change the way we conceive of (good) animal care and responsibility, and the way humans perceive their animals. This technology does not just mediate existing relationships, but it reconfigures them. It changing how carers perceive, understand and interact with their companion animals. Knowing your animal increasingly means reading a dashboard in addition to, or rather than attentive cohabitation and embodied familiarity. This shift in the epistemic basis of the relationship moves from intersubjective, experiential knowledge to data-driven representation.

The animal's perspective is underexplored here too. What does continuous device-wearing, virtual fencing, and remote intervention do to the animal's experience of the world, and of his or her carer? Continuous surveillance and remote intervention potentially undermine an animal's autonomy and privacy, and it could compromise animals' capacity to navigate the world on their own terms. Unlike child monitoring devices, popular as well as controversial, for whom parental monitoring follows a developmental logic toward autonomy. Companion animals are usually adults and therefore the logic of continuous control has no natural endpoint. Additionally, there are currently no protocols for habituating animals to these devices, and no guidance on signals of discomfort or on when not to use the technology.

Conclusion

The discussion presented in this paper is a first explorative inventory of potential risks and impacts on human-animal relationships. Bringing together perspectives from surveillance studies, wildlife ethics, science and technology studies and philosophy of technology allows us to understand how this technology and practice aligns with and differs from similar dataveillance practices. In doing this, we show how companion animal care produces ethical questions that established thought from these fields cannot adequately address. Companion animal tracking falls between regulatory regimes: neither wildlife protection ethics nor consumer privacy adequately covers it.

It is important to emphasize that companion animal tracking is not unethical per se, but that currently it is ethically under-theorised. Technology increasingly mediates human-animal relationships. Companion animals and their carers live through the practical, real-life implications of the increasingly fast advances in smart technology and its embedding in the (more than) human world. This topic requires attention to attempt to reduce the growing gap between the development of smart tracking and the ethical attention paid to it. Without sufficient attention to it, there is a risk of normalising and legitimising harmful practices. By presenting what is at stake in using smart trackers, we propose to put this topic on the agenda of animal ethics. In our future research, we will further investigate the issues presented above. We aim to contribute to the development of an ethical framework that adequately addresses this topic. In addition to a theoretical ethical literature review, we aim to study this topic by empirical-philosophical research, as well as bringing in a cultural studies perspective, which allows us to examine how the practice is embedded in and shaped by broader socio-cultural narratives and norms around care, control and human-animal relationships.

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Smart assistants – the role of AI in veterinary practice

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Abstract

The use of Artificial Intelligence (AI) in small animal veterinary practice involves technical considerations, but also raises ethical questions among veterinary professionals. What should we do with these technologies? What should these technologies do for us, our clients and our patients? How do we want the veterinary profession and healthcare to be in the future? To address these and other questions, and to come up with initial ideas for possible courses of action, we organised a workshop for stakeholders involved in the small animal veterinary sector. Participants discussed a theme in small groups in the form of SWOT dialogues, based on potential strengths, weaknesses, opportunities, and threats. This was followed by a general reflection on the aspects covered. The thematic groups that participants could opt for were: 1) veterinary diagnosis in times of AI, 2) future perspectives for veterinary education, 3) virtual veterinary nurses for managing client relationships, and 4) teamwork with AI as member in veterinary teams. Across all themes the conversations sparked a number of fundamental questions. These included questions of what constitutes the essence of being a veterinarian, but also to which extent animals have privacy and who has the right to decide which of their data are shared or monitored. Participants saw the benefits of veterinary AI primarily in a reduction of workload, emphasised the importance of human contact and communication, and expressed concerns about dependency and lack of control of AI systems and their developers. With this participatory approach we facilitate reflection on ethical challenges of veterinary AI within the profession.

Keywords: artificial intelligence, nonhuman animal, professional identity, veterinarian

Introduction

Artificial intelligence (AI) is becoming increasingly prevalent in small animal veterinary practice. Some algorithms developed for specific tasks in diagnostic imaging already surpass the assessment of trained veterinarians (Boissady et al., 2020; Scharre et al., 2025). Healthcare apps offer caregivers the opportunity to assess pain in their companion animal at home (Steagall et al., 2023). In addition, virtual veterinary nurses promise an optimal organisation of processes in the practice and a better management of client relationships (VetIntelligence, n.d.).

It is obvious that the development of veterinary AI will bring about major changes for the veterinary profession. Veterinarians not only need to be able to operate these AI-based tools from a technical perspective, they also need to embed them into the context of building relationships with caregivers and animal patients (Giersberg & Meijboom, 2025). This also requires a (re-)negotiation of professional identities and a (re-)construction of professional values to figure out which type of veterinarian one aims to be (Armitage-Chan, 2020). Coghlan & Quinn (2024) analysed ethical challenges veterinary AI may pose for companion animals. However, little is known about potential chances and risks of these technologies for the veterinary profession. How do veterinarians experience these developments? Do they welcome them, actively promote them, or are they mainly concerned about risks of AI?

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In this paper, we present the results of a workshop on different areas of application for AI in small animal veterinary practice. With this activity, we pursued the following two objectives: (a) to get an impression of how stakeholders within the sector view the development and use of AI in veterinary practice and in the related domain of veterinary education, and (b) to offer these stakeholders a first opportunity to talk about the subject, share their ideas and connect with each other.

Dialogue on the veterinary practice of the future

The overarching subject of the workshop was 'the small animal veterinary practice of the future'. Given that a constructive dialogue on this requires relevant knowledge of and involvement in the small animal veterinary sector, we invited participants on a selective basis. The 21 participants who joined the workshop worked in small animal practices, in veterinary research and education, for a veterinary professional association, in an animal welfare organisation, and in the marketing and communication branch.

The workshop of one afternoon was opened by the chairpersons and three inspiring pitches by veterinarians from different professional fields. Participants then split into small groups for the dialogues on a specific theme during a 1,5hour session. The themes participants could opt for upon arrival at the workshop were: 1) veterinary diagnosis in times of AI, 2) future perspectives for veterinary education, 3) virtual veterinary nurses for managing client relationships, and 4) teamwork with AI as member in veterinary teams. Each group consisted of a maximum of six participants and a moderator who briefly introduced the theme, guided the group through the different phases and facilitated a constructive dialogue. In line with our objectives, we chose the format of a SWOT dialogue, in which participants talked about a respective theme based on potential strengths, weaknesses, opportunities, and threats. We provided the moderators with a set of questions they could ask the participants to encourage a more in-depth exploration of the theme. However, in a dialogue, it is important that the conversation flows naturally. Moderators could therefore deviate from the pre-defined questions or ask additional ones if that seemed more appropriate for the group.

In the following, the results of the dialogue groups are reported per theme. These are based on the notes of the moderators and the observations of the chairpersons during the activity.

Veterinary diagnosis in times of AI

In this group, participants from different backgrounds including veterinary medicine, ethics and communication, talked about the role of AI-based tools which can partly or completely take over what has traditionally been the veterinarian's expertise: providing a diagnosis.

Participants identified the provision of more and more detailed information as the key strength of AI-based diagnostic tools. This information can help veterinarians and caregivers to gain deeper insights into an animal's health, welfare and care. It can also benefit the animal directly. If a caregiver could diagnose their animal at home by using AI, unnecessary visits to the veterinarian that may be stressful for the animal could be avoided. In addition, it was mentioned that AI-based diagnostic tools can aid a more efficient management of the veterinary practice. In radiology, for instance, AI performs certain tasks more accurately and more economically than a veterinarian. AI-based diagnostic tools may also assist veterinarians with triage in emergency situations. When it came to weaknesses, the group distinguished between those inherent to the tool and those arising from its use. One participant pointed out that during the training of algorithms, emphasis may have been placed on practical feasibility rather than on data quality and validation. In addition, veterinarians may become reliant on AI-based tools and struggle when different tools come to different conclusions for the same case. A reliance on such tools

could also lead to a decline in contact and communication among colleagues, if veterinarians prefer to consult a tool for advice instead of an experienced colleague.

According to the group, AI-based diagnostic tools that can be used by caregivers at home offer the opportunity to improve and strengthen the relationship between veterinarian and caregiver, and to enhance the quality of medical care. Veterinarians gain access to more information about the animal patient compared to the usual snapshot taken during a consult, which may allow them to provide 'contextual care'. The development of diagnostic AI also gives the profession the opportunity to actively contribute, in collaboration with other stakeholders, to the validation, benchmarking and oversight of AI-based tools in this field. Finally, the emergence of new technologies is a chance for the profession to engage in a dialogue on fundamental questions: what is, or should be, the essence of our profession? Which tasks do we want to leave to AI, and which do we not? One potential threat identified by the participants was that AI-based diagnostic tools can cause veterinarians to become reliant on these technologies, which may undermine their own critical judgement. Participants pointed out that AI has the potential to spread misinformation, both among veterinarians and among caregivers. Another threat may be that the development of AI-based diagnostic tools could be driven by commercial interests as opposed to evidence-based medical knowledge. AI-based tools may also lead to caregivers continuing to consult AI until they receive the advice or confirmation they expect ('AI shopping'), rather than visiting the veterinarian in time.

The group agreed that the use of AI-based tools can have both positive and negative impacts. Better diagnostics, improved care through early detection and monitoring, and the likelihood of caregivers taking their animals to the veterinarian at the right time were summarized as positive impacts. Negative impacts were attributed to commercial AI-based diagnostic tools of questionable quality and reliability, which may suggest unwarranted authority. Participants were also concerned about the overall changes AI-based diagnostic tools bring about, and the high demands these changes place on veterinary education and the profession.

Future perspectives for veterinary education

This theme addressed what knowledge of, and skills related to veterinary AI students in veterinary programmes need to learn. How can this be integrated into the curriculum so that students are trained to become future-oriented veterinarians?

According to the participants of the dialogue session, a major strength of integrating education on veterinary AI into the curriculum is that students learn how to use these tools responsibly and to understand both the opportunities and limitations of veterinary AI. Teaching about veterinary AI can enable students to acquire the knowledge needed to master these tools. The group saw this as an advantage for students when applying for positions in veterinary practices. However, it was unclear whether and to what extent lecturers at veterinary faculties currently have expertise in veterinary AI. To teach this subject properly, one participant suggested that lecturers should obtain a certificate on digital competencies, similar to the Dutch Basic Teaching Qualification. In addition, education on veterinary AI cannot serve as a substitute for learning how to communicate and interact with caregivers and how to conduct an anamnesis during a consultation.

The group saw it as an opportunity that veterinary AI collects data on real-life cases and patients in practical settings. If these data are made available to students using the same tools, they may learn in a more practice-oriented way. Similarly, new data and insights from veterinary faculties could be shared with the profession. On the one hand, integrating AI into veterinary education in this way may facilitate

an earlier exchange between students and veterinarians. On the other hand, however, this was also seen as a threat if students do less in-person internships in veterinary practice.

The main conclusion of the group was that AI cannot replace the interaction with animal caregivers. Students need to learn communicative and interpersonal skills, as these were regarded as essential qualities for veterinarians. Education on veterinary AI must not result in students having fewer or later encounters with veterinarians and cases in practice. In order to apply veterinary AI effectively in education and to ensure the quality of teaching, it is also important to establish and monitor standards for the quality of models and (training-) data. If commercial AI tools are used in education, it is important to make clear agreements with external parties regarding intellectual property rights and data usage.

Virtual veterinary nurses for managing client relationships

This multidisciplinary group engaged in conversation about the use of virtual assistants that take on administrative tasks in veterinary practices or clinics and what this means for the work of veterinarians and veterinary nurses.

The group identified several strengths of using virtual nurses in veterinary practice: they save time, reduce the administrative load, and produce standardised reports which are available immediately and contain less errors. Depending on the features of the virtual assistant, caregivers can schedule appointments outside the opening hours of the practice, they can seek veterinary advice more easily and are reminded of appointments or to give medication to their animal. The group agreed that standardised data collection and follow-ups can lead to better treatment compliance and post-treatment care, which benefit the animal's health. As weaknesses the participants mainly mentioned technological aspects of virtual assistants. Such systems need continuous training and improvement, and their responses may not always be reliable. Technical inaccuracies and errors can cause caregivers to become frustrated and reject the technology.

The largest opportunity was seen in an increased accessibility of veterinary care. By communicating with virtual assistants, caregivers can seek timely veterinary advice. The profession retains more control over the content of the advice caregivers get than if they search random internet fora or websites for information. Depending on the advice given, virtual assistants offer the opportunity to schedule an appointment with the veterinarian directly. Participants noted that some groups of caregivers prefer to message with a virtual assistant than to call a veterinary practice. Participants agreed that some of the opportunities also pose potential threads. For some caregivers, the preferred way of communication may actually be a phone call instead of a text message. Standardised replies may be perceived as impersonal. The group pointed out that it is unclear whether caregivers want to share sensitive information about their animal with a virtual assistant and have it stored electronically.

Reflecting on the conversation, the group formulated two conditions for the use of virtual veterinary nurses: a) the advice they provide needs to be developed and updated in a responsible way, in collaboration with the scientific community, and b) they must function flawlessly from a technical perspective before they are introduced. Participants expressed concerns about the environmental impact of AI systems, the commercialisation and costs of virtual assistants, and the fact that, due to their self-learning and -improving capacities, such systems may become impossible for humans to control in the future. The dialogue also led to new questions among the attendees: how do veterinarians communicate the existence and use of virtual veterinary nurses? Which data does the system share with whom? What about the privacy of the caregiver and the animal? Who is allowed to make decisions on data recording, storing and sharing on behalf of the animal?

Teamwork with AI as member in veterinary teams

Whether AI-based diagnostic tools or virtual veterinary nurses are concerned, the use of AI does not only affect the work of the individual veterinarian, but also how they collaborate with their colleagues as a team.

Participants in this group identified the potential of veterinary AI to support and reduce the workload of the human team members as main strengths. Veterinary AI can provide additional knowledge to inexperienced colleagues. In addition, veterinary AI can take on time-consuming administrative tasks: handling and filtering phone calls and only forwarding those that require the expertise of a veterinarian, and carrying out reporting tasks. Participants noted that AI can also be used to improve communication within the veterinary team: by combining information from different sources (e.g. text messages, emails, phone calls) and feeding it to one single system, everyone in the practice is kept up to date. As a weak point of working with AI as member in veterinary teams it was mentioned that this may lead to less human interaction, both within the team and with animal caregivers. The group also highlighted that AI can provide incorrect information.

When talking about opportunities, the group emphasised that client satisfaction can be improved by AI systems that independently follow up on cases, schedule appointments, and use the caregiver's preferred language. These aspects can lead to economic benefits, as AI offers the opportunity to keep a practice running with fewer staff during staff shortages. Improving communication flows within the team by means of AI may also reduce the time spent for staff meetings. Participants viewed a reliance on AI as a threat. Such reliance may lead to less collaboration with colleagues, causing people to become isolated, potentially reflecting less, debating less and becoming complacent. This can also result in the human team no longer being able to act if the AI system fails, for instance due to a power cut.

Participants were most excited about integrating AI systems into veterinary teams to reduce the workload of the human colleagues. Their main concern was that AI is by definition not human and cannot replace human interaction. The group concluded that when deploying AI as a veterinary team member, it needs to be ensured that humans retain responsibility. In addition, ways need to be found to prevent dependence on big tech for data collection, processing and storage.

How to proceed?

Across the four thematic groups participants identified for nearly every opportunity of veterinary AI a corresponding threat. This shows that these developments are neither exclusively welcomed or rejected, and that they require a more nuanced assessment. For instance, AI-based tools could continuously monitor an animals' health status and thus contribute to early diagnosis, enabling earlier or even preventive care. However, the same tools could also spread misinformation or over- or underdiagnose the patient, which corresponds to some of the risks identified by Coghlan & Quinn (2024). In all groups, veterinary AI was seen as a source of additional information and as a means to reduce workload and save time. This is in line with the meaning veterinarians attributed to the application of Precision Livestock Farming in pig production (Giersberg & Meijboom, 2023). In all thematic contexts, participants emphasised the importance of human contact and communication. It should be investigated further what makes these aspects so highly valued. After all, contact and communication with caregivers could also be experienced as stressful (Armitage-Chan, 2020).

The conversations sparked a number of fundamental questions, for instance about what constitutes the essence of being a veterinarian, but also to which extent animals have privacy and who has the right to decide which of their data are shared or monitored. In this way, the current situation with its major

technological advances can be used as an opportunity to address these questions within the veterinary profession and beyond, and to identify possible courses of action. As the profession is concerned about a dependency on certain AI-based tools and big tech, it should now take the initiative to co-develop veterinary AI systems and gain control about their content, validation and use to some degree.

Conclusion

The introduction of AI in the small animal veterinary sector raises complex questions for which no simple answers exist. The outcomes of the presented dialogues provide a good starting point for more in-depth conversations. What does the veterinary profession value? How can AI be used to support these values? To keep ahead with the field of veterinary medicine and to develop and use AI-based tools in an effective and responsible way, the veterinary profession needs to collaborate with stakeholders, including from the scientific community, industry and policy making.

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Animal welfare in the world of digitalization: Computer Vision in the context of foundational structures

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Abstract

Computer Vision is an emerging technology within Precision Livestock Farming (PLF), combining camera systems with artificial intelligence to monitor animal well-being. While animal ethicists recognize its potential benefits, they also raise concerns about possible negative implications for animal welfare. This paper reflects on Computer Vision not only within the context of the farming practice but also in relation to society-wide foundational structures. Foundational structures concern how the world is experienced and understood, what is taken as self-evident. Over centuries, humans have increasingly delegated tasks to machines and standardized the world in doing so. This process has fostered growing trust in the outcomes of (digital) technologies. Farmers, as members of society, are unlikely to be exempt from this trend. Therefore, reflection on PLF must go beyond the farming practice, to explore how digital technologies are a part of reshaping foundational structures society-wide. Computer Vision is taken as an epitome technology of PLF and analyzed both within the context of changing foundational structures in animal husbandry and in society at large. This paper argues that Computer Vision should be examined not only within the farming context but also as part of a structural change in which human experience and understanding are reshaped by digitalization across society. Therefore, addressing ethical issues of Computer Vision cannot rely on solutions targeting isolated ethical risks; rather, possible solutions must take into account the technology's embeddedness within foundational structures too.

Keywords: precision livestock farming, ontology, artificial intelligence, animal welfare, animal ethics, computer vision

Introduction

A recent advancement in precision livestock farming (PLF) is Computer Vision – a technology that employs cameras integrated with AI technologies (Guo et al. 2023) From an ethical perspective, Computer Vision in animal husbandry is recognized for its potential to help farmers monitor natural animal behaviors. However, concerns arise about the use of wearables that are often required to link behaviors to specific animals, the technology's reliance on intensive farming conditions, and effectiveness of algorithms across different hen morphologies in laying hens versus dual-use hens (Putten et al. 2022).

This paper argues that Computer Vision should be examined not only within the farming context but also as part of a structural change in which human experience and understanding are reshaped by digitalization across society. Situating Computer Vision within this broader trend enables extrapolation of how farmers' experience of animal husbandry tends to evolve and facilitates consideration of the ethical implications of these changes.

Computer Vision is embedded within foundational structures that extend beyond the farming practice. They determine how the world is experienced and understood. Or in other words, what we regard as self-evident. Since we cannot choose what to regard as self-evident, foundational structures are very difficult to change. Therefore, it is important to understand such fundamental changes early in in technological

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development. Computer Vision is in its early stages of development, with limited adoption (Bianchi et al. 2022). This makes Computer Vision an epitome technology for reflecting the ethical implications of the digitalization of farming. The research question of this paper therefore is: What are the ethical implications of a shift in foundational structures wherein farmers come to rely fully on Computer Vision?

Computer Vision

To understand Computer Vision in its technological evolutionary process, first precision livestock farming (PLF) needs to be situated in its evolutionary context. PLF can be traced back to the 1970s with the development of the cattle code – an automatic identification system for cows used in automated feeding systems. During the 1980s, researchers began building databases to assist farmers and veterinarians in interpreting the health status of individual cows across a range of diseases (Bartlett et al. 1986). In the same decade, prototype milking robots were designed that included sensors capable of measuring milk quality and detecting diseases such as mastitis (Butler, 1988). Today, the Internet of Things (IoT) has enabled far more extensive monitoring than was possible in previous decades. PLF now includes a wide range of sensors, devices such as cameras and microphones, and algorithms capable of analyzing many aspects of animal welfare (Rowe et al. 2019).

It is important to note that Computer Vision is unlikely to become a standalone technology in PLF. It will always be integrated with other sensors that measure parameters in complementary ways or help validate the findings of Computer Vision. Nevertheless, its role is expected to grow in the coming decades due to several key advantages. First, Computer Vision can analyze animal behavior in barns, which can be interpreted as a response to environmental conditions and welfare. As such, behavior analysis is a valuable indicator of animal well-being (Rowe et al. 2019). Second, Computer Vision is versatile: it can measure more than just behavior, as will be demonstrated in the remainder of this subsection. Third, because it relies on cameras, Computer Vision is non-invasive for animals (Nakrosis et al. 2023).

The use of cameras in PLF dates back to the 1970s, when researchers used cameras to study cow behavior and determine spatial needs, with the footage analyzed by a computer (Friend et al. 1977). Today, various types of cameras are used in Computer Vision, including 2D, 3D, and thermal imaging. This allows the technology to go beyond behavior analysis (Menezes et al. 2024). It can measure body weight and muscle depth (Oliveira et al. 2021), detect lameness, monitor feed intake, identify mastitis in cows (Menezes et al. 2024), analyze poultry droppings (Nakrosis et al. 2023), early fever and diseases detection, identify stress, breeding, and birth signs (Reza et al. 2024).

Computer Vision is thus a non-invasive and versatile PLF technology capable of measuring and analyzing a wide range of parameters to support animal welfare. In other words, these cameras enable farmers to continuously observe their animals – and even perceive more than the human eye can, such as infrared data.

Precisely because farmers' reliance on Computer Vision may lead to changes in meaning within farming, it is important to recognize that this can lead to both new meanings and to the loss of meaning. Since foundational structures – how the world is experienced and understood – are deeply resistant to change because we cannot choose what to regard as self-evident, it is essential not to wait until Computer Vision becomes self-evident in farming. Instead, it is necessary to reflect on how this technology may reshape the way farming is experienced and understood, and to consider its ethical implications.

Foundational structures of Computer Vision

Foundational structures are meaning-based (Heimann, 2021). They define how humans relate to things and how this relationality is structured by experience and understanding. These structures are dynamic: they evolve over time altering our experience and understanding of the world. Our experience and understanding of the world can, for instance, be structured by science (Blok, 2020). An example is the Copernican Revolution. Before this revolution, the sun was understood as orbiting the earth, and human life was experienced as central to the universe. Afterward, although nothing physical changed, human experience and self-understanding transformed profoundly. This example illustrates several points:

- Foundational structures concern experience and understanding, not physical properties. The earth was already rotating around the sun and still does, nevertheless, the revolution led to a different experience. Foundational structures are therefore not measurable (Blok, 2024).
- Before and after the Copernican Revolution, humans experience and understand themselves in a certain relation to the sun and the rest of the universe. As humans, we are always in a situation in which our experience and understanding of the world is structured by certain meanings (Blok, 2020; Heimann, 2021). Foundational structures are always there, but they change gradually, not overnight. Humans did not suddenly experience human life differently after Copernicus made his discovery.
- Once established, they are difficult to reverse; we cannot choose what to regard as self-evident.

A point regarding foundational structures that is less evident from this example is that it is not always clear what triggers these changes (Blok, 2023). Science and technologies are often part of such changes, as the steam engine (Blok, 2023) and digitalization (Bosschaert, 2025) but they are not the sole cause of these changes. Five types of meaning structures, which are foundational structures, are distinguished: Time, space, quantity, differentiation, and datafication.

Time as meaning structure

Currently, farmers observe their animals multiple times per day to ensure well-being. If Computer Vision becomes the default mode of observation, this system will enable continuous monitoring and provide farmers with a complete historical record of each animal's welfare. Moreover, the system is also focused on the future. In the current situation, when animals show no symptoms yet, farmers need to decide whether to test or treat their animals, depending on costs and benefits (Aklilu et al. 2024). With Computer Vision, farmers will shift from forming impressions based on a few visits a day to relying on continuous histories and analytics. The question is what this abundance of continuous data will change how the farmer acts.

Space as meaning structure

Currently, farmers get their information from the animals within the physical stable. With Computer Vision, this space extends to the monitor, which could be regarded a digital stable, from where they can get information too. This creates a duality of spaces from which stockpersons can access information. The critical question is how they will navigate this possibility: will they engage with both spaces and integrate the information, or will they gravitate toward one? Given the broader societal trend of increasing reliance on digital technologies, it is plausible that stockpersons may spend significantly more time in the digital stable than in the physical one. However, this shift entails notable differences. In the physical stable, stockpersons experience a multisensory environment – smell, sound, spatial presence – immersing themselves in the stable as a holistic entity. Such embodied experience cannot be replicated through a monitor.

Quantity as meaning structure

Currently, farmers can observe only a certain amount of animals. This is a natural limit of how many animals a farmer can have. With Computer Vision, this limit disappears, as machines assume the task of observation and farmers will have all equipment in place to be alarmed about pre-symptoms, to predict any welfare issues, and to suggest actions (Nakrosis et al. 2023). The new constraint may become the number of alerts farmers can manage – a far less tangible threshold, since Kleen and Guatto (2023) note that farmers sometimes ignore alerts. Ignoring an alarm on a screen differs from ignoring possible symptoms in a living animal the farmer observes personally.

Differentiation as meaning structure

Computer Vision promises to individualize animals within large groups, enabling early detection of welfare issues in specific individual animals. Consequently, whereas hens currently vanish in the large group, Computer Vision turns them into individuals. However, this individualization depends on standardization, more so than current farming practices. Animals that move unpredictably or obscure camera's – such as pigs covered in mud – may produce false readings (Reza et al. 2024). In this sense, Computer Vision does not help to distinguish the individual among many, but rather makes all animals more alike. The farmer–animal relationship thus oscillates between differentiation and homogenization.

Datafication as meaning structure

If Computer Vision becomes the default way to understand animals, farmers will understand them from a screen that consists of binary data. Currently, farmers walk through the stables and use their senses and embodied knowledge to observe animal welfare. This includes physical contact between the farmer and animal, which can affect animal welfare positively. The right kind of touch can strengthen the farmer-animal relationship and reduce animal stress (Cooke, 2021). Human observation also helps farmers recognize animals as individuals (Bock et al. 2007). Activities such as milking foster bonding (Balzani and Hanlon, 2020).

Data of Computer Vision tends to exclude physical contact between famer and animal. It gives the farmer possibilities, such as continuous observing of the animals, even beyond human capabilities, zooming in to analyze details such as droppings, and thermal imaging. This can be integrated with other information that is relevant to the welfare of animals, such as the environment of the stable and weather conditions. However, things that do not fit this binary system will not be part of this understanding of the animals, which includes physical contact, sensory information, embodied knowledge.

Discussion: added value to animal ethics

The previous section identified five meaning structures – time, space, quantity, differentiation, and datafication – that reshape relationships among actors on the farm when Computer Vision becomes the default mode of understanding animals. These structures interact and reinforce one another, amplifying changes in farmers' experience and understanding of animal husbandry. Because these are structural changes, the ethical question is not merely conceptual but relational: how do these shifts alter interactions among farmers, animals, and technologies?

First, how may Computer Vision transform farmers' approach to sickness? With features that surpass human capabilities, farmers detect pre-symptomatic indicators such as rising body temperature before visible signs of illness appear.

Second, farmers could come to regard human observation as outdated. Computer vision can monitor the animals continuously and can surpass human capabilities in various ways, which reinforces their reliance on Computer Vision. This turns animals slowly into datasets (datafication).

Third, farmers could come to regard refresher training in sensory observation as unnecessary. A solution to the risk of loss of embodied knowledge is to offer farmers training on sensory observation. However, since foundational structures concern what farmers regard as self-evident, if human observation is regarded as outdated, the question is why a farmer would be willing to follow such a training.

This analysis does not predict outcomes but extrapolates from patterns observed in the technological evolution of digitalization, PLF, and Computer Vision. It can inform strategies for possible solutions, but such strategies must address structural changes rather than isolated ethical concerns.

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How does the digitalization of livestock farming disrupt the life-world of animals?

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Abstract

There is a growing awareness that the digitalization of livestock farming in the form of Precision Livestock Farming (PLF) brings with it a new range of challenges that demand critical reflection. However, the changes brought about by PLF extend beyond technical questions or even their social, economic or political dimensions. These changes pertain to changes in the lived experience of both farmers and animals. We argue that phenomenology with its concept of the life-world forms a productive lens with which to approach the case of the digitalization of livestock farming and with which to explore the impact on both humans and animals. We argue that PLF impacts how humans and animals, at a fundamental level, experience others and the world.

Keywords: phenomenology, human-animal relation, lived experience, digital technology

Introduction

Livestock farming needs to respond to a changing and increasingly complex context, determined by concerns for food security, climate and environmental impacts, animal health and welfare, social equity and consumer demands whilst keeping costs as low as possible (Chen et al., 2025). Against this backdrop, the digitalization of livestock farming in the form of Precision Livestock Farming (PLF) is increasingly considered not only viable, but necessary in order to respond adequately to today's situation (Bist et al., 2026). PLF can be defined as 'the management of livestock production using the principles and technology of process engineering' (Bos et al., 2018, p. 78) and involves the use and implementation of a variety of smart and interconnected digital technologies such as 'GPS, drones, smart cameras, sensors, and automated feeding systems' (Bosschaert, 2025, p. 2). Through the digitalization of livestock farming, farms are increasingly becoming data-rich environments enabling farmers to monitor and manage farmed animals on the basis of continuous and real-time data of individual animals (Losacco et al., 2025). Importantly, PLF is advanced by its proponents as 'a win-win strategy that combines production efficiency with sustainability goals and animal welfare' (Bos et al., 2018, p. 77).

There is a growing awareness that the digitalization of livestock farming brings with it a new range of challenges that demand critical reflection, pertaining to e.g. (the monetization of) large-scale data collection and management and the emergence of the so-called "digital divide" (Chen et al., 2025; Monteiro et al., 2021; Rotz et al., 2019). However, the changes brought about by PLF extend beyond technical questions or even their social, economic or political dimensions. These changes pertain to changes in the lived experience of both farmers and animals. Not only the farmers have to adapt to the changes brought about by the integration of new technologies within the ecosystems of the farms, but the animals too have to adapt to changes brought about by new technologies such as milking robots (Kramer and Bovenkerk, 2024) or smart sensing collars that not only collect data, but also actively intervene in the case of virtual fencing (Musinska et al., 2025). Furthermore, though much more difficult to bring into view, could it not be possible that the human-animal relation is fundamentally changed through the impact of digitalization? If the human-animal relation is increasingly mediated by digital technologies,

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by a data-driven interface that turns animals into a collection of datapoints so to speak, how could this impact the lived experience of both humans and animals? In this contribution, we pursue this line of questioning with an eye to the normative implications of such changes.

Phenomenology and the life-world: intersubjectivity and technology

In order to address questions relating to the lived experience of humans and animals, we turn to phenomenology and the concept of the life-world. Rather than denote a totality of things that carry their meaning within themselves so to speak, the concept of the life-world points to the meaningful whole within which things take on a meaning for situated and embodied subjects by virtue of the complex of relations within which these subjects are actively – or in a phenomenological register, intentionally – engaged. To give an example made famous by Sarah Ahmed (2006), a table is not just a physical object with certain properties that can be measured and determined objectively (length, width, height, colour, material), but something that will appear differently to different subjects under different conditions (of embodiment and situatedness). To some subjects it might appear as something to write on (philosopher), whereas to others it might appear as something designating a space of care labour (traditionally women) or as something to nap on (cat). Furthermore, in lived experience these meanings are pre-reflectively grasped and enacted, rather than deduced in a step-by-step analysis. Since most of the time we are immersed in our activities and the meaningful relations that sustain them, we do not actively reflect on such processes of making sense. As such, the life-world points to the domain of the things that we take for granted, that we take for self-evident but that form the meaningful background – again, in a phenomenological register, the horizon – that is continuously presupposed in the activities we do.

Through phenomenology we make explicit the conditions of possibility, the structures, of our meaningful experience of the world. Thus, the life-world is prior to any and all theorizing activity and escapes being fixed within one interpretive framework (such as for instance a natural scientific framework that reduces things to motion and force or a digital framework that reduces everything to zeros and ones). Rather, it points us to the open space within which meaning is continuously generated by virtue of the relations between situated and embodied subjects and their world, this being both shaped historically, socially and culturally and yet always open to possible revisions and reinterpretations (Steinbock, 1995). Importantly, the life-world is both characterized by the structure of intersubjectivity and by technology. That is, the life-world is always already shared between me and others and the life-world is, for both humans and nonhumans, a deeply technological life-world. Yet, most of the time, we are not aware of how our lived experience is in fact reliant on the structures of the life-world. Lisa Guenther, for instance, argues that the testimonies of subjects in solitary confinement reveal to us how our sense of the life-world as the real world that is continually, objectively there for me is fundamentally co-constituted with embodied others. In this way she argues that prolonged solitary confinement cannot have a legitimate justification, since it 'structurally undermines both the essence of personhood and the conditions for the possibility of having a meaningful experience of the world' (Guenther, 2011, p. 275).

Whereas the case of solitary confinement reveals intersubjectivity as a condition of possibility for lived experience, changes in the technological infrastructure of the life-world can similarly impact the lived experience of subjects. For instance, Hannah Arendt discusses how the experience of distance is fundamentally changed under the influence of modern technological innovations, connecting maps and navigation charts to modern transport systems that emerge with the steam engine, steamships and airplanes. Under the influence of these technology-driven changes, the experience of distance as distance is abolished (Arendt, 1958/2018, p. 250). Arendt keenly observes that those 'submitting to the call of the distant' certainly did not intend to shrink the earth and abolish distance, in fact, 'nothing, to be sure, could have been more alien to [their] purposes' (Arendt, 1958/2018, p. 250). These two cases differ in nature. The case of solitary confinement discussed by Guenther presents a limit case that destabilizes the

lived experience of subjects such that the very condition of possibility of the world to appear is revealed as dependent on intersubjectivity. However, the case of the technologically-driven change tracked by Arendt does not announce itself in the same way, i.e. we do not have access to this phenomenon in the same way since the change she tracks cuts through time. It is only through the historical dimensions of Arendt's reflections on lived experience that what she refers to as the abolishing of distance becomes in a way accessible to us. This is important in light of our investigations into the impact of digitalization on the human-animal relation and the lived experience of both farmers and farmed animals, since this too is a change (or perhaps a set of changes) that cuts through time and in an important sense has already taken place.

Thus, on the basis of our discussion of the concept of the life-world, it is becoming clearer how the concept of the life-world can function as a lens through which to approach the question of the impact of digital technologies on livestock farming. Since the life-world is fundamentally always the shared life-world, the concept reorients our attention within the context of livestock farming to the lived experience, not only of humans, but of animals as well and to how digitalization impacts the relations that obtain between them. The life-world refers to the meaningful whole within which a subject experiences itself, others and the world, and yet refers to an open-ended process of making sense that cannot be reduced to one interpretive framework – e.g. a natural scientific framework. It thus awakens us to the possibility that the impact of digitalization has to be sought at the level of how things appear to us, i.e. at the level of meaning constitution. Following up on these methodical clues, we follow more recent research on how digitalization impacts the human and nonhuman world. For instance, concerns have been raised about how digitalization leads to a new form of objectification of animals (Bos et al., 2018) or about how digitalization should be perceived as a broader phenomenon changing at a fundamental level our experience of the world (Blok, 2023; Bosschaert, 2025).

The case of digitalization of livestock farming

We now turn to the digitalization of livestock farming. Reoriented by the phenomenological lens of the (intersubjective and technological) life-world, we ask how farmed animals appear to farmers under the influence of digitalization. Let's recall that digital systems available to farmers can collect data to, amongst other things, 'recognize group behavioural patterns, identify individual animals, detect the occurrence of fertility, disease and discomfort, as well as to measure changes between individuals and groups of animals over time' (Bos et al., 2018, 78). Within the context of PLF, the lens through which farmed animals are approached is determined by the type of data, i.e. biometric parameters that can be quantified and measured, that the technologies in question are able and preprogrammed to collect. The animal thus appears or – expressed more strongly – seems to be reduced to a source and collection of datapoints within a horizon of efficiency and optimization of performance. Even though more empirical research needs to be done pertaining to the factual changes, it seems plausible that a combination of the following two patterns is likely to emerge. First, farmers will spend less time with the animals. Since digital systems allow for the precise targeting of individual animals that require attention, it is no longer necessary to pay regular visits trying to keep an eye on all the animals on the farm. Second, the interaction between farmers and animals is increasingly mediated by digital systems. Meaning that in an important sense, even the direct interaction that continues to take place will take on an indirect character. Rather than pay attention to their own lived experience of the animal, farmers will likely approach the animal through the directives of the digital systems at their disposal.

Of course, this raises the question, even if these patterns emerge, what is the problem? One initial reply could be that, since the interaction between farmer and animal is increasingly mediated by a digital interface so to speak, the farmer pays less and less attention to the actual animal in front of them. This would make it more and more difficult for the animal to appeal morally to the farmer, since the farmer

relies on the digital system to alert them to the necessity of action rather than on the interaction with the animal herself. One objection to this reply could be that these digital systems are meant to do just this: they are meant to automate the interaction between farmer and animal such that the farmer will no longer need to rely on the animal to indicate that something is wrong. As mentioned before, proponents of PLF consider it a win-win strategy, since these systems are designed to optimize not only efficiency and production, but also animal welfare. However, here it is important to observe that the design of the system presupposes an understanding of what animal welfare is. Currently, these systems are designed for identifying e.g. stress or early symptoms of disease. If we introduce a distinction between negative and positive animal welfare, these systems operate on an understanding of animal welfare as solely the absence of negative animal welfare. That is, they are designed to reduce stress and suffering through alerting farmers when there are physical indicators of such states.

However, can and should animal welfare be thought of in these terms? Animal welfare scientists increasingly picture positive animal welfare as an oscillation between moments of stress that are followed by resolution of the stressful situation through appropriate action that leads to meaningful behaviour such as play, curiosity or bonding between animals (Mellor and Beausoleil, 2015; Ohl and Van der Staay, 2012). This means that, if these systems are designed to create and sustain the situation that any early signs of stress or suffering are immediately dealt with, the very conditions for positive animal welfare to emerge could be actively undermined. These changes might go unnoticed if these systems are unable to identify positive animal welfare behaviour such as play, curiosity or bonding between animals. Furthermore, it has already been pointed out that animal agency is shaped by technology, for instance in the case of automated milking systems where these systems impact 'how they move through space and regiment their time, how they interact with other cows' (Kramer and Bovenkerk, 2024, p. 3). We might easily extend this to the technique of virtual fences where data-driven collars not only collect data about animals but can also be programmed to actively intervene with an animal's activity once a predetermined limit has been reached. That is, the long-term influence of new technologies might lead to the internalization of norms and the consequent modification of behaviour of animals. In the human context, this amounts to a so-called "chilling effect" whereby individuals modify their behaviour due to a fear of the potential consequences if that behaviour were to be observed by others (Cf Rautenberg and Murray, 2024). Thus, digital systems currently operate on a narrow understanding of animal welfare and the long-term effects might lead to a process of the internalization of norms whereby animals modify their own behaviour imperceptibly. This, at the very least, raises critical questions about the optimistic view that PLF is a win-win strategy for both farmers and animals.

But we would like to deepen our investigation by referring back to Arendt's paradox, discussed previously, of how the technologically-driven exploration of the world led to a fundamental change in the lived experience of distance where precisely distance disappears as what it is itself. We would like to argue that something similar is happening in the case of PLF. Whereas through digital systems farmers have access to continuous and refined data collection of the status of animals, at the same time, the animals, paradoxically, seem to somehow disappear in the process of gaining ever more knowledge about them. That is, under the influence of digitalization, the animal increasingly appears as a collection of datapoints. The notion of the life-world as shared seems to be put under pressure in the sense that the human and animal worlds drift apart. Rather than having to spend time with the animals, e.g. to see if there are signs of disease or to milk cows, these activities can increasingly be delegated to (data-collecting and automated feeding or automated milking) machines. This leads to questions pertaining to the (further) objectification of animals and a process of mutual alienation of both the farmers from their animals and vice versa. Although it is not possible to develop this further here, we would like to conclude by gesturing toward an important element in the phenomenology of animal subjects, namely surprise (Lestel et al., 2014). Animals can surprise us. The experience of surprise might even manifest as a momentary being overwhelmed by the presence of the animal, a transformative and potentially enriching experience (cf.

Young, 2017). We might here think of Jacques Derrida's account of his being overwhelmed by the gaze of his cat, suddenly experiencing a surge of shame at his own nakedness. The encounter with his cat initiates an event, which Derrida suggests could be the very origin of thinking (Dufourcq, 2025; Derrida, 2008). In the context of PLF, what does it mean to encounter the animal? Is it still possible to be surprised by the animal, or does the animal appear to farmers only indirectly, as a collection of datapoints? Such an imperceptible shift in the perception of the animal is reminiscent of Husserl's "garb of ideas" that imperceptibly shifts in front of the life-world under the influence of the natural scientific gaze (Husserl, 1970). It is important to make explicit such changes at the level of the life-world, since such changes have an impact on the way in which subjects at a fundamental level experience themselves and the world.

Conclusion

Although these reflections remain as of yet tentative, we hope to have made a strong case for the urgency to reflect on the impact of digitalization on the life-world of humans and animals. Furthermore, we hope to have made sufficiently clear that phenomenology with its concept of the life-world forms a productive lens with which to approach the case of the digitalization of livestock farming and with which to explore the impact on both humans and animals. Under the influence of digitalization, animals are increasingly experienced as collections of datapoints. Our phenomenologically inspired investigations have highlighted how this puts pressure on the notion of the life-world as shared in the sense that digitalization seems to drive the human and animal worlds apart. This raises questions about the further objectification of animals, leading to a process of mutual alienation of both the farmers from their animals and vice versa. Furthermore, this raises questions about the conditions under which subjects can encounter each other as a genuine other. That is, as subjects that can both surprise and appeal to us morally.

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Techno-fixing Norwegian mariculture: a defence

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Abstract

The techno-fix objection expresses valuable moral intuitions. The objection criticizes technological solutions that alleviate symptoms of societal problems, without addressing their root causes. This potentially deflects moral attention, and weakens motivation for systemic change. In this paper, we argue that the concept of techno-fix should be understood as a *techno-moral* term, signalling a need for ethical scrutiny rather than rejection. Following the challenge of this conference, we explore if and how techno-fixing Norwegian mariculture – a sector facing severe environmental and animal welfare challenges – can be ethically defended when framed within our perspective.

Keywords: engineering ethics, techno-moral change, salmon farming, moral deflection

Normative problems in Norwegian mariculture

Mariculture, especially of breeded salmon species, is a major Norwegian industry, vital to the production of fish products on the international market. Norwegian mariculture also sustains coastal fishing culture and rural economy and settlement (Iversen et al., 2025), contributes to food security, increases availability of healthy diet products, and aims to deliver a global climate-friendly protein source (Bohnes et al., 2022). These are significant ethical and political goods.

At the same time, the Norwegian salmon farming industry has huge environmental and animal welfare problems. These are related to very high levels of salmon lice on both farmed and wild salmon, high risk of genetic introgression on wild salmon, adverse environmental effects on seabed conditions, and millions of injured and dead salmons and cleaner fish each year (Grefsrud et al., 2026). A recent report from the Norwegian Institute of Marine Research concludes that "the industry continues to face major challenges. Poor animal welfare in farming facilities and the negative impact of salmon lice on wild fish remain the main obstacles to achieving sustainability" (Grefsrud et al., 2026:4).

The legitimacy of the industry thus faces a host of challenges in need of being addressed. One of these is the problem of escaped farmed salmon genetically polluting wild salmon, thus threatening the survival of wild salmon stocks (Vitenskapelig råd for lakseforvaltning, 2025). This problem has prompted a set of technological solutions to preserve wild salmon, such as AI-based monitoring and management (Yang et al., 2025), and gene-editing for sterilization of farmed salmon (Olsen et al., 2025). In addition, we have conservation biology strategies like breeding of threatened wild salmon for release (Crates et al., 2023), including surrogate broodstock technology (Kleppe et al., 2025).

While these interventions explicitly aim to preserve wild salmon, critics argue that such technological strategies fail to solve the underlying and real problem, which is the very set-up of the industry as such. Regarding the strategy of sterilizing farmed salmon by gene-editing, Winther and Myskja argue:

> A sterile farmed salmon can indeed help to preserve wild salmon, but this is fixing a symptom rather than the underlying problem, namely that thousands of farmed salmon

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> escape from their cages and become part of an environment in which they do not belong. Fixing the fish to adapt them to the industry rather than adapting the industry so that the salmon do not escape and can live a good life as livestock means that we continue and reinforce an already morally problematic practice where animals are made into production units [and] undermines the living conditions of wild salmon through the spread of parasites and disease and through genetic pollution (Winther and Myskja, 2024:277, our translation).

We read this as a *moral* critique of a technological fix, framed to be a "quick-fix" rather than a durable solution, and to address the symptoms rather than the disease. Technology as a quick-fix thus both mask real and persistent problems, and uphold unwanted or unethical practices. This moral critique can be expressed by naming technological solving practices as "techno-fixes", highlighting a distinction between technological (fake) and social (real) solutions. The *techno-fix* in the case of sterilizing salmon accordingly avoids the hard but more apt changes involved in fixing the disease (the social and moral configuration of the industry), rather than just techno-fixing its symptoms.

Technological solutions and sociotechnical imaginaries

Technological success often depends on backgrounding social, economic, and ecological conditions. This backgrounding might create moral blind zones, where central issues remain obscured. Identifying a solution as a techno-fix expresses a judgment that such deflection has occurred. Metaphorical expressions like techno-fixing or symptom-management, however, risk to reproduce a simplified understanding of the nature of engineering activity as cast in a dichotomy between social and technological problem-solving. This might restrict our view of ways to move forward.

In this paper, we propose an alternative ethical analysis of the dynamics of fixing problems with technology. We understand moral deflection – masking the real and persistent problems – as a general risk of any technological problem-solving activity, not only when it is singled out by moral philosophers as a "techno-fix". In our view, it is standard and good engineering practice to translate societal problems into technical problems. Engineers routinely find and make technological solutions that are so efficient that they escape our attention, together with the problems they solve. This is an engineering virtue, not a vice – part of the *ethos* of being an engineer. We consequently propose to understand and use the notion of techno-fix as a *techno-moral* – rather than a purely *moral* – term. This move should bring clearer into view how technological solutions interact with, rather than just aggravate, societal problems, and how engineering inherently involves moral risk by being a techno-moral activity.

We have argued elsewhere that the identification of a solution as a techno-fix signals a need for ethical scrutiny, rath than closure (Nydal and Ursin, 2025). The techno-fix objection can be met through strategies of counteracting moral deflection – for example, through increased visibility of the technology implementation (Nydal et al., 2023). A technological solution might still be morally contested, but if accompanied by strategies that maintain public visibility, the morality of the technological fix can be and remain available for assessment.

We also hold that allegations of irresponsible technological solutions need to be investigated case by case. In our previous papers, we have discussed how the implementation of technological solutions can avoid moral deflection in cases like viticultural resilience against climate change, and use of drugs to counteract obesity as a public health problem. Moving to the case of mariculture, we will add Jasanoff and Kim's concept of *sociotechnical imaginaries* to our analytical framework (Jasanoff and Kim, 2015) This concept highlight how technological fixes enable and are part of visions of the future where specific moral and societal problems are solved.

Jasanoff and Kim define their concept of sociotechnical imaginaries as "collectively held, institutionally stabilized and publicly performed visions of desirable futures, animated by shared understanding of forms of social life and social order attainable through, and supportive of, advances in science and technology" (Jasanoff and Kim, 2015:4). These imaginaries are collective *social* imaginaries of our pursuit of desirable futures, of that which "enables, through making sense of, the practices of a society" (Taylor, 2004:2). They are further *sociotechnical* imaginaries as they emphasise how the technological contingency of the imaginaries has consequences for the moral analysis.

The translation of complex societal problems into technologically solvable problems is reductive, but at the same time guided by and conductive to social imaginaries. The concept of sociotechnical imaginaries calls attention to how engineers already operate within existing, technology mediated, visions of the future. Multiple and conflicting sociotechnical imaginaries gives sense to different available technological solutions. These alternative visions of desirable futures should be articulated, brought to view, and discussed.

Techno-moral visions of Norwegian mariculture

Salmon farming has become a key part of Norwegian mariculture, transforming coastal culture. It is enabled by numerous technologies, and due to its commercial success, it instantiates a powerful vision of efficiently bringing popular, affordable and healthy salmon to the world in large quantities. Norwegian maricultural industry actively seek social legitimacy by posing itself as upholding rural fishing culture, economic prosperity, and food safety. A governmentally supported goal of the industry is continued growth through continued use of technological invention and implementation to reduce and eliminate its environmental and animal welfare challenges (Regjeringen, 2025). Such stated goals, however, need not be in line with or express social imaginaries in full, and can emphasise some shared goods in conflict with or at the expense of others.

Stated goals, in our perspective, should be analysed against a background of a complex set of sociotechnical visions. In Valerie Berseth's analysis of wild salmon preservation and management in Canada, she identifies four major visions of large-scale artificial breeding programs of salmon in hatcheries: Abundance, sporting, wild, and resilient (Berseth, 2025). These visions are moved by different aims and logics. *Abundance* aims for commercial growth in wild fisheries, *sporting* aims for recreational and social benefits, *wild* aims for conservation of wild salmon, and *resilient* aims for production of salmon adapted to climate change. These visions shift but also accumulate, resulting in concurrent and conflicting imaginaries of salmon management.

In the Norwegian context of salmon farming, analogous visions could be: Economic prosperity, nature conservation, coastal culture, and food security. *Economic prosperity* aims for commercial success and growth, *nature conservation* aims for preservation of the environment, animal welfare and animal integrity, *coastal culture* aims for securing rural settlement and fishing traditions, and *food security* aims for domestic food production in times of international instability.

Such visions are enabled by the engineering capacity to offer a range of powerful transformative trajectories for salmon management. In the imaginary of wildness as the main aim of salmon management in Canada, the protection of the thus relevant genetic set-up is given prominence:

> In order to achieve the contradictory visions of abundant, sporting salmon and wild salmon, hatcheries have adopted a range of genomic tools and strategies for producing salmon that are as wild as possible. This has produced a reciprocal and co-constitutive

> relationship between hatcheries and genomics, where an intensification of genetic management is required to satisfy multiple objectives (Berseth, 2025:3179).

In Berseth's account, the wild salmon appears in a context of a multitude of sociotechnical salmon imaginaries involving techniques to preserve culturally valued fishery cultures, indigenous traditions, and leisure activities in an age of climate change. These engineering management strategies of wild salmon involve tensions, or even paradoxes, given the ways in which wild salmon conservation also involves producing salmon more genetically fit for survival in a changing climate.

Here, we are not primarily interested in discussing the specific challenges of such engineering practices, but rather how we enable good assessments of the envisioned futures of these practices. How are we in position to ask if they are worth wanting? In our view, most – if not all – contemporary shared imaginaries of desirable futures are conditioned by engineering practices. It is a matter of how we live by technological solutions. Here, the notion of techno-fix draws attention to moral risks of technological opacity: That the technologies we live by might be morally formative in ways that pass us by.

When the techno-fix term is evoked in an assessment of strategies for saving wild salmon in Norway, it expresses in our interpretation a worry that the proposed activity of sterilisation of farmed salmon will enforce unwanted sociotechnical imaginaries. The hiddenness of sterilisation can lead to moral blindness and deflection, making us collectively morally misguided. The techno-fix blocks our awareness and hampers a discussion of whether, or to what degree, the vision thus pursued stands the trial of moral scrutiny. A remedy for techno-fixing would in this case consequently be to go against the basic ethos of engineering, and make the workings of technology visible, in order to enable an open assessment of the given solution.

The techno-fix objection can arise from different concerns, that relate to independent aspects of the use of technological solutions. One aspect is the vision that the technological solution is part of. This vision can of course be disputed, but also be hidden and thereby hard to discuss and evaluate. This calls for articulation of the technology-mediated vision, in terms of an identification of sociotechnical imaginaries. Another aspect is the risk of moral deflection inherent in the standard engineering work of giving societal problems technical solutions. These solutions tend to hide the problem and its possible societal solutions. This might lead to (self-) deception, and calls for making the technological solution visible, in order to retain the room for moral assessment of the solution and its alternatives. These two aspects are the ones that we are preoccupied with in this paper, in contrast to a third and fourth aspect of the techno-fix critique.

The third aspect is the critique that a techno-fix just treats symptoms instead of the underlying disease. This is, if correct, more of a knock-down argument that points out that the quick-fix technological solution will not work, or even make matters worse. This calls for a more solid technological – or rather a societal – solution to the problem. The fourth aspect is the moral critique that a techno-fix entails an instrumentalization of humans or animals that is unacceptable, and goes against basic dignity or intrinsic value. This calls for a ban.

We quoted Winther and Myskja criticize salmon sterilization by saying: "Fixing the fish (...) means that we continue and reinforce an already morally problematic practice where animals are made into production units [and] undermines the living conditions of wild salmon through the spread of parasites and disease and through genetic pollution." (op. cit.) In our reading, their "production unit" critique exemplifies the fourth aspect of the techno-fix objection, while their "genetic pollution" critique exemplifies the two aspects we deal with in this paper.

The possible loss of wild salmon challenges valuable imaginaries largely shared in Norwegian society in ways that questions the legitimacy of fish farming as such. If escaped salmon (along with the major salmon lice problem) is acknowledged as posing a threat to wild salmon, Norwegian mariculture is put under pressure to move onshore, or to closed containment systems, submersible cages or offshore farms. Large-scale land-based farming would entail massive ecological disruption, cultural loss of coastal fishing culture, and huge economic costs. We can contrast this strategy to a set of seemingly far less interventionist strategies of saving wild salmon, including the sterilisation of domesticated farmed salmon.

The term techno-fix does not seem appropriate to describe a move from coastal to onshore farming, as it would make the current challenges of the industry more visible than ever, rather than obscuring them. Relocating salmon from current open water nets in the fjords, to giant water tanks on land, involves highly visible interventions like blowing away coastal rocks and islands to install the land-based aquacultural industry. Likewise, it does not seem appropriate to use the term techno-fix to describe the numerous technologies enabling current fish farming activities, even if societal problems are given technical solutions, as their moral visibility and readiness for normative assessment are high.

Sterilisation, however, is prone to be termed a techno-fix, given the ways in which it conserves the industry by backgrounding rather than foregrounding its problems. Comparing the alternatives of genetic sterilisation and moving onshore, it can still be argued that the former solution can represent the least harmful and most adaptive path, provided that its implementation remains visible and subject to ethical oversight. Here, closed containment systems, submersible cages or offshore farms might provide middle grounds.

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Blue Carbon Ecosystems: the ethical conflict between nature-based carbon sinks and local livelihoods

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Abstract

This paper explores, from an ethical perspective, the conflicts that arise between protecting and restoring Blue Carbon Ecosystems (BCEs) for climate change mitigation and adaptation and economic activities that support the livelihoods of local communities. While BCEs act as important carbon sinks and natural coastal defences, BCEs climate action often clashes with local subsistence economic practices driving ecosystems loss. Through the adoption of a human rights approach, we show in the present paper that climate action remains of first priority for human rights protection, even if it is expected to undermine local livelihoods. First, we establish that human rights issues arise both when implementing protection and restoration projects and when not. Second, framing climate change as an emergency and a case of non-compliance allows us to argue that measures implying risks and burdens on third parties and their livelihoods can be nonetheless justified as legitimate. Third, as there must be a limit to what can be deemed allowable, we conclude with considerations on where to set the threshold for acceptable burdens for third parties.

Keywords: climate change, human rights, mitigation, adaptation, emergency, non-compliance, sufficiency threshold

Introduction

Despite being valuable allies in the fight against climate change, Blue Carbon Ecosystems (BCEs) – mangroves, seagrasses and tidal marshes – face some of the highest loss rates among all ecosystems, consequently releasing substantial amounts of CO_2 (Pendleton et al., 2012). Measures aiming to stop and reverse their loss can nevertheless disrupt the activities currently contributing to their degradation, as well as carrying dispossession and disempowerment risks, potentially jeopardizing local livelihoods (Macusi et al., 2022; Reyes-García et al., 2022). This paper aims to explore the ethical challenges associated with such cases, analysing whether and to what extent it is justifiable to implement BCEs measures while being aware of the possible downsides on local communities, often already facing poverty and food insecurity.

To address this question, this paper adopts a human rights perspective, which is relevant given the threats to human rights posed by climate change (Levy and Patz, 2015) as well as the risks related to ecosystems-based mitigation and adaptation measures (Reyes-García et al., 2022). As an analysis of the BCEs case through this lens shows that human rights issues arise in both courses of action, we rely on the concepts of emergency and non-compliance to argue that stronger mitigation and adaptation policies can be justified despite their adverse consequences on local livelihoods. Since these impacts must be limited to a level deemed acceptable, we conclude with considerations on the concept of "rights-protected basic interests".

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BCEs as a climate strategy: benefits and challenges

Due to the exceptionally high productivity of their vegetation, as well as the waterlogged and saline nature of their soils, BCEs have a unique carbon sequestration and storage capacity (Christianson et al., 2022). The carbon thus stored is protected from fire-related losses and can be retained for millennia. Based on the global extent and annual carbon absorption values provided by Siikamäki et al. (2013), BCEs capture and store approximately 43.75 million tons of carbon annually. If large-scale restoration efforts were carried out, they would absorb between 0.72% (Siikamäki et al., 2013) and 3% (Macreadie et al., 2021) of the total annual anthropogenic CO2 emissions. Beyond carbon storage, BCEs prove to be important allies in climate change adaptation. Mangroves trap sediments and shield against cyclones, sea-level rise, and saline winds, while salt marshes provide similar protection plus flood buffering during heavy rains (Zhou et al., 2018). Seagrasses excel in slowing currents, attenuating waves, and stabilizing seafloor sediments through their rhizome systems (Ondiviela et al., 2014).

Despite the many climate benefits they provide, it is estimated that 25-50% of BCEs has already been lost over the past 50-100 years, with mangrove forests showing the highest rate of destruction (67% lost worldwide) (Pendleton et al. 2012). Once degraded, BCEs quickly start to release all carbon previously stored, and contrary to terrestrial forests, deeper soil layers are also affected (Donato et al., 2011). BCEs loss rate is so high that their annual carbon emissions (approximately 55.6 million tons of carbon per year) exceed the amount they sequester and store each year (Siikamäki et al., 2013).

Among the main drivers of BCEs loss, are land reclamation for infrastructure, sand and coral extraction, harmful fishing techniques (Unsworth et al., 2018), intensive logging and over-harvesting of wood products (Chow, 2017), as well as agricultural expansion of pastures and plantations and drainage for pest management, as governments often prioritize food security through large-scale agricultural development plans (Van Dam et al., 2023). The primary driver of degradation continues to be the conversion – especially of mangroves – into shrimp farming ponds (Barbier, 2007). Many people nevertheless depend on these activities for income and food to support their livelihoods (Macusi et al., 2022). In several developing regions, aquaculture has indeed been promoted to enhance living standards and offer a pathway out of poverty for economically disadvantaged households (Olaganathan and Kar Mun, 2017).

Although protection and restoration measures negatively impact local economic activities, the resources required to provide alternative livelihoods are often not available (Bennett and Dearden, 2014). Additionally, due to frequent exclusion of local communities from the decision-making and implementation phases, rights to land ownership and access to natural resources are often jeopardized (Reyes-García et al., 2022).

Besides socioeconomic ones, several technical issues add to the difficulty of protecting and restoring BCEs (Macreadie et al., 2021): overestimated sequestration rates; lack of baseline data and poor estimates of ecosystem extent (Taillardat et al., 2018); vulnerability to climate change impacts (Chow, 2017); high initial setup costs (Friess et al., 2022); underdeveloped restoration techniques (Bayraktarov et al., 2016); delayed improvements in carbon storage and habitat stability due to slow ecosystem maturation (Bayraktarov et al., 2016).

Climate change impacts and the downsides of BCEs initiatives

In order to examine these tensions, this paper adopts a human rights approach which focuses on recognising and protecting the moral rights of individuals and communities, regarded as the foundation

for ethical decisions (Timmermann et al., 2024). Violating human rights means depriving individuals of their fundamental moral entitlement.

Such an approach proves fruitful considering that climate change threatens several rights outlined in key human rights documents (Bell, 2011), with some arguing that these are already being violated by climate change rather than just threatened (Caney, 2009). By driving extreme weather, water scarcity, and disease vectors, climate change jeopardizes the rights to life, food, water, and health (Levy and Patz, 2015), and can undermine the right to self-determination through forced displacement and sovereignty loss (Bordner, 2019). While climate change represents a threat to everyone (Bell, 2011), people living in poorer countries, who have contributed the least to climate change, are suffering the most (Wewerinke-Singh, 2019).

By placing an emphasis on BCEs protection and restoration, local people could face a range of significant adverse effects, which might even go so far as to endanger their human rights. Conversely, if current economic and development practices driving the decline of BCEs persist, a valuable mitigation and adaptation strategy would be overlooked, thereby exacerbating the climate crisis and its threats to human rights. While the negative impacts of climate change will ultimately affect everyone, only local communities bear the immediate harmful consequences of BCEs protection and restoration projects.

Arguments for increased BCEs protection and restoration in light of climate change can be synthesized into three: 1. less/no BCEs loss > less BCEs carbon emissions > increased safeguard of human rights; 2. protection of existing BCEs and large-scale restoration > enhanced carbon sequestration > increased safeguard of human rights; 3. protection of existing BCEs and large-scale restoration > improved climate change adaptation > increased safeguard of human rights. Equally, it is possible to narrow down arguments against increased BCEs protection and restoration to three broad ones: 1. technical uncertainties and obstacles in BCEs protection > high risk of losing funds > high risk of stagnation or deterioration of the human rights situation; 2. mismanagement in the design of BCE protection projects > high risk of rights infringement; 3. local disempowerment > higher threat to the right to self-determination.

This overview of broad categories of arguments on both sides shows that the issue of human rights violations arises both when placing emphasis on BCEs protection and restoration projects or not. It is therefore worth further exploring this issue.

Climate change as an emergency: justifying BCEs initiatives against local interests

We suggest to analyse this conflicting human rights issues through the lens of emergency and non-compliance since both allow to argue for a way out of this challenge. An emergency can be defined as an unchosen, temporary event that poses human survival under threat and calls for immediate action (Rand, 1964). In an emergency, there is concrete risk of severe consequences, such as substantial harm to an individual's life, a community's livelihood or regional food chains, and qualifies as such even if the exact timing and extent of that harm remains uncertain (Alexander, 2005).

Huggel et al. (2022) propose that existential threats such as those posed by climate change can be described in terms of different levels of severity (from well-being to basic needs and survival) and scales of impact (from individuals to humanity). Local communities facing risks to their livelihoods because of BCEs measures downsides and climate change adverse consequences both match the concept of existential threat, but play out differently on the two axes. While in both cases the emergency is severe,

the scale of impact differs greatly. The larger scale of the climate emergency potentially threatening humanity as a whole may justify extraordinary measures at the costs of accepting local drawbacks.

Additionally, climate change represents a situation of non-compliance. Many actors resist change, are unwilling to act fairly, and avoid taking the first step (or any action at all) (Brandstedt, 2019). Three responses to non-compliance in relation to climate change seem particularly relevant in the BCEs case and may contribute to justify measures entailing risks and impacts on local livelihoods. First, in an emergency, extraordinary measures that would not be acceptable under normal circumstances become viable (Caney, 2020). Second, ethical standards and obligations that usually limit how climate action is carried out are loosened to increase compliance (Caney, 2016). Lastly, third parties might take on responsibilities and burdens that should, in principle, be fulfilled and discharged by others (Hohl and Roser, 2011).

These arguments point towards the justification of stronger mitigation and adaptation policies, despite their adverse consequences to local communities. In this sense allowing local communities to endure some of the detrimental effects of BCEs protection and restoration projects might be deemed justified, if not imperative. However, in the BCEs case, these adverse effects could involve jeopardizing human rights, which cannot be considered tolerable. According to Caney (2012), there might not be a solution to this controversy at all. Given the number of people on the planet, it seems that some will not have their human rights fully protected if GHGs are to be substantially reduced. This clearly points to a moral dilemma. Byskov et al. (2021) identify a similar trade-off, highlighting the tension between climate mitigation and the development needs of vulnerable communities. To navigate such a situation, they argue that a clear rights threshold must be established to guarantee the specific level of development low-income populations need to building resilience and adaptive capacity to climate change (Byskov et al, 2021; Wallimann-Helmer 2023).

Limiting impacts on local communities

This argument in favour of a thresholds points towards a solution to the dilemma. It involves accepting some adverse impacts while making every effort to limit them to a level deemed acceptable. Brandstedt (2019) mentions a sufficientarian "basic needs principle", meaning that efforts to mitigate climate change should not come at the expense of meeting anyone's basic needs. Meyer and Stelzer's (2018) "risk-adverse weak sufficientarianism" approach is consistent with this line of reasoning when arguing for the safeguard and the fulfilment of "rights-protected basic interests", which take precedence over non-essential needs. Although sub-threshold risks often cannot be fully avoided, this should not stall the decision-making process, as the consequences of inaction will potentially be massive, with those already disadvantaged being the most affected (Meyer and Stelzer, 2018). According to this, BCEs mitigation and adaptation targets and their implementation practices are called into question and should be adjusted to avoid harms below the sufficiency threshold.

While Meyer and Stelzer (2018) leave open the question of which rights should define the sufficiency threshold, Moyn (2021) quite irrefutably argues that the very concept of human rights is intrinsically linked to sufficiency. International law, conversely, allows states to restrict or even to derogate from these rights during a public emergency, particularly under Article 4 of the International Covenant on Civil and Political Rights, while nonetheless clarifying in General Comment No. 3 (1990) of the Committee on Economic, Social and Cultural Rights that states must, under any circumstances, guarantee "core obligations", namely an essential level of each right. It is safe to say that, as for where to set the "rights-protected basic interests" threshold, full compliance with the core obligations of economic, social and civil rights must be ensured. Furthermore, cultural values may be equally of significance in determining what rights might demand priority (Kräuchi and Wallimann-Helmer, 2024).

In the context of BCEs-related climate action in developing countries, risks to human rights apparently arise both from implementing and from failing to implement protection and restoration measures. However, these risks are not necessarily intrinsic to the projects themselves, but in many cases result from flaws in their design and implementation. Recognizing climate change as both an emergency and a situation of noncompliance can justify the adoption of firmer solutions, including the acceptance of greater risks as well as certain burdens on third parties. Nevertheless, every effort should be made in order to limit those consequences to well above a certain sufficiency threshold safeguarding people's rights-protected basic interests, with core obligations under the International Covenant on Economic, Social & Cultural Rights and cultural values further informing the placement of such threshold.

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Section 4.
AI futures in food systems environment, culture and justice

The moral priority of forward-looking responsibility in alien species management

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Abstract

As a consequence of human-induced environmental change, alien species are becoming better able to establish themselves in new habitats. This phenomenon poses potential threats to native species, ecosystems, and human communities. However, for determining whether an alien species poses a threat to native environments, it is imperative that the species has already established, as it is challenging to ascertain their presence prior to their settlement. For this reason, the present paper discusses three arguments for why assigning forward-looking, capacity-based responsibility is morally superior to assigning responsibility primarily backward-looking by relying on responsibilities for their introduction. These arguments are the pragmatic, recognition, and conceptual arguments. This analysis elucidates the superiority of the latter approach in terms of its comprehensive nature and granularity.

Keywords: alien species, neonative species, backward-looking responsibility, forward-looking responsibility, moral responsibility, environmental ethics

Introduction

As human-induced environmental change progresses, alien species are becoming better able to establish themselves in new habitats. This phenomenon poses potential threats to native species, ecosystems, and human communities (Bacher et al., 2025). The term "alien species" is employed to denote those species that would not have become established in an ecosystem if they had not been introduced, either intentionally or unintentionally, by human beings (Essl et al., 2019). The management of these species necessitates significant financial investment to mitigate the risks of economic and biodiversity loss. While the most evident allocation of responsibilities for their management would be according to causal responsibility for their introduction, this is most frequently unfeasible in practice (Bacher et al., 2018; Blackburn et al., 2014). In order to determine whether an alien species poses a threat to native environments, it is imperative that the species be in situ, as it is challenging to ascertain their presence prior to their establishment.

For this reason, the present paper discusses three arguments for why assigning forward-looking, capacity-based responsibility is morally superior to assigning responsibility primarily backward-looking by relying on responsibilities for their introduction. These arguments are the pragmatic, recognition, and conceptual arguments. This analysis elucidates the superiority of the latter approach in terms of its comprehensive nature. This approach appears to be more complete for the purpose of justifying the differentiation of responsibilities in the management of alien species. This argument is developed in the following, by discussing these three arguments in turn.

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The pragmatic argument in favour of forward-looking responsibility

The introduction of species to an environment outside of their native range, followed by their successful establishment, has the potential to adversely affect the environment to which they are introduced. This can have consequences for the biodiversity, ecosystems, and human communities in the recipient environment (Roy et al., 2024). These species are classified as alien species, which are distinguished from neonative species. While the establishment of alien species is contingent upon human introduction, neonatives exhibit the capacity to expand their range into new areas once introduced by humans (Essl et al., 2019).

The introduction of alien species occurs in two ways (Hulme et al., 2008): intentional release and unintentional entry. The former involves the deliberate release of an alien species into a new environment through human activity, such as the intentional importation of the species as a commodity or as a contamination of another, intentionally imported commodity. For instance, during the 19th and 20th centuries, European acclimatization societies deliberately introduced new species from Europe. Conversely, a considerable number of alien species have been unintentionally introduced, often referred to as "hitchhikers", as humans and commodities move to new territories. According to the aforementioned mechanisms, species enter new territory through more indirect and unintentional human influence as part of a stowaway of a transport vector, such as shipping containers or ballast water of ships.

In the context of human-induced environmental change, neonative species undergo range expansion independently (Essl et al., 2019). Neonative species are moving to new territories via previously unavailable corridors that have emerged due to the construction of human infrastructure, such as pipelines or canals, between previously unconnected bodies of water or lands. The emergence of novel corridors for species movement was unintentional; the objective was to construct new infrastructure. The construction of the Suez and Panama Canals, for example, has effectively eliminated biogeographic barriers, thereby establishing novel pathways for species to inhabit previously unoccupied habitats (Castellanos-Galindo et al., 2020).

Additionally, human activities possess the potential to indirectly modify species' ranges. The impact of human activity on the natural environment leads to alterations of environmental characteristics that are inherently associated with species distribution patterns. For instance, rising global temperatures resulting from human-induced climate change may enable the persistence of species in regions where they previously lacked the capacity to thrive due to their thermal tolerances (Spence and Tingley, 2020). Land-use change, overexploitation, eutrophication, and pollution are also contributing factors to environmental change, thereby allowing species to move beyond their natural ranges.

In all these cases, species invade territory and ecosystems in which they previously did not exist. The primary challenge for their management is that knowledge about their negative impacts often only emerges after they have established themselves and their negative impacts become visible (Henriksen et al., 2024). It is frequently challenging, if not unfeasible, to ascertain whether species with the potential to exert deleterious effects are being introduced or whether neonative species are utilizing novel corridors to migrate and establish in novel locations before such effects manifest. As a consequence, a considerable time lag frequently exists between the introduction of a species, its establishment as a population, and the manifestation of its deleterious effects. This temporal discrepancy complicates, and at times renders impossible, the identification of the agents responsible for the introduction of such species.

The pragmatic argument in favor of forward-looking responsibility in alien and neonative species management starts off from this observation. The pragmatic argument in favor of forward-looking responsibility posits that this fact alone is sufficient to justify the assignment of responsibilities to

manage the negative impacts of alien and neonative species in a forward-looking manner. Given the unavailability of the parties responsible for their establishment, it is preferable to allocate responsibility to those who are capable of managing their negative impacts rather than to refrain from assigning responsibilities altogether.

Once alien species or neonatives have become established in new environments and begun to exert deleterious effects on their receiving environments, a forward-looking approach is to assign responsibility to those that have the capacity to deal with the problem (Wallimann-Helmer, 2019). Such an approach is plausible on the condition that it is not possible to ascertain the agent responsible for their dissemination. This approach is forward-looking in nature, as it allocates responsibility based on capacity rather than on causation. It ignores who are the agents who introduced alien species or facilitated the propagation of neonatives.

These arguments presented in support of forward-looking responsibility are pragmatic (not pragmatist!). Proponents of this viewpoint contend that a forward-looking approach is imperative, given the challenges, if not the impossibility, of assigning responsibility due to the factual introduction or facilitation of establishment or range expansion. The pragmatic argument for allocating forward-looking responsibility for the management of alien or neonative species disregards the underlying causes of the problem. Notwithstanding the plausibility of this argument, it is not without its problems. In the subsequent section, these problems will be discussed in relation to the recognition argument for assigning forward-looking responsibility.

The recognition argument in favour of forward-looking responsibility

The pragmatic argument in favor of forward-looking responsibility for the management of alien and neonative species appears to be the most straightforward method of assigning responsibilities. However, this assertion is confronted by two pivotal challenges. Firstly, it allocates responsibility based on empirical evidence, devoid of any normative justification. Secondly, the pragmatic argument presupposes that the management of alien species and neonatives is justified, despite the potential for harm and destruction, without considering the moral entitlements of these living beings or their populations. This constitutes an unjustifiable form of discrimination against individual living beings or populations that are not native to an area, favoring local ecosystems, individual animals, plants, and human communities.

For assigning responsibilities factual information is of paramount importance. E.g. it is imperative to ascertain whether a species was introduced by humans or migrated independently and established itself in a novel environment. It is also important to know whether an agent was cognizant of the importation of alien species or the creation of migration corridors in novel environments. Nevertheless, mere facts do not provide a sufficient basis for justifying the allocation of responsibilities on ethical grounds. Facts do not provide a sufficient ethical basis for determining who should assume responsibility. This assertion would constitute a naturalistic fallacy (Zdzislawa, 2002). The fallacy of deriving normative conclusions from empirical observations.

One might posit a plausible forward-looking justification to circumvent the naturalistic fallacy, predicated upon a normative principle that demands the most efficient action in light of the severe negative impacts of alien species. This justification suggests that in cases of severe impacts, the allocation of responsibility should not be based on the causal factors that led to the problem, but rather on the efficiency with which the problem can be solved (Wallimann-Helmer, 2023). In the absence of any normative premise, the introduction of alien species is merely an observation, lacking any normative justification for the attribution of responsibility.

However, any normative principle that relies on the necessity of managing alien and neonative species in favor of local human communities, species, and ecosystems tends to fail to adequately consider the rights or entitlements of former, who are also living beings and form flourishing populations. The management of alien species tends to prioritize the rights of human communities and local ecosystems. Disfavoring the rights or entitlements of non-locals is problematic. Although alien and native species have been demonstrated to inflict harm upon local human communities and ecosystems, they can nevertheless be classified as sentient beings, living plants or as forming flourishing populations. According to many ethical theories, these entities are therefore owed a degree of consideration that is commensurate with that afforded to humans and local species and ecosystems (Palmer et al., 2014). According to these approaches, managing alien species and neonatives in a manner disfavoring their rights constitutes an unjustifiable form of discrimination.

The ethical consideration of alien and neonativ species and their communities as entities with rights and entitlements of the same importance as those of local humans and non-human species and communities complicates the justification of decisions that favor local human communities or non-human species and ecosystems (Noll and Davis, 2020). It is imperative to acknowledge the rights or entitlements possessed by both the alien populations and the local human and non-human communities and ecosystems. Notwithstanding the reasons why species and communities exist in new locations or the extent of the damage they cause, it is imperative that all living entities be acknowledged as rights holders and accorded the respect and treatment befitting such status. In consequence, it becomes imperative to manage alien and neonative species and their communities in a manner that ensures proper balance with the interests and survival of local human communities, species and ecosystems.

This is the recognition argument in favor of forward-looking responsibility in the management of alien and native species. It is rooted in an argument posited by Clare Palmer, who contends that the process of human settlement in former habitats of animal species necessitates the recognition of their existence within a human community as a form of redress (Palmer, 2010). In a similar vein, the recognition argument in favor of forward-looking responsibility in alien species management posits that human communities facing the establishment of alien species or neonatives and their negative impacts must recognize their existence and refrain from seeking disfavoring their rights or entitlements. This argument can be regarded as supporting forward-looking responsibility, as it implies that all individuals and communities residing in a particular location are expected to recognize the presence of non-human, non-local species and communities, despite any potential causal involvement in their emergence in that specific place.

The superiority of the conceptual argument in favour of forward-looking responsibility

The recognition argument in favor of forward-looking responsibility demands the acknowledgement of the rights or entitlements of local human communities and ecosystems, while balancing them with the rights or entitlements of non-local, alien, and neonative species as living beings and communities. The crux of this argument lies in its inability to provide a compelling rationale for allocating responsibilities in the management of alien and nonnative species. This argument posits that, under optimal conditions, the management of alien and neonative species should be balanced with the interests of local human communities and ecosystems. However, the question of who should assume such forward-looking responsibilities remains unanswered. The conceptual argument in favor of forward-looking responsibility in alien species management has the potential to be more fine-grained in this regard, while recognizing that these species are introduced by humans or their range expansion is made possible by human influence.

The conceptual argument relies on the conceptual definitions of alien and neonative species. According to these definitions, both kinds of species are capable of establishing in a particular location only in the context of human influence. The establishment of alien species in novel environments is a consequence of both intentional and unintentional introduction by humans. Range expansion of neonative species is facilitated by human activity, enabling these species to spread and establish populations in new areas. Considering the two arguments discussed so far, this suggests that humans bear not only responsibility for their management but also for recognizing their rights as living beings.

Therefore, given the frequent inability to identify the causal agents responsible for the introduction or spread of alien and neonative species, there are surely pragmatic arguments in favor of allocating forward-looking management responsibilities to those humans who are best equipped to fulfill them. Concomitantly, because human beings also bear responsibility for the introduction and range expansion of non-human species, they must also recognize their rights or entitlements. This implies that despite pragmatic justifications for the management of these species, such management must also acknowledge the rights or entitlements of these living beings and their communities. Hence, combining the pragmatic and the recognition arguments requests balancing management interests in favor of locals with recognition of aliens and neonatives.

In the context of assigning responsibilities in a forward-looking manner, these considerations bear two important implications. Firstly, it must be acknowledged that humans have not only obligations to address alien and neonative species in a variety of ways, but they are also bound by the imperative to do so in a manner that respects their rights. It is incumbent upon management to ensure that any measures taken are designed to avoid or, at the very least, minimize harm to both aliens and neonatives (Katz, 2024). Therefore, capacity relevant to assign forward-looking responsibility not only concerns efficiency but also knowledge about minimizing harm in managing these species. Secondly, an approach that is most plausibly applied in the context of the potential occurrence of negative impacts on aliens and neonatives is pre-cautionary (Hansson, 2020). Despite its pragmatic character, this approach possesses the capacity to circumvent potential harm to both aliens and neonatives by virtue of its proactive caution. In this case, as well, responsibility can be assigned in a forward-looking manner based on capacity. Those with the capacity to introduce precautionary measures to avoid the importation of potentially harmful species should assume the primary responsibility for doing so.

Consequently, the assignment of forward-looking responsibility for the management of alien and neonative species according to their conceptualization is more complete because it relies on both pragmatic and recognition considerations. The conceptual argument in favor of forward-looking responsibility is characterized by its enhanced level of granularity. This process entails the assignment of causal responsibility for introduction, capacity considerations in light of efficiency as well as harm reduction in managing alien and neonative species. For assigning forward-looking responsibilities This implies crucially a significant emphasis on the recognition of the rights or entitlements of all living beings, flourishing populations, and human communities – be they local, alien, or neonative.

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A multispecies justice approach to the epistemic considerations in AI for nonhuman communication

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Abstract

This paper examines the epistemic implications of AI for nonhuman animal communication through a multispecies justice lens. While recent developments in computational approaches offer new possibilities for understanding nonhuman animal communication, they also raise important concerns. These include epistemic harms, asymmetries in knowledge production, and the potential reproduction of hierarchical and colonial ways of knowing. By analysing recent scholarship, this paper argues that AI for nonhuman animal communication presents an ambivalent case for multispecies justice. The technology cannot be straightforwardly evaluated as either beneficial or harmful for multispecies justice, as it simultaneously challenges and reinforces anthropocentric epistemic frameworks. In response, the paper highlights the importance of epistemic humility and calls for further exploration of how technological approaches might be integrated with embodied, affective, and alternative forms of knowing.

Keywords: interspecies communication, multispecies justice, artificial intelligence, epistemic justice, anthropocentrism

Introduction

In 1967, Roger Payne and colleagues revealed that humpback whale vocalizations are structured and evolving patterns rather than random sounds. This discovery transformed understandings of nonhuman communication and suggested the potential presence of complex forms of meaning-making in nonhuman communication. According to the Cetacean Translation Initiative (Project CETI), it contributed to broader cultural and political shifts, including the *Save the whales* movement (Project CETI n.d.).

Inspired by Payne's discovery, Project CETI is creating artificial intelligence to decode whale communication. Convolutional neural networks have already been able to identify the vocal clan to which certain whale codas belong (Bermant 2019), potentially suggesting dialectal differences between whale groups. In addition, Project CETI suggests that whale codas may function in ways comparable to human vowels and diphthongs, based on machine-learning analyses (Beguš et al. 2025). The Earth Species Project, another project researching nonhuman communication, has recently introduced NatureLM-audio, an audio-language model designed specifically for animal vocalizations and sounds (Earth Species Project 2024). It can identify individual animals within recordings and even recognise patterns in the vocalizations of species it has not previously encountered. NatureLM-audio is a significant step towards a future in which humans can decode nonhuman animal communication with machine learning. Mustill (2022) points out that there is an opportunity to better understand animal vocalizations by correlating them with behaviour and actions on a large scale. Some scholars suggest that these technological advances may make more sophisticated forms of interspecies communication possible in the near future (Bakker 2022).

The initiatives present their work as a potential breakthrough in how humans understand and relate to other animal species (Project CETI n.d.; Earth Species Project n.d.). At the same time, their approaches

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raise questions about how nonhuman communication is understood, interpreted, and represented. This paper examines recent scholarship on the epistemic implications of AI for nonhuman animal communication through a multispecies justice lens.

Epistemic considerations

Multispecies justice recognises other beings as possessing unique forms of intelligence, ways of being, and integrity shaped by their ecological histories, embodied capacities, and relationships (Celermajer et al. 2021). According to Celermajer et al. (2020), multispecies justice theorists should continually seek to understand the interests of different beings by engaging with different ways of knowing and being, while at the same time recognising that other beings' experiences cannot be fully grasped through the human experience. Researching how nonhumans communicate is central to multispecies justice to understand their needs and interests, according to Hamilton and Taylor (2017). It may entail deploying technological methods to understand nonhuman communication (Hayward 2010). From this standpoint, AI for animal communication offers possibilities for advancing multispecies justice. In *Listening to our animal kin: legal and ethical principles for nonhuman animal communication technologies,* Rodríguez-Garavito, Gallant and Crowe (2025), suggest that these technologies could spark curiosity about, and empathy toward, other animal species. They compare the potential of this technological development to the effect of Roger and Katy Payne's *Songs of the humpback whale.*

Epistemic harms

At the same time, the research into this technology gives rise to epistemic harms for nonhuman ways of knowing, which can be critiqued from a multispecies justice perspective. Rodríguez-Garavito, Gallant, and Crowe identify several risks that can be understood as epistemic harms for nonhuman animals. They note that human use of nonhuman communication systems may disrupt animals' ability to interpret and trust communicative signals, potentially leading to confusion. In particular, when humans replicate signals to test the technology in playback experiments, animals may recognise them as originating from an individual within their social group. It could harm the animals by possibly generating false beliefs about reality. Additionally, the noise pollution can compromise social coordination and thereby collective meaning-making within species (Rodríguez-Garavito et al. 2025). The epistemic harm comes from the loss or distortion of information due to disrupted or confusing communication.

Epistemic asymmetry

A related concern is how this technology relies on epistemic asymmetry in the extraction of knowledge. In their report, Rodríguez-Garavito, Gallant, and Crowe also point out that nonhuman animals may be drawn into processes of data collection without the capacity to understand or contest how their communicative signals are recorded, analysed or used. As a result, they become sources of information while humans have control over how that knowledge is produced, applied, disseminated, and utilised in the future (Rodríguez-Garavito et al. 2025).

Implications of epistemic hierarchies

Furthermore, they argue that the (inappropriate) use of AI for animal communication may reinforce assumptions of human superiority by treating nonhuman communication as fully understandable through the human lived experience. In doing so, it could reduce the more-than-human world to what is 'intelligible within modern science' and marginalises ways of understanding grounded in 'different ontologies and epistemologies' (Rodríguez-Garavito et al. 2025, p.19).

Susam-Saraeva further elaborates on this in her article *Translation rights of the more-than-human: thoughts on whale bioacoustics* (2026). According to her, marine science is 'still based on an antiquated and fractured worldview that operates through dualisms such as nature vs. culture, society vs. environment, technoscientific 'objectivity' vs. 'subjective' empathy and care' (Susam-Saraeva 2026, p. 14). She suggests this binary worldview reflects a limited understanding of the world, which overlooks underlying power relations. Susam-Saraeva develops this argument by comparing it to hierarchies within human languages. She explains that certain languages are treated as more legitimate or complex, not because of their inherent qualities, but because of the socio-economic power of their speakers. Some languages are researched in more depth, documented and analysed in more complex terms, and more widely circulated. Within these hierarchies, more-than-human communication systems are even further marginalised. This is reflected in the persistent division between humans and nonhumans, for instance, in the terms used to describe communication, where 'sounds', 'calls', and 'vocalizations' are distinguished from terms used to describe human language (Susam-Saraeva 2026).

Multispecies justice directly challenges these kinds of binaries by questioning hierarchical dualisms, such as human/nature, man/woman, and human/animal, that systematically assign value to one side while devaluing the other. It emphasises that nonhuman animals possess their own forms of knowledge, communication, and sociality, which cannot be fully understood through human-created categories (Celermajer et al. 2021). From this perspective, the hierarchical division identified by Susam-Saraeva can be understood as a form of epistemic injustice insofar as it marginalises nonhuman animals as knowers and limits the recognition of their capabilities and communicative complexities. However, AI for animal communication is an interesting case because it both challenges and reproduces these binaries. It treats nonhuman communication as meaningful, but it does so by translating it into human-centered concepts and evaluations that risk reinforcing the very distinctions it seeks to overcome. For instance, current computational approaches often interpret nonhuman vocalisations through human linguistic frameworks. It risks reinforcing human language as the benchmark for meaningful communication, rather than allowing alternative communicative systems to be understood on their own terms. Paradoxically, the human-centered linguistic frameworks that dominate our thinking about language, according to a multispecies justice approach, can also be challenged by experimental technological explorations.

Epistemic consequences of technological solutionism

However, caution is needed when framing AI as the solution in this context. In *Dr Doolittle uses AI: ethical challenges of trying to speak whale*, Ryan and Bossert (2024) warn that the use of AI to decode animal communication may constitute a form of technological solutionism or technofixing, in which complex problems caused by humans are approached through technological solutions without confronting the structural conditions that produce them. Similarly, Susam-Saraeva (2026) cautions against an overemphasis on technological approaches that focus on word-for-sign translation. It risks flattening the richness of more-than-human communication into human-interpretable units and overlooks meanings that emerge through embodied, relational, and situational contexts.

In this line of thought, Zengiaro (2025) argues these current developments in the field of animal communication mark a shift away from earlier forms of field-based, ecological observation, such as those associated with researchers like Jane Goodall, toward more distant, data-driven approaches. This shift is partly due to practical limitations in human perception and data processing, but he suggests it is also driven by a broader pressure to produce quantifiable results, which is often at the expense of situated understanding. In his article *AI and animal communication: a generative zoosemiosis perspective*, Zengiaro (2025) emphasises that by converting signals into computational representations, these approaches separate communication from the embodied beings that produce it. In doing so, he argues, lived and relational meaning is replaced by algorithmically evaluated outputs. Zengiaro argues that this

reflects a wider shift toward artificial semiotic environments, in which meaning is generated through computational models rather than through interspecies interaction. This growing gap between data and lived experience poses an epistemological challenge. According to Zengiaro, nonhuman animal communication should not be treated as a fixed message to be decoded, but must be understood as meaning that emerges within the specific, embodied context of the being's *Umwelt*.

Concerns regarding the influence of colonial epistemologies

Susam-Saraeva (2026), based on interviews with involved ecologists, highlights that researchers are often aware of the profound differences in *Umwelt* between humans and marine mammals. These vast differences are for many the motivation for studying cetaceans. She draws a historical parallel with translation in the human context and cautions for forms of 'othering' that frame 'the other' as fundamentally separate and knowable objects. A dynamic that, also from a multispecies justice perspective, reinforces hierarchical distinctions between humans and nonhumans. She explains that such othering historically has been tied to unequal power dynamics, in which 'the other' was treated as an exotic subject of curiosity and a resource to be exploited. Susam-Saraeva (2026) further argues that translation is deeply entangled with colonial power relations and cannot be treated as neutral. Colonialism depended on the large-scale destruction of ecosystems, the extraction of 'natural resources,' and the exploitation and enslavement of both human and nonhuman life. These systems were supported by scientific practices such as measurement, comparison, and classification which categorised people, languages, cultures, and species into ranked systems, and were presented as neutral and objective. They framed certain groups and knowledges as 'advanced' and others as 'primitive,' which helped to legitimise unequal treatment and control. The denial of language and cultural expression became a tool of domination. Susam-Saraeva argues that contemporary attempts to translate cetacean communication cannot be separated from these histories. Based on her observations, she further notes that an awareness of these asymmetrical power relations is largely absent in current computational bioacoustic research. Translation is often presented as objective, neutral, and transparent, thereby reproducing the same universalist assumptions that historically underpinned imperial and colonial epistemologies. From a multispecies justice viewpoint, these assumptions suggest the need for caution, as they position human epistemology and lived experience as a neutral and objective standard against which other forms of intelligence and communication are interpreted and evaluated. This risks overlooking that nonhuman animals possess their own forms of embodied knowledge, intelligence, and ways of being that may not be fully captured through human understanding.

The ambivalence of AI for animal communication for multispecies justice

At the same time, it is worth noting that, compared to earlier forms of animal communication research, current approaches are in certain respects more in line with multispecies justice. Throughout decades of research, scientists have attempted to communicate with nonhuman animals by teaching them human communication systems. For example, Allen and Beatrix Gardner taught chimpanzees American Sign Language, David Premack developed a symbolic token system, and researchers created computer interfaces for bonobos to select words and form sentences (Gardner and Gardner 1969; Premack 1971; Rumbaugh et al. 1973). According to Ryan and Bossert (2024), AI for animal communication is a shift away from training animals to adopt human communication systems, toward attempts to understand communication as it occurs in natural environments. They also suggest that computational approaches may help reduce anthropocentric bias by enabling humans to perceive signals and patterns in animal communication that exceed the limits of human senses. Taken together, these discussions illustrate that AI for animal communication cannot be straightforwardly evaluated as either beneficial or harmful from a multispecies justice perspective. The technology simultaneously challenges and reproduces key concerns within multispecies justice theory.

The need for epistemic humility

Mustill noted about the technological development in his book *How to speak whale* (2023): 'There may be no similarities in the patterns of relationships between the units of humpback whale-speak and those of English, but knowing this would still be illuminating. Discovering rich, complex structures and relationships within nonhuman communication systems that bear no resemblance to those in human language would be a revelation in itself, hinting at parallel animal worldviews.' However, the recognition and even acknowledgment of this as a possibility requires a significant degree of epistemic humility. According to multispecies justice theory, this is precisely what is called for: an effort to engage with other beings' ways of knowing and communicating, while recognising that these cannot be completely translated or understood in human concepts (Celemajer et al. 2021).

The need for including embodied, affective, and aesthetic forms of knowing

Finally, from a multispecies justice viewpoint, even though deploying technological methods to understand nonhuman animal communication is welcomed, it is recognised that these efforts are hindered by dominant ways of thinking that prioritise human-centered language evaluations. This marginalises alternative embodied, affective, and aesthetic forms of knowing. In light of this, multispecies justice advocates should utilise communication and engagement approaches such as arts, storytelling, embodied communication, and emotion, as they may increase the public's ability to communicate with and about other species (Celemajer et al. 2021). This points to the need for further exploration of how embodied, affective, and aesthetic forms of knowing might be brought into dialogue with technological approaches to nonhuman communication.

Conclusion

This paper argues that AI for animal communication presents an ambivalent case for multispecies justice. Computational approaches may reduce anthropocentric bias and improve our understanding of other animal species' interests, but they also raise epistemic concerns, including abstraction, asymmetries in knowledge production, and the potential reproduction of hierarchical and colonial ways of knowing. From a multispecies justice perspective, these tensions suggest the need for critical and reflective engagement rather than straightforward endorsement or rejection. This includes a commitment to epistemic humility and further exploration of how technological approaches might be integrated with embodied, affective, and alternative forms of knowing.

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The ethics of multiple crises: ideal and non-ideal principles of crisis management

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Abstract

This paper examines how the "fact of multiple crises" affects the development and assessment of normative principles of crisis management. While existing literature addresses individual crises or crisis ethics in general, it largely neglects how simultaneous crises reshape normative reasoning in ways that go beyond familiar problems of scarcity and partial compliance. Drawing on the distinction between ideal and non-ideal theory, the paper argues that multiple crises do not merely intensify existing challenges but generate structurally new ones: the causal entanglement of crises renders a jointly optimal ideal state problematic or even theoretically incoherent, and makes it unclear what the non-ideal is non-ideal with relation to. The paper concludes that while this indicates a limitation of ideal/non-ideal theory, such theory is still useful as an analytical tool for assessing and improving our principles.

Keywords: democratic institutions, biodiversity, political philosophy, conservation

Introduction

We live in a time of multiple crises. Alongside climate and biodiversity crises, we face war, geopolitical instability, trade conflict, democratic backsliding, and growing pressures on global agriculture and food systems – further complicated by rapid developments in artificial intelligence and digitalization. While there is extensive discussion of individual crises and on crisis ethics more generally (see, e.g., Svedin 2011), little attention has been given to how simultaneous crises – or what in this paper will be referred to as *the fact of multiple crises* – affect normative reasoning.[1] The current paper examines how the fact of multiple crises affects the development and assessment of crisis management principles.

A crisis is typically characterized by urgency and uncertainty (Svedin 2011) as well as a normative judgment that something is seriously wrong (Armstrong 2024, 5). Drawing on the distinction between "ideal theory" and "non-ideal theory" (Valentini 2012), I argue that multiple crises do not merely intensify existing challenges for addressing crises – such as scarcity of resources, conflicting interests, and compliance – but generate new structural problems for ideal as well as non-ideal crisis management approaches: the causal entanglement of crises (Lawrence et al. 2024) renders a jointly optimal ideal state problematic or even theoretically incoherent, and makes it unclear what the non-ideal is non-ideal with relation to. The paper concludes that while this suggests a limitation to using ideal/non-ideal theory to construct normative principles of crisis management, such theory is still useful as an analytical tool for assessing and improving such principles.

[1] The linking together or entanglement of multiple global crises is sometimes referred to as "polycrisis" (e.g., Lawrence et al. 2024). I will use this term occasionally in the paper, but a detailed discussion of the polycrisis literature will be delayed until the full paper.

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The project is methodological in nature. I do not aim to propose or develop specific principles for crisis management. Nonetheless, the project has practical relevance in so far as it has important implications – or so I'll argue – for the development of sound principles of crisis management amid multiple crises.

Ideal principles

By "principle of crisis management" I mean (roughly) a normative statement about how agents should act in response to a crisis. A normative principle can be "ideal" in at least three different senses (Valentini 2012). First, a principle can be ideal in the sense that it is end-state oriented (Sen 2009). A principle which is end-state oriented proposes an ideal or ultimately desirable end-state. For example, the Greatest Happiness Principle of classical utilitarianism suggests the ultimate goal of achieving the greatest possible sum of "happiness" in the world (Mill 2001 [1871], 938), whereas John Rawls' (1971) theory of justice proposes an ideal end-state of full justice among members of society.

End-state principles are contrasted by Sen (2009) to what is called "transitional" principles, which are principles for the transition to morally better (e.g., more just) – but not best – states of affairs. We'll look closer at transitional principles in the next section. With regard to crisis management, ideal principles can be taken to state what the optimal solution to a crisis is. For example, the optimal solution to the biodiversity crisis may be to arrive at a state where half of the Earth's biodiversity is preserved and protected (Wilson 2016).[2] An end-state (ideal) principle of biodiversity crisis management would incorporate or be structured by this optimal solution/end-state.

Secondly, a principle can be ideal in the sense that it assumes full compliance (Rawls 1971). It is here assumed, when developing the principle, that all relevant actors will comply to the principle (or the actions or obligations it implies). Since it is typically not the case that everyone will comply, this is considered a false assumption – but posed anyway for some theoretical (or other) purpose. For crisis management, it will mean that when one develops an ideal principle in this sense, one will assume (falsely) that everyone will comply to it, for example because one does not see lack of compliance as relevant to what we should (ultimately) do (Rawls 1971, Estlund 2020).

Thirdly, a principle can be ideal in the sense that it is "fact insensitive" (or fact independent). This position, developed by Cohen (2003), implies that a crisis management principle can be valid even though it does not take into account any nonmoral facts (or facts about the empirical world). More strongly stated, it implies that such facts have no bearing at all on the justification of the principle. Estlund (2020) suggests a modified version where principles can ignore "bad facts", such as facts about morally problematic motivations.

Crises can pose problems for ideal theory along all three dimensions. The fact of multiple crises multiplies these problems, but can also create new ones. First, consider end-state orientation. Crises are characterized by urgency, suggesting that in many cases, one cannot wait to achieve the optimal end-state, such as a fully just outcome. This implies that there will be some transitional period where injustice, or at least incomplete justice, occurs – which is not permitted by the ideal principles. The fact of multiple crises exacerbate the problem: One now has to weigh urgencies against each other, while also taking into account how the crises interact. But it also creates new, structural problems.

Consider the biodiversity crisis. Protecting half the Earth's biodiversity (Wilson 2016) may be optimal to combat the crisis. But the end-state oriented optimal solution collapses when considering how protecting biodiversity may mean moving resources from health-related crises to habitat protection,

[2] That this solution is optimal is controversial (see Armstrong 2024), but that's not important for the point I'm making here.

thereby exacerbating the health crisis, which may mean resources must be moved away again from biodiversity protection, which might affect global warming (consider the Amazon rain forest), which may in turn affect biodiversity and health in unpredictable ways – and so on (Lawrence et al. 2024, Langlois 2024). In brief, whereas in single crises end-state orientation can be difficult, the complexity of multiple crises seems to pose a structural problem that makes such orientation close to impossible. The ideal state of affairs where every crisis achieves an optimal solution does not seem available even in theory, given the empirical/causal (Lawrence et al. 2024) and normative (Langlois 2024) complexity of the fact of multiple crises (or polycrisis).

Now consider full compliance. Every crisis involves conflicting interests, making it unlikely that full compliance will actually take place. But this is not assumed by (ideal) "full compliance theory"; it assumes full compliance, knowing it will not occur. Thus, there must be some function this serves. However, it's hard to see what the assumption could achieve with regard to multiple crises, where full compliance is hard to make sense of even theoretically; epistemically sound compliance seems a super-human affair, given the complex interactions between crises.

If one cannot meet what a principle of crisis management requires without full compliance, and full compliance won't happen, then the principle, it seems, has no practical relevance. We'll discuss this issue further below – for now it suffices to say that it seems to pose serious problems for ideal theory. The idea of fact-insensitivity meets similar problems. It's hard to see how any principle of crisis management can be valid without taking into account at least the most central "facts on the ground" – one such fact being the immense complexity created by multiple crises.

The upshot is that while ideal principles may function as aspirational standards, their role in crises is problematic, and becomes even more problematic under conditions of multiple crises, given the structural problems raised above. A move to non-ideal principles thus seems necessary or justified. Let's consider how they might look and whether or to what extent such a move is, on closer inspection, justified.

Non-ideal principles

Mirroring the ways in which principles can be ideal, principles can be non-ideal in three different ways. Before explaining them, let's sum up and keep in mind for the following discussion what can be taken to be the main motivation for the move from ideal to non-ideal theory: that ideal theory is not "realistic" enough, or lacks practical relevance.

Now to the non-ideal principles. First, a principle can be non-ideal in the sense of being transitional (Sen 2009). For example, because of budget constraints, one might have to be transitionally rather than end-state oriented with regard to full justice; a transitional period of "injustice" might be necessary to reach or approximate the aim of justice. Second, in the sense of assuming not full, but partial compliance. Third, of being "fact-sensitive", or of paying serious attention to how facts on the ground affect the feasibility of the principles, or the likelihood that what they imply can be achieved.

Recall now the motivation for turning to such non-ideal principles. First, consider realism. Principle A, it is assumed, is better than principle B if it is more realistic than B. This is intuitively appealing in the context of crisis management. If a principle of crisis management is unrealistic, this seems to be a serious defect in the principle – to the extent that crises are real-world events that require immediate action, rather than lofty ideals.

On the other hand, it doesn't seem to be the case that a normative principle is always better if it's more realistic. Consider what Estlund (2020) calls "complacent realism". The most realistic principle, Estlund points out, takes the world as it actually, empirically is, and uses this as a standard against which principles are assessed and developed. This, however, makes them too complacent in the sense that they become (or at least risk becoming) *normatively mute*: they will basically just suggest leaving things as they are (Estlund 2020).

Second, consider practical relevance. It seems important that principles are practically relevant, for example in the sense that they are action guiding (for the relevant agents). In other words, they should imply something about how a real agent should act with regard to a crisis. However, it is not necessarily the case that ideal principles are less practically relevant than non-ideal principles, at least not in the action-guiding sense. The utilitarian greatest happiness principle is ideal, but it provides clear guidance in many cases. It tells you, straight up, to choose the act which maximizes (expected) happiness or "utility". Making this principle less ideal, for example by allowing transitional orientation or partial compliance, does not seem to make it (necessarily) more action-guiding.

How would it help, then, for crisis management principles to be non-ideal? A crisis, we might say, is in itself a non-ideal circumstance. It demands attention to trade-offs, conflicting interests, and other features of our non-ideal world. Until the ideal solutions are within reach, we have to settle with the second, third, or fourth best alternatives (cf. Heath 2014). However, there is a problem with this intuitive idea. Non-ideal theory presupposes a coherent ideal to fall short of, but with multiple crises, a coherent ideal state may be unspecifiable – not just hard to reach in practice, but theoretically unavailable – because the causal interactions between crises (Lawrence et al. 2024) mean that optimally resolving one crisis may structurally preclude optimally resolving another. In real life decision making, a principle of crisis management has to be fact-sensitive, allowing transitional injustices and partial compliance when the facts dictate it; in brief, it needs to be non-ideal. The problem arises when, given the fact of multiple crises, it is not even clear what the non-ideal is non-ideal with relation to.

Ideal/non ideal crisis management – a research agenda

I've argued that the fact of multiple crises poses intricate structural problems for ideal as well as non-ideal theory. Does this mean the distinction is not helpful in this context? My discussion suggests that ideal/non-ideal theory may have limited use as a direct tool for constructing principles of crisis management, especially under multiple crises. However, this does not preclude the use of such theory as an analytical tool for identifying strengths and weaknesses or defects in normative principles and approaches to crisis management – which in turn is useful for improving them. Exactly how requires further discussion and is an important research question for the full paper.

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Agriculture, AI, and farmworkers: interconnectedness and cascade failures

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Abstract

The integration of artificial intelligence (AI) into agriculture has transformed farming practices through automation, predictive analytics, and data-driven decision-making. However, this technological evolution also exposes deep social and economic vulnerabilities within agricultural labor systems. I argue that AI's rapid adoption, when pursued without consideration of farmworker justice, risks creating cascading failures across interconnected agricultural and socioeconomic systems. While AI technologies such as autonomous tractors and precision crop management tools enhance efficiency, they simultaneously threaten to displace farmworkers whose experiential knowledge and adaptive skills are essential for agricultural sustainability. Mismanagement of labor as a resource can undermine productivity, destabilize rural economies, and compromise food security. To mitigate these outcomes, I propose three key strategies. First, inclusive technology development must integrate farmworker perspectives in AI design and implementation to ensure equitable participation. Second, comprehensive retraining and education programs should enable workers to operate and complement AI systems, supporting economic mobility. Third, ongoing monitoring and regulation are required to assess AI's social and labor impacts, preventing the deepening of existing inequalities. By situating AI adoption within its social and political context, I contend that sustainable agricultural transformation depends not solely on technological innovation but on a deliberate commitment to equity, ethical governance, and the preservation of labor as a vital resource in agricultural ecosystems.

Keywords: labor, farming, agricultural technologies, AI

The integration of artificial intelligence (AI) into agriculture promises improved efficiency, precision, and profitability. From automated harvesting machines (such as John Deere's Autonomous 9RX Tractor), to predictive analytics for crop management (such as Climate FieldView), AI has transformed the landscape of modern farming. However, this technological evolution raises critical questions about its impact on farmworker justice and the socio-political implications of neglecting the realities of farmworker livelihoods. Ignoring these issues risks cascading failures in agricultural systems due to resource mismanagement, particularly the mismanagement of labor.

Farmworkers are the backbone of global agriculture, ensuring the food supply for billions. Despite their indispensable role, many farmworkers face precarious working conditions, low wages, and limited legal protections in the US context. Their labor is often invisible to consumers and policymakers, and this marginalization has persisted for decades. Technological advancements in agriculture, particularly AI, stands to further marginalize farmworkers by automating and replacing tasks traditionally performed by human labor. While this technology may increase efficiency and profitability for farm owners, it also threatens the livelihoods of workers who depend on multiple positions in agriculture simultaneously for their survival. (Charlton et al. 2022) Displacement without adequate measures for retraining, support, or alternative employment could exacerbate existing inequalities, creating a class of economically disenfranchised individuals with limited options.

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Sociopolitical ignorance by technologists could create a feedback loop of resource mismanagement. Agricultural sustainability is not just about crops and technology; it is deeply intertwined with social, economic, and environmental systems. Ignoring the human dimension of farmwork can lead to cascading failures in interconnected systems. Labor shortages can delay critical farming tasks, leading to inefficiencies and wasted resources. Many technologists and policymakers championing AI in agriculture often lack an understanding of the socioeconomic dynamics of farm labor. This ignorance can result in decisions that prioritize technological efficiency over equitable labor practices. Developing AI tools that replace human labor might overlook the economic dependence of rural communities on having multiple agricultural jobs available throughout the year. A farmworker does not simply perform one task statically: an apple pruner one season is a hops cutter, another. Should pruning become automated, the average farmworker in the US state of Washington (for example) will lose roughly $8,000 USD of her $32,000 USD annual income (E. Nicholson, personal communication). This is untenable. When jobs disappear without alternative opportunities, more than one field will be affected.

Technological innovation in agriculture has often overshadowed the importance of effective labor management. While AI can optimize resource use through precision agriculture, it cannot at present replace the nuanced decision-making and adaptability of human labor. Farmworkers possess invaluable experiential knowledge about local ecosystems, soil conditions, and crop behavior that is necessary for healthful growing seasons.

Mismanagement of labor as a resource can lead to systemic failures in agriculture. For instance, over-reliance on AI without considering the need for skilled labor to operate, maintain, and complement these systems can create gaps in the agricultural process. If key labor-intensive tasks are inadequately addressed, the efficiency gains promised by AI may never materialize.

Modern agriculture operates as an interconnected system where the success of one crop often depends on the labor and resources dedicated to others. If labor resources are mismanaged due to AI adoption, interconnected practices can fail. For example, if our H2A laborer in the US state of Washington prunes apple trees one season, she may harvest hops the next. The laborer in one orchard, when they lose their position, could leave the area for more stable work, impacting the other crops they work on during different seasons. As such, our H2A worker might leave the hops to rot on the vine. In short: a lack of skilled labor to manage a single crop could lead to reduced yields and increased vulnerability across multiple agricultural sectors.

The sociopolitical fallout of labor mismanagement can ripple through agricultural supply chains. When farmworker livelihoods are disrupted, rural economies suffer, reducing the quality of local infrastructure that supports farming itself. This can create a vicious cycle where declining labor conditions lead to reduced productivity, potentially further incentivizing reliance on AI and exacerbating the original problem.

The fragility of these interconnected systems is particularly evident in the context of global food security. Mismanagement of labor can lead to disruptions in crop production (such as crop rot) that have far-reaching consequences. These outcomes are not caused by a lack of technology or climate change alone but by a failure to recognize the centrality of labor as a resource in agriculture.

The integration of AI in agriculture presents both unique opportunities and challenges. While it has the potential to revolutionize farming, its impact on farmworker justice and labor management cannot be ignored. Addressing these challenges requires a commitment to ethical and inclusive practices that prioritize the well-being of farmworkers and the sustainability of agricultural systems.

To address these challenges, it is essential to adopt a holistic approach to agricultural AI that prioritizes farmworker justice. As Carolan (2016) states, "we cannot expect a technological fix to solve a problem that is fundamentally social, political, and economic in nature." (56) This requires ethical considerations and policy interventions that balance technological innovation with labor rights and social equity. As such, we ought to consider:

I. Inclusive Technology Development: Technologists ought to incorporate farmworkers in the design and implementation of AI systems to ensure that the needs and perspectives of these communities are considered. This can lead to more practical and equitable solutions, enhancing productivity without displacing workers.

II. Retraining and Education Programs: Governments and industry stakeholders should invest in retraining programs to equip farmworkers with the skills needed to both operate and complement AI systems. This may create pathways for economic mobility and reduce resistance to technological adoption.

III. Monitoring and Regulation: Governments should establish regulatory frameworks to monitor the impact of AI on labor and ensure that its adoption does not exacerbate inequalities or inequities. The integration of AI in agriculture presents both opportunities and challenges. While it has the potential to revolutionize farming, its impact on farmworker justice and labor management cannot be ignored. Addressing these challenges requires a commitment to ethical and inclusive practices that prioritize the well-being of farmworkers and the sustainability of agricultural systems.

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Ethics in series: teaching ethics through television narratives

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Abstract

This article addresses the challenge of teaching ethics to interdisciplinary student cohorts with diverse academic backgrounds. It argues that television series constitute an effective didactic tool in this context, as their narrative structure enables accessible yet complex engagement with ethical issues. Drawing on narrative ethics, the paper conceptualises how serial storytelling shapes moral perception by embedding ethical conflicts within social, emotional, and institutional contexts. Based on teaching experience from an international summer course, the article explores the Black Mirror episode 'Hated in the Nation' as a case study. The episode's themes – artificial intelligence (AI), ecological crisis, surveillance, and distributed responsibility – illustrate key ethical tensions in contemporary sociotechnical systems, understood here as configurations in which technological infrastructures, human actors, and institutional arrangements are structurally interdependent, and create opportunities for students to critically engage with both ethical content and its narrative framing. The article concludes that television series can foster inclusive and reflective ethics education, whilst highlighting the need for their more systematic integration into interdisciplinary teaching.

Keywords: robo-bees, swarms, narrative ethics, interdisciplinary ethics teaching, socio-technical systems

Introduction

Interdisciplinary ethics teaching routinely confronts a distinctive difficulty. It must address cohorts of students whose academic backgrounds vary widely and who cannot be presumed to command the methods standard in the humanities. Interdisciplinary ethics teaching must therefore develop and refine didactic responses adequate to these conditions (Meisch, 2025; Meisch and Hofer-Krucker Valderrama, 2022).

This article argues that an effective response lies in the use of television series as a didactic tool. As a narrative form, contemporary television series are often widely familiar to students and structurally well suited to sustained engagement. Series do not merely present moral situations; they actively configure them, shaping how audiences perceive and evaluate ethical problems. In this sense, they function as sites in which reflection on the kinds of societies we might wish – or refuse – to inhabit is both prompted and guided. Ethical questions thus arise not only at the level of representation but also through the aesthetic framing of moral issues. For the purposes of ethics teaching, moreover, series offer a comparatively accessible point of entry, particularly for students without formal training in philosophy.

To render television series fruitful for ethics teaching, lecturers may draw on narrative ethics, which directs attention to the ways in which stories organise moral experience, embed conflicts within narrative structures, and invite – or foreclose – specific interpretive responses. It conceives moral reflection as emerging through the interpretation of narratively structured experience rather than through abstract rule application alone. In this way, it provides a framework that enables a theoretically informed and critical engagement with both the ethical content and the aesthetic construction of serial narratives.

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This article builds on multi-annual teaching experience gained in the course 'Bees, Sustainability and Society', taught within the track 'What's the Buzz? Society, Social Media, and Artificial Intelligence in Europe Today' as part of the Summer School organised by Tübingen International and European Studies. The course brings together students from a range of disciplinary backgrounds and diverse pedagogical cultures, predominantly from North America and East Asia. It employs the *Black Mirror* episode 'Hated in the Nation' (season 3, episode 6, 2016) as an entry point into the course, laying out a broad range of interconnected ethical issues that are subsequently expanded, specified, and explored in greater depth throughout the seminar. This dystopian narrative proves particularly attractive for teaching, as it condenses complex socio-technical, ecological, and ethical tensions into an accessible and engaging storyline that invites interdisciplinary reflection.

To substantiate this claim, the article proceeds as follows. It first outlines how narrative ethics can provide a conceptual framework for working with television series. It then offers a brief account of 'Hated in the Nation' (hereafter also 'HITN') before examining its potential for addressing ethical challenges. Finally, it concludes by drawing on selected teaching experiences and reflecting on the broader pedagogical potential of TV series in interdisciplinary ethics teaching.

Ethics in television series

Television series are a form of storytelling deeply embedded in the lifeworlds of young people. As elements of contemporary culture, they open narrative spaces in which questions of the good life and right action are negotiated; herein lies their didactic potential. Ethics teaching can engage these familiar narratives and cultivate moral reflection by proceeding from concrete, experientially accessible situations (Meisch et al., 2022).

This potential is especially evident in series that unfold complex stories over extended temporal horizons, in which characters develop, act, and confront moral conflict. Such conflicts do not arise in isolation but are embedded in networks of social relations, affective attachments, and institutional settings. Series thus render visible the context-dependence of moral agency. They invite viewers to inhabit a plurality of perspectives and to sustain ambivalence (Meisch et al., 2022).

Narrative ethics provides a framework for engaging such storytelling (Haker, 2010; Meisch, 2019). It proceeds from the view that moral questions are not abstract but arise within stories about actions, relationships, and consequences. It distinguishes two ways in which stories matter for ethics. First, individuals make sense of their experiences by narrating them; narrative ethics interprets how they understand and evaluate their situations. Second, stories may be deliberately crafted, as in literature or television; here, narrative ethics examines how moral issues are aesthetically shaped and presented. In both cases, ethical reflection depends on interpreting situations in context. Stories do not simply present events but organise them, emphasise certain elements, and guide interpretation. Ethical reflection therefore examines how narratives shape our sense of what matters and how we ought to respond.

Crucially, Düwell (2000) suggests that the capacity to formulate ethical judgements depends on a broader set of abilities that enable agents to orient themselves in the world, foremost amongst them the ability to adopt the standpoint of others and to envisage their ends and perspectives. Accordingly, the ability of moral agents to test their maxims against the categorical imperative already presupposes such perspective-taking, since agents must consider whether their maxims could be acceptable to all other agents. So, moral deliberation depends on abstract reasoning as well as on the capacity to imagine possible courses of action and to relate them to different perspectives. Aesthetic experience is fundamental here, as it creates a reflective distance from the immediacy of action and opens a space

in which agents can explore alternatives and reconsider established orientations. Only where such alternatives can be envisaged is meaningful moral choice possible.

Didactically, this entails cultivating imaginative perspective-taking, rendering narrative media especially valuable in ethics education. Presentational media, as Peters (2017) argues, offer a low-threshold and motivating entry into philosophical inquiry by rendering complex issues perceptible, eliciting affective engagement, and encouraging independent thought. Their use is not tied to any fixed moment in a teaching sequence but can be deployed flexibly at the beginning, during development, or at the conclusion of a unit. They may function as an initial stimulus that focuses attention and provokes tentative interpretation or productive irritation; guide students into a topic or support consolidation by distilling central problems and reinforcing prior learning; and sustain inquiry by making abstract theories accessible, staging thought experiments narratively, and rendering moral conflicts tangible in concrete situations.

Black Mirror: 'Hated in the Nation'

'HITN' presents a dark and unsettling narrative at the intersection of online hostility, advanced technology, and surveillance. At its centre are Detective Karin Parke and her colleague Blue Coulson, tasked with investigating a series of unexplained deaths. A striking commonality soon emerges: each victim had been subjected to intense public vilification on social media. The investigation leads to a viral hashtag through which users nominate individuals they 'hate'. What appears at first as a familiar instance of online pile-on culture quickly assumes a more sinister form: those most widely targeted are subsequently killed in seemingly inexplicable circumstances.

As Parke and Coulson delve deeper, they uncover the involvement of highly sophisticated robotic bees. These so-called *Autonomous Drone Insects* (ADI) were introduced in response to the collapse of natural bee populations, intended to sustain large-scale crop pollination. This ecological rationale, however, conceals a broader function within a system of pervasive surveillance. The drones operate as a distributed, networked infrastructure embedded in everyday environments, capable of continuous observation, recording, and data transmission. Their minute size and ubiquity render them an almost invisible monitoring apparatus, aligned with the logics of surveillance capitalism, enabling the continuous extraction and aggregation of behavioural data from everyday life.

Technically, the bees are coordinated through a centralised system enabling real-time targeting and control. When compromised, this infrastructure can be repurposed: here, the drones are hacked and turned into instruments of precision killing, entering the human body, and lethally attacking neural tissue. Designed as a self-sustaining system, they can reproduce themselves, ensuring persistence while rendering containment extremely difficult once control is lost. The investigation ultimately reveals an individual who exploits both this technological infrastructure and the volatile dynamics of social media, turning public participation into a mechanism of selection and complicity. The narrative culminates in a chilling conclusion: the consequences extend far beyond the initial victims, implicating potentially thousands who had engaged in the online abuse. What emerges is a logic of the swarm, in which distributed online participation and networked autonomous agents converge to produce collective yet untraceable effects.

Theorising 'Hated in the Nation'

The didactic promise of 'HITN' lies in its narrative appeal and the ethical problems it condenses. Across disciplines, scholars use it to analyse central tensions in contemporary sociotechnical orders.

Reconstructing these perspectives situates the episode within broader socio-critical debates and illustrates its value for interdisciplinary teaching.

First, the literature frames the swarm as a form of distributed agency that challenges conventional accounts of responsibility. Rather than attributing causality to individual actors, 'HITN' foregrounds outcomes arising from collective interaction. Graae (2020) describes swarms as decentralised, dispersed, and non-hierarchical formations, thereby raising the problem of how such diffuse systems can be governed. This perspective informs readings of the episode's social media dynamics. Online hate campaigns function through aggregated participation, thereby diffusing accountability. The structure of the 'game' further reinforces this by trivialising lethal intent and encouraging users to treat it as harmless expression rather than consequential action (Novák, 2020). Crucially, responsibility is not removed but redistributed across the network, as participation becomes embedded in collective and technologically mediated processes (Graae, 2020; Schnepf, 2024).

Second, Novák (2020) examines how the episode stages ecological substitution alongside an illusion of technological mastery. The replacement of extinct bees with artificial drone insects is presented as a remedy for environmental collapse, already normalised as an accepted response to ecological loss, yet in doing so shifts attention away from underlying responsibility, obscuring the ecological damage it purports to address. This reflects an assumption that technological innovation can address ecological crisis while simultaneously obscuring underlying responsibility (Novák, 2020). As Strand et al. (2018) argue, such framings are characteristic of dominant sociotechnical imaginaries in which technological innovation is expected to secure sustainable development through substitution, control, and continuous optimisation. In this sense, the episode articulates a form of technological solutionism embedded within contemporary sustainability discourses. As the narrative unfolds, however, this assumption is destabilised, as the system becomes uncontrollable and lethal, exposing the limits of technological control. Efforts to harness swarm systems do not secure stability but instead generate new risks, as attempts to impose direction on inherently decentralised systems introduce political and technical vulnerabilities. Technology thus appears not as a stable tool but as a fragile and contested assemblage, shaped by competing interests and open to misuse (Graae, 2020).

Third, the literature highlights bees as both a biomimetic model and a key element of surveillance infrastructures. The ADIs reproduce not only pollination but also the decentralised coordination of natural swarms, whereby simple local interactions generate complex collective behaviour (Graae, 2020). This biomimetic design makes them especially suited as distributed sensing systems. Accordingly, their use is closely linked to expansive surveillance practices, as the network enables large-scale monitoring, while authorities can access the drones' visual data on an ongoing basis (Putri and Nafisah, 2020; Kiesewetter and Schmieder, 2018; Graae, 2020). In this sense, the artificial bee functions as an ideal medium for pervasive and largely invisible observation across physical and digital spaces. This convergence of sensing, surveillance, and targeting foregrounds concerns about control, accountability, and the diffusion of agency within socio-technical systems (Graae, 2020).

The politics of the swarm

To understand the resonance of the artificial bees in 'HITN', it is useful to situate them within the long history of the bee as a political symbol. Long associated with natural or divine order, political organisation, and military discipline, the bee proves highly adaptable across contexts. The following remarks offer only a brief indication of this broader tradition. Within it, bees function both as a model of ideal community – structured by division of labour and the common good – and, in Aristotle's account, as animals living in groups (*agelaia*), whose highly organised sociality has been taken to approximate aspects of the *zōon politikon* (Aristotle, 1965–1991). They are, however, also imagined as a militarised

formation. The swarm appears as a collective body organising defence, even to the point of self-sacrifice. Vergil's *Georgica* gives this its most vivid expression, depicting a swarm that gathers, arms itself, and confronts the enemy with coordinated intensity. Extending this line, Polleichtner (2005) shows that, building on Homer and Apollonius, Vergil develops the bee simile from a figure of collective movement and defence into a narrative device that serves to naturalise and legitimise a particular vision of political order.

Across these examples, elements of natural or divine order, hierarchy, swarm intelligence, and martial capacity are variously foregrounded and recombined in shifting historical contexts. In modern discourse, this symbolic repertoire is further transformed – the swarm no longer serves merely as a metaphor for the state but, as in 'HITN', becomes legible as an organisational principle characterised by decentralisation, de-individualisation, and distributed control (Graae, 2020). Whether in socio-historical interpretations of disciplined (fascist) societies (Becker, 1991), in literary depictions of social life as a densely interwoven collective, such as Camilo José Cela's *La colmena* (1951), in literary scenarios of technologised swarms such as those found in the work of Ernst Jünger (*Gläserne Bienen*, 1957) or Claudia Praxmayer (*Bienenkönigin*, 2017), or in speculative explorations of hierarchical and epistemically controlled hive societies, such as Laline Paull's *The Bees* (2014), or in contemporary military and technological applications (Bakker, 2022), the same structural features – swarm, coordination, and potential martiality – are repeatedly reconfigured, often in ways that foreground their ambivalence between order and control.

The bee thus functions as a dynamic site of meaning-making and *everyday fantasies* (Gebhard, 2015). As such, the beehive becomes a symbolically charged figure through which subjective, often implicit imaginaries – of order, community, hierarchy, and control – are articulated and negotiated. These imaginaries do not merely organise knowledge but mediate the relation between learners and the object, linking scientific understanding with experiential, affective, and culturally embedded meanings, and thereby shaping how such systems are perceived as acceptable, naturalised, or contestable. In this way, the bee motif informs perception, evaluation, and ethical orientation. In the context of 'HITN', these symbolic layers shape how viewers interpret the artificial swarm not merely as a technological artefact but as a politically and morally charged formation, in line with its simultaneous roles as infrastructure, instrument of control, and site of distributed agency. For teaching purposes, making these cultural imaginaries explicit can help students to critically reflect on how narrative elements guide ethical judgement. These symbolic dimensions converge with concrete ethical concerns regarding responsibility, substitution, and surveillance.

Basic ethical questions

The issues discussed above crystallise in crucial ethical questions that 'HITN' raises in ways that can start a discussion with students. From a narrative ethics perspective, however, it is necessary to critically examine how such representations pre-structure ethical understanding and public debate, not only by what they render visible, but also by what they obscure or render unthinkable (Düwell, 2013). Narrative representations such as 'HITN' shape moral perception by foregrounding technological response, control, and distributed responsibility, while leaving ecological collapse largely in the background, thereby normalising it. They may also narrow attention to dramatic configurations of harm while underrepresenting the more diffuse, systemic, and often less visible ethical challenges that arise in real-world socio-technical systems – in particular, whether the proliferation of such systems leaves sufficient institutional capacity to protect individual rights and ecological integrity against the interests of multiple, largely ungoverned actors.

Three such challenges arise from integrating living bees into socio-technical systems. The first concerns animal autonomy and welfare. When bee behaviour is deliberately modified or redirected – as in bio-

hybrid systems that integrate colonies into data-driven infrastructures for monitoring, coordination, and control (Ilgün et al., 2021) – the question arises to what extent bees remain living beings with their own integrity, and to what extent they are reduced to tools within technological systems (Bossert and Coeckelbergh, 2024). Sensors and AI-assisted analytics collect and process environmental and behavioural data, enabling continuous observation and management while also opening possibilities for influencing collective behaviour (Šabić et al., 2025), a trajectory that extends beyond ecological contexts to military and security applications such as chemical detection – where bees are inserted into cartridges and discarded once spent (Bakker, 2022). The second concern is relational, as integrating bees into such infrastructures reshapes human–animal relationships and may shift their moral status, especially as the boundaries between the biological and the technical become increasingly blurred (Bakker, 2022). The third is systemic, raising questions of control, responsibility, and governance, including who manages and benefits from the data produced, and what it means that nature itself is increasingly captured, monitored, and turned into data (Zacepins et al., 2015; Šabić et al., 2025).

Conclusion

In response to the challenge of teaching ethics in diverse classrooms, this article argues that television series such as *Black Mirror* offer an accessible entry point by combining familiar storytelling with ethical complexity. Drawing on narrative ethics, such formats not only convey moral problems but also shape how these are perceived, thus enabling students to engage critically with both content and framing. 'HITN' is particularly well suited to interdisciplinary ethics teaching because it brings together technological, ecological, and social questions within a single narrative, allowing students from diverse backgrounds to identify different ethically relevant aspects and engage them in a shared, yet plural, framework of reflection. In the context of the course described here, students, drawing on their diverse cultural backgrounds and perspectives, have consistently highlighted different aspects as ethically relevant and found it engaging to articulate and justify their intuitions, thereby deepening the ethical discussion. This, in turn, points to a broader challenge for ethics teaching, namely to integrate serial narratives more systematically into interdisciplinary curricula and to develop corresponding didactic frameworks capable of harnessing their analytical and reflective potential. Future research on ethics teaching should therefore examine how such narrative formats can be operationalised across different disciplinary contexts and learning environments, particularly with regard to their capacity to connect theoretical reflection with accessible entry points for diverse student cohorts.

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Rational vs. wise futures: on the sustainability of the capitalist food regime

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Abstract

This study argues that ongoing contestations over the sustainability of the capitalist food regime can be framed as a struggle between 'rational' and 'wise' futures, the two prevailing counter-tendencies regarding the future of agriculture and food. On the one hand, corporate-based bio-industrial approaches present the issue as a question of rationalising agrifood relations: fine-tuning systemic imbalances through cutting-edge technologies (e.g., genome editing, digital agriculture, etc.), complemented by political and socio-cultural restructuring (e.g., so-called comprehensive legislative frameworks, awareness-raising, etc.). On the other hand, alternative socio-ecological imaginaries and practices are proliferating, as reflected in concepts such as agroecology, food sovereignty, peasant agriculture, and alternative food networks. These alternatives – by criticising mainstream rationalisation attempts as capitalist, industrial, modernist, Euro-Atlantic-centric, patriarchal, and more – highlight the significance of the wisdom implicit in peasant and indigenous knowledges and traditional agrarian and food practices. As those mainstream corporate attempts aim to sow rational futures by harvesting the previous successes of a developmentalist past, they appear as the most progressive, scientific, and incontestable solutions to our problems. In contrast, yet in connection with this, as those alternative imaginaries try to harvest wise futures by re-sowing socio-culturally and ecologically sustainable and inclusive pasts, they appear romantic, not only in their conceptions of our past but also in their attempts to address the escalating agrifood problems jeopardising the future, such as feeding the growing world population. By situating the divide between rational and wise futures within the socio-historical and ecological tendencies and contradictions of the capitalist food regime (i.e., planetary agriculturalization and de-agriculturalization of food), this study argues that neither the rationalist camp is as progressive as it claims to be, nor are the alternative imaginaries as romantic as they seem.

Keywords: agrifood system, agrifood digitalisation, planetary agriculturalisation, de-agriculturalisation of food

Introduction

This study argues that ongoing contestations over the sustainability of agrifood relations can be framed as a struggle between *rational* and *wise* futures, which, arguably, represent the two prevailing counter-tendencies regarding the future of agriculture and food. On the one hand, corporate-based bio-industrial approaches present the issue as a question of *rationalising* agrifood relations, that is, fine-tuning systemic imbalances through cutting-edge technologies (e.g., genome editing, digital agriculture), complemented by political and socio-cultural restructuring (e.g., comprehensive legislative frameworks, awareness-raising). On the other hand, alternative socio-ecological imaginaries and practices (e.g., agroecology, food sovereignty, peasant agriculture, and alternative food networks) foreground the significance of the *wisdom* implicit in peasant and indigenous knowledges and traditional agrarian and food practices, by criticising mainstream rationalisation attempts as capitalist, colonial, modernist, Euro-Atlantic-centric, and patriarchal.

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As those mainstream corporate attempts aim to sow rational futures by harvesting the previous 'successes' of a developmentalist past, they appear as the most timely, progressive, scientific, and incontestable solutions to our problems. In contrast, as those alternative imaginaries try to harvest wise futures by re-sowing socio-culturally and ecologically sustainable and inclusive pasts, they appear romantic, in terms of not only their conceptions of our past but also their attempts to address the escalating agrifood problems jeopardising the future, such as feeding the growing world population. By situating the divide between rational and wise futures within the socio-historical and ecological tendencies and contradictions of the capitalist food regime – specifically, what this study calls *planetary agriculturalisation* and the *de-agriculturalisation of food* – it is argued here that neither is the rationalist camp as progressive as it claims to be, nor are the alternative imaginaries as romantic as they seem.

Agrifood system(s) in crisis

There is now, arguably, a well-established consensus that the agrifood system, regardless of how it is defined, is in crisis. It is possible to trace this consensus in discussions on various issues, including the degradation of on- and off-farm environments, the prevalence of hunger and food insecurity, the erosion of bio-ethnic-cultural diversity, and deteriorating public health and working conditions. On this ground, mainstream actors and alternative movements alike acknowledge that the industrial agrifood system cannot be sustained in its current form.

It should, however, be emphasised immediately that how this crisis is understood and how we can overcome it are subjects of intense debate. For example, the mainstream narrative runs as follow: the world population continues to grow rapidly, requiring at least a doubling of current food production by 2050 (FAO, 2009); shifts in dietary preferences increase pressure on existing agricultural areas (FAO, 2017); and climate change restricts yield growth while total agricultural land decreases alongside urbanisation, making it crucial to produce more output with fewer resources (TÜSİAD, 2020).

This narrative, at first glance, appears reasonable and incontestable – a data/fact-based account that no one can object to. Yet one of the constituting features of critical agrifood scholarship has been exposing the implicit assumptions in this prevailing narrative by asking further questions, such as: Why do hunger and malnutrition persist despite record food production levels? If agriculture has historically involved working with nature, why has food production become one of the most significant drivers of ecological destruction, fuelling climate change, biodiversity loss, and soil depletion on a planetary scale? It can be argued that the divide between rational and wise futures, as understood here, represents two contested answers to these kinds of questions.

Corporate answer to the agrifood system crisis: rational futures

A noteworthy trend among hegemonic responses to the agrifood crisis has been the increasing interest in utilising digital technologies and tools throughout the agrifood system – from data collection and decision-making to production and distribution. At the core of this lies the adoption of information and communication technologies, including the Internet, mobile technologies, and data analytics, leading to a greater focus on the Internet of Things (IoT) and Big Data (OECD, 2022: 5). Various labels have been associated with this adoption: 'smart agriculture', 'Agriculture 4.0', 'smart farming', 'digital agriculture', and 'precision agriculture'.

These frameworks identify the underlying causes of the crisis, at best (in institutionalist frameworks), as a lack of awareness, inadequate infrastructure, or insufficient legislative capacity; or, at worst (in orthodox liberal accounts), as the limited development of the 'free market' itself. In either case, the main task becomes the rationalisation of the agrifood system: to synchronise its various components and actors

in a 'rational' manner. The crucial point here is that, regardless of how it is labelled, mainstream actors present agrifood digitalisation as the most fit solution to this task; almost as a *deus ex machina* – a divine solution to the multifaceted crisis of our agrifood system. It is on this basis that mainstream liberal efforts seek to sow rational futures by harvesting the previous 'successes' of a developmentalist past.

Within this framework, agriculture is no longer treated primarily as a site of food production but as a strategic node in the management and valorisation of life processes. Through sensors, satellite imagery, data analytics, and algorithmic decision-making, digital technologies render agricultural production and ecosystems legible, measurable, and governable at unprecedented levels of 'detail' for capital accumulation processes. In this regard, a central promise of agrifood digitalisation is the possibility of 'tailor-made' interventions at micro-scales. Variable-rate technologies enable inputs to be adjusted at the level of individual plots, plants, or animals, replacing field-wide standardisation with granular management. While this micro-scale precision is often presented as a rupture with earlier industrial models, it is understood here more as their fine-tuning – an intensification and refinement. As capital's capacity to intervene moves to finer scales, its value frontier expands, extending accumulation beyond land ownership to data extraction, ecosystem services, and bio-geological processes themselves.

Alternatives' answer to the agrifood system crisis: wise futures

A fundamental structural conflict characterises the contemporary agrifood system: on one side, billions of agricultural producers and consumers who struggle with hunger, poverty, diet-related health problems, and the consequences of environmental degradation; on the other, agrifood corporations that monopolistically control agricultural and food production and can be counted, at most, in the hundreds if not tens (cf., Clapp, 2025). This conflict has given rise to various movements, frameworks, and alternative imaginaries of agrifood relations: the food sovereignty movement against liberal understandings of food security; agroecological perspectives and practices against the industrial agricultural complex and its reductionist 'scientific' knowledge; peasant agriculture against corporate agriculture; the slow food movement against fast-food culture; and 'food from somewhere' against 'food from nowhere', as reflected in the case of local food systems and alternative food networks.

These movements have been advancing a rich set of concepts and demands, including the right to food, food democracy, food justice, fair trade, agrarian citizenship, food citizenship, food and seed sovereignty, and agroecology. On this ground, they have also created platforms and spaces that reconfigure the rural-urban nexus: food networks, ecological and producers' markets, urban agriculture, producers' and consumers' cooperatives, alternative kitchens, and food collectives.

Crucially, unlike mainstream rationalisation attempts, these alternatives advocate for a revaluation and appreciation of peasant and indigenous knowledges. They sharply criticise those rationalisations as capitalist, industrial, colonialist, modernist, Euro-Atlantic-centric, and patriarchal, and so on. Instead, they highlight the wisdom implicit in traditional agrarian and food practices – wisdom often dismissed as archaic by liberal approaches. It is, arguably, on this ground that these alternative imaginaries try to harvest wise futures by re-sowing socio-culturally and ecologically sustainable and inclusive pasts.

With that, the opposition between rational and wise futures, however necessary as a political and analytical distinction, does not capture the full socio-historical depth of what is at stake. To understand the complex relations co-constituting these two broader interrelated counter-tendencies, it is necessary to situate both within the long history of the capitalist food regime and its defining contradictions.

Capitalist food regime: planetary agriculturalisation and the de-agriculturalisation of food

The food regime concept has provided a valuable framework for analysing the historical trajectories of agrifood relations through distinct regimes, each marked by interconnected yet unique dynamics (cf. Friedmann and McMichael, 1989; McMichael, 2013). Building on these insights and by mobilising Marxism as a critical theory of society, this study seeks to contribute to the food regime framework by exploring what unifies these distinct yet related regimes and establishes their fundamentally capitalist character. It argues that agrifood relations throughout the long history of capitalism have been shaped by two intertwined and contradictory tendencies: *planetary agriculturalisation* and the *de-agriculturalisation of food* (Büke, 2025). In this regard, these concepts serve as critical analytical tools for theorising capitalism itself as an encompassing food regime, i.e., different food regimes understood not merely as successive historical periods but as the forms of the contradictory movement of capital as a socio-ecological relation.

Planetary agriculturalisation: Though the emergence of agriculture in human history can be traced back approximately 10,000 years, it is only with capitalism that the planet itself has come to be imagined and reorganised as a giant field. Here, what is at stake are all those processes associated with capitalist development in agriculture, such as commodification, commercialisation, industrialisation, and proletarianisation. These include the transformation of vast areas of land across the Americas, Australia, Africa, and Asia; the intensification of processes through mechanisation and chemicalisation; the so-called Green Revolution technologies and techniques; and the transformation of entire species, plant varieties, and ecological settings. More recently, we have witnessed developments in genetics and biology, the emergence of precision farming and vertical farming, and the increasing use of digital technologies – manifested in slogans such as 'soil as the new data'. The capitalist food regime is, in this sense, the history of planetary agriculturalisation. The relentless emphasis is on the need to produce more, as reflected in the aforementioned mainstream narrative. The rural, nature, life, and being itself turn out to be nothing but a function of agricultural production. As the former prime minister of Türkiye, Binali Yıldırım (2022), put it in a formulation that captures this spirit with unintentional precision: 'Farm! Farm like crazy! Farm everywhere, farm the mountains, farm the stone!'

De-agriculturalisation of food: As capitalism reconstitutes food as a commodity, the primary motive becomes producing food as much as possible, wherever and whenever possible. Food becomes nothing but a 'by-product' of capital accumulation. In this regard, capital confronts the organic, living nature of food and food production as an obstacle to its own valorisation processes. This 'obstacle' is further compounded by the capital's own agriculturalisation of the rural-nature nexus. As capital agriculturalises, it renders agriculture itself increasingly impossible in ecological and social terms; as it does so, it expands its attempts to de-agriculturalise food – presenting this expansion as a solution to the socio-ecological problems it has itself created. It is on these grounds that capital tends to pull apart the historical, cultural, ecological, spatial, and social ties between food and the agriculture-rural-nature nexus. The processes at work here include the despatialisation and detemporalisation of food; its nutrification and technicalisation through developments in substitution technologies, biotechnology, and digitalisation (e.g., the emergence of 'lab-foods' and the tendency to reconstitute 'food as software'). In other words, the capitalist food regime is, in this sense, the history of the deagriculturalisation of food, which can also be traced in the dominant scientific and technological paradigm at each moment. From the late nineteenth century, developments in chemistry and physics led to the extension of the commodity frontiers for food (e.g., synthetic fertilisers, preservatives, artificial colouring, chemical flavourings). From the 1990s, the leading role shifted to biology and genetics – genetically modified organisms, genome editing, and the industrialisation of livestock. More recently, we are witnessing the increasing hegemony of informatics and information technologies, within which agrifood digitalisation represents the latest moment.

Concluding remarks

Within this framework, *rational futures* (i.e., the ontological politics of digital agriculture, its effort to redefine what agriculture, food, nature, and rural mean) is not a rupture from the capitalist food regime but its most recent and most technologically ambitious expression. Agrifood digitalisation creates new frontiers for agriculture (e.g., 'agriculture without farmers'), for food (e.g., 'food as software'), and for agrifood knowledge (e.g., big data, data analytics). However, these 'new' aspects qualify as new only within the trajectories of capital as a socio-ecological relation and its food regime(s). In this regard, agrifood digitalisation is best understood as a discontinuity within the continuity of capital as a moving contradiction.

This framework also helps explain why *wise futures* is not as romantic as it may appear. Alternative imaginaries (food sovereignty, agroecology, peasant agriculture) do not operate outside the capitalist food regime but within and against it. Their project of re-sowing sustainable pasts necessarily engages with a present shaped by planetary agriculturalisation and the de-agriculturalisation of food. Their insistence on the wisdom of peasant and indigenous knowledge is not a nostalgic appeal to a pre-capitalist golden age but a politically grounded claim about the social and ecological adequacy of non-industrial food production – a claim that becomes more analytically plausible, not less, when situated within the systemic critique of what capital has done to both agriculture and food.

It should be noted that the discussion provided here is certainly an oversimplification of a complex terrain and debate. Yet it is hoped that it corresponds to what Donna Haraway (2015: 160) calls 'big enough stories' – narratives that are 'just big enough to gather up the complexities and keep the edges open and greedy for surprising new and old connections.' The contest between rational and wise futures is not simply a contest between the future and the past, between science and tradition, or between progress and romanticism. It is a contest over what kind of social and ecological relations will organise the production, distribution and consumption of food in the coming decades, and, by extension, over what kind of planet we are collectively making. That contest is already underway, and its outcome is not predetermined.

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Clustering mental models of structural change in agriculture: mapping folk ethics of technology and profit

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Abstract

Structural change in European agriculture is widely contested, yet we know little about how people understand its consequences. Using survey data from Germany (N = 1,642), this conference paper examines how respondents expect agriculture to change when profit, technology, or small-scale farming is prioritised, and how desirable they find each model. Latent profile analysis identifies five distinct profiles of expected consequences, across which respondents' desirability ratings are then compared. Most respondents hold weakly differentiated expectations but favour small-scale farming, while only a small minority supports profit-oriented agriculture. Technology appears as a comparatively less polarizing dimension.

Keywords: latent profile analysis, normative preferences, agricultural transformation

Introduction

Across Europe, agricultural land markets are increasingly contested, with growing calls to regulate ownership, limit concentration, and protect small and locally embedded farms. These demands emerge in a context of ongoing structural change, characterized by farm consolidation, technological intensification, and rising land prices (Odening & Hüttel, 2021). While such transformations are often justified in terms of efficiency and productivity, they also raise concerns about rural continuity and the legitimacy of market-based land allocation. As a result, debates over land markets are not only technical but deeply normative, reflecting competing views about what agriculture should look like and who should have access to land.

Despite the prominence of these debates, we know little about people's mental models of structural change in agriculture, understood here as the causal beliefs through which they connect different agricultural priorities with expected social, economic, and environmental outcomes. Existing research typically focuses on isolated attitudes – such as willingness to pay or support for specific policies or products – while overlooking the causal reasoning through which individuals link agricultural policies to their expected outcomes. The available evidence, therefore, suggests a desire for multiple, often competing outcomes, while offering little insight into how individuals reconcile the trade-offs inherent in different models of agriculture.

This paper examines such mental models using survey data from Germany. Respondents evaluated the expected consequences and desirability of prioritizing profit, technology, or small-scale farming in agriculture. Using latent profile analysis, we identify five recurring belief profiles, showing that views on structural change are structured into coherent combinations of causal expectations and normative preferences. In doing so, the study offers an empirical contribution to folk ethics, understood here as the public moral intuitions through which people evaluate desirable and undesirable pathways of agricultural transformation and the role of markets within them (Pies, 2023).

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Methods

The paper uses data from the open-access dataset *Public Perceptions of Agricultural Land Markets in Germany* (Brea Martínez-Collado and Jauernig, 2025), based on a quota-sampled online survey to approximate the adult German population (N = 1,642). Among other objectives, this dataset captures mental models of structural change by asking participants to evaluate whether prioritizing profit, technology, or small-scale farming in agriculture would improve or worsen (1) food quality, (2) consumer prices, (3) product variety, (4) business success, and (5) environmental impact (7-point Likert scale). Additionally, it assesses the desirability of each of these priorities (3-point scale), allowing us to jointly observe causal expectations and normative evaluations, thus forming a mental model.

Groups of respondents with shared mental models of structural change are identified by clustering individuals based on similar expectation patterns across the fifteen outcome evaluations (five outcomes for each of the three agricultural priorities). Latent profile analysis (LPA) is used for this purpose, treating the fifteen 7-point Likert indicators as approximately continuous and grouping respondents according to their joint response patterns rather than predefined categories. Models with two to six profiles are estimated under a constrained specification with equal variances and zero covariances across indicators, chosen as a parsimonious modelling strategy given the relatively large number of indicators and the exploratory aim of identifying interpretable mean-response profiles.

The final number of profiles is selected based on information criteria (AIC, BIC, SABIC), classification quality (entropy), and minimum class size. Although model fit improves with additional profiles, the six-profile solution yields a very small class (<1% of the sample) and does not generate substantively distinct patterns, indicating overfitting. The five-profile solution is therefore retained as the most parsimonious and interpretable specification (Table 1). Differences in desirability across profiles are evaluated using Kruskal–Wallis rank-sum tests.

Profile membership is then used to compare mean desirability ratings for profit-, technology-, and small-scale-oriented agriculture across the five profiles, with differences evaluated using Kruskal–Wallis rank-sum tests.

Results

Our results show that, in general, profit-oriented agriculture is associated with negative outcomes and low desirability. Technology-driven agriculture is linked to improvements in quality and variety but also higher prices, resulting in more mixed evaluations. In contrast, small-scale farming is associated

Table 1. Fit statistics for latent profile models with 2–6 profiles

Statistic	K = 2	K = 3	K = 4	K = 5	K = 6
AIC	69,046.782	67,480.929	66,940.699	66,609.951	66,402.316
BIC	69,295.351	67,815.957	67,362.185	67,117.896	66,996.719
SABIC	69,149.216	67,618.993	67,114.392	66,819.274	66,647.267
Entropy	0.625	0.781	0.833	0.858	0.761
n_min	0.342	0.105	0.033	0.024	0.009
n_max	0.658	0.566	0.585	0.561	0.502

with positive outcomes, particularly for quality and the environment, and is overall the most preferred model despite expected price increases.

The latent profile analysis identifies five distinct belief profiles, shown in Figure 1. The largest group, Moderates (56.1%), holds relatively muted expectations across all pathways, with only slight positive associations for profit-oriented and small-scale farming and largely neutral views on technological change. In contrast, Modernization optimists (8.1%) consistently anticipate beneficial outcomes across all three pathways and stand out as the only group expecting structural change to reduce both food prices and environmental harm. Tech-first optimists (2.4%) express a more targeted optimism, attributing improvements primarily to technology-driven agriculture while holding more reserved expectations for the other pathways. At the opposite end, Structural pessimists (3.1%) anticipate broadly negative consequences regardless of how agriculture develops, indicating a generalized scepticism toward structural change. Finally, Small-scale romantics (30.3%) sharply differentiate between pathways, viewing small-scale farming as beneficial while associating both profit- and technology-oriented agriculture with adverse outcomes.

Desirability ratings further differentiate these profiles (Figure 2). Preferences align closely with the underlying belief structures: Tech-first optimists show a pronounced preference for technology-driven development, while Small-scale romantics strongly favour small-scale farming and are distinctly negative toward profit-oriented agriculture. Moderates and modernization optimists display comparatively broad support across all pathways, whereas Structural pessimists consistently assign low desirability scores. These differences are statistically significant across all three pathways (Kruskal–Wallis tests: profit $\chi^2 = 299.88$; technology $\chi^2 = 90.69$; small-scale $\chi^2 = 150.28$; all $p < 0.001$), confirming that normative evaluations vary systematically with the underlying expectation patterns.

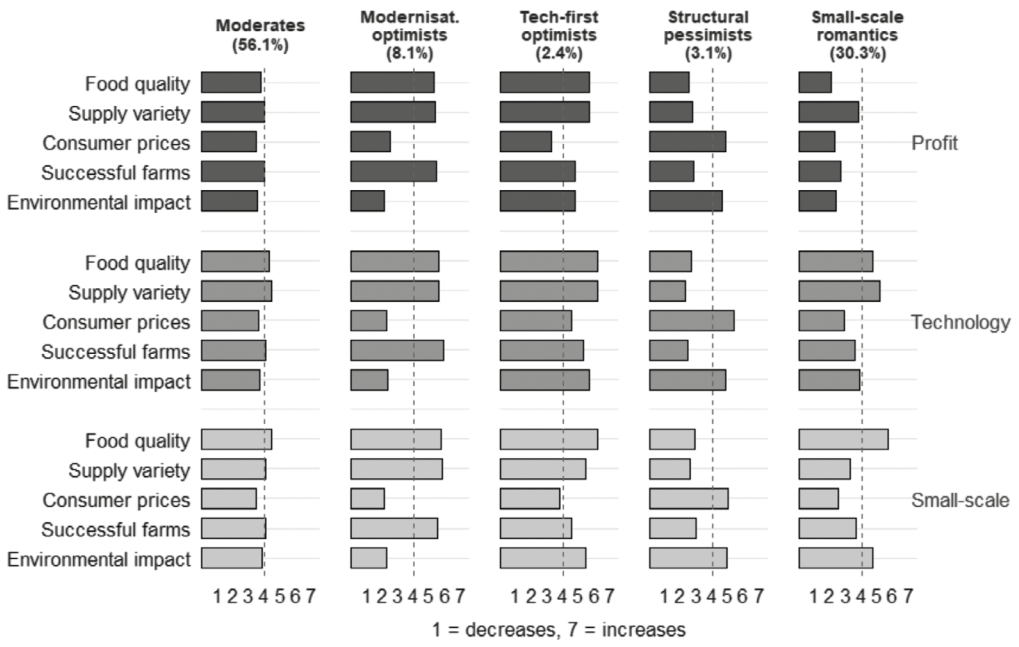
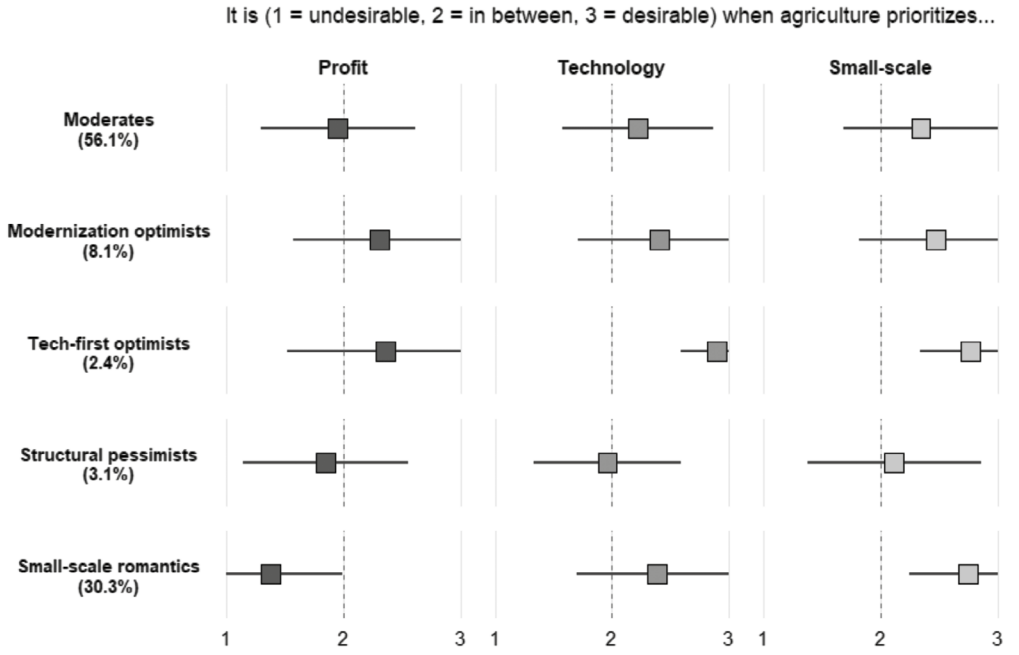


Figure 1. Mean expected effects of prioritizing profit, technology, and small-scale farms

Figure 2. Mean desirability of agricultural priorities across latent profiles. Note: horizontal lines represent standard deviation.



Discussion and limitations

As one might expect, a majority of respondents do not hold sharply defined views about the consequences of different models of agriculture, instead expressing relatively muted or neutral expectations across outcomes. Within this majority, however, there is a clear preference for small-scale farming, which is generally seen as desirable despite anticipated trade-offs such as higher prices. Beyond this group, we observe more polarized views. A substantial minority of small-scale romantics strongly favours small-scale farming while rejecting alternative pathways, whereas only a very small group consistently supports a profit-oriented model of agriculture. This profit-scepticism might help illuminate the broader societal unease with contemporary agricultural systems organized around market returns and scale economies. Oppositely, technology appears as a more integrative dimension, attracting limited opposition and thus offering a potential common ground across otherwise divergent belief profiles.

This relative openness toward technology is especially relevant in light of current debates on digitalisation, automation, and precision agriculture, which are increasingly framed as central pathways of agricultural transformation. The findings suggest that public responses to technological change may depend on the agricultural model associated with each technology. Technology may be more acceptable when perceived as supporting quality, environmental improvement, or farm viability, but more contested when linked to profit-driven consolidation and scale economies. Future research should therefore distinguish more clearly between different forms of agricultural technology and examine whether digital tools are evaluated differently when they are framed as serving small-scale, environmental, or productivity-oriented agricultural futures.

Several limitations should be noted. First, the study relies on a non-probability sample from Germany, which limits generalisation to the wider German population and to other national contexts. Second, the technology pathway is measured in relatively general terms and does not distinguish between specific forms of digitalisation, automation, or precision agriculture. Methodologically, the LPA treats 7-point Likert indicators as approximately continuous, which allows the use of Gaussian mixture models but may smooth over the ordinal nature of the response scale. Finally, the two smallest profiles in the LPA, Tech-first optimists and Structural pessimists, are substantively distinct but should be interpreted cautiously because their small size makes them potentially less stable than the larger profiles.

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Feminist approaches to AI in agri-food

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Abstract

The increasing integration of artificial intelligence (AI) into the agrifood sector has prompted growing attention to its ethical, legal, and social implications (ELSA). While existing scholarship addresses issues such as risk, trust, power, and interdisciplinarity, the gendered dimensions of AI in agrifood systems remain significantly understudied. Preliminary analyses of the small body of literature at this intersection suggest that concerns about justice, fairness, labour, and power asymmetries are recognised, yet deeper engagement with the broader traditions of AI ethics and with structural gender inequalities in agrifood remains largely absent. At the same time, extensive feminist scholarship in agrarian studies has long shown that women face systemic disadvantages in agriculture, including the invisibility of their labour, limited access to land and technologies, and constraints on autonomy within household and market structures. These disadvantages, rooted in colonialism, industrialisation, and capitalist restructuring, risk being reproduced or intensified as AI systems become embedded in agricultural decisionmaking.

Parallel feminist critiques of digital technologies highlight how AI and automated systems often encode and amplify social inequalities. Scholars have demonstrated how datadriven tools reproduce racialised and gendered biases, obscure labour, and reinforce existing power structures under the guise of neutrality and efficiency. Such work underscores the nonneutrality of technology and the ways in which algorithmic design can privilege dominant perspectives while marginalising local, experiential, or subsistencebased knowledge. These insights are especially pertinent for agriculture, a domain historically shaped by extractive models of productivity that disregard ecological knowledge and undervalue women's contributions.

This paper brings these two bodies of research into conversation by asking: What potential insights can genderfocused agrifood and AI ethics literature offer for emerging applications of AI in the agrifood sector? Through a conceptual synthesis, it shows that AI in agriculture is likely to reproduce entrenched gender inequalities if the data, assumptions, and structures underpinning its design reflect existing biases within agrifood systems. Conversely, agricultural histories and power relations shape the knowledge that AI systems draw upon, meaning that agrifood inequities become encoded into computational logics. The interaction between AI and agrifood is therefore reciprocal and mutually constitutive. A feminist lens, one attentive to distributed agency, invisible labour, and ecological and social justice, is essential for ensuring that AI does not deepen inequality but instead supports more equitable, sustainable, and inclusive food futures.

Keywords: gender, feminism, digital technologies, digitalisation

Introduction

Recently there has been an increase in research on the ethical, legal, and social aspects (ELSA) of artificial intelligence (AI) in the agri-food sector (Ryan et al., 2024; van Hilten et al., 2025). A range of topics is being explored, such as risk (Sparrow et al., 2021), power (Ryan, 2020), trust (Gardezi et al., 2023), identity (Ogunyiola and Gardezi, 2022), inclusion (Ayris et al., 2024), and interdisciplinarity (Ryan et

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al., 2023). This research also often involves the impacts of AI on various actors in the agri-food chain, including farmers, producers, consumers, and society.

The impact of AI on women (see Heidari et al., 2016 for a definition of gender) in agri-food remains underrepresented in the literature. Ryan and Rijswijk (personal communications) provided a preliminary examination of trends in the literature on the impacts of AI on gender in agri-food. The most-discussed ELSA aspects in the literature on gender and AI were justice and fairness, costs and other economic aspects, labour, and power asymmetries. However, within the small sample (N=16) that Ryan and Rijswijk analysed, there was little engagement with the broader, more developed line of research within AI ethics literature, nor did the sample look into the structural issues of gender and agri-food more broadly, such as women's capabilities or financial means to access technology.

These thus far seemingly separate bodies of literature show that women in the agri-food sector have often faced disadvantages due to unequal access to resources and opportunities, institutional structures that disadvantage them, systematic exclusion, and confinement to traditional roles (Gondwe, 2024). This disadvantage may be exacerbated by a further lack of access and disparities in the benefits of digital technologies (such as AI) (Gondwe, 2024; Idowu, 2024). Therefore, the design and actual use of digital technologies (such as AI) may pose further challenges to inclusion, diversity, and gender representation in the agri-food sector (McCampbell et al., 2021). The divergence in the design, use, and perceived benefits of adopting AI in the agri-food sector between men and women may further exacerbate existing gender challenges and concerns. In addition, there has already been extensive research on implicit and explicit gender bias caused by AI, intersectional challenges, racial inequalities, and gender imbalances in access to resources and welfare (Benjamin, 2023; Eubanks, 2018; Noble, 2018).

This paper therefore provides a preliminary sketch of feminist scholars in the field of agri-food and of digital technologies and AI, proposes the following research question: What potential insights can the current gender-focused agri-food and AI ethics literature offer for the emerging applications of AI in the agri-food sector? To answer this question, this paper evaluates gender-focused literature in agri-food and AI ethics to identify intersections between the two bodies of research.

Feminist approaches to agri-food

A range of feminist authors have written about gender, and women in particular, in agriculture. Agarwal (2020), for example, highlights the invisibility of female (unpaid) labour in rural family enterprises, as female labour is often labelled as a contribution to the livelihood of the family. This labelling also causes female labour to go unnoticed in data about labour-force participation. The underlying structural issues that cause female labour to be invisible are often related to a lack of skill development, a lack of access to new technologies, and having to do caring tasks in the households, which reduce their efficiency. Shiva (2014) also argues that women's traditional and local seed and food economy is not regarded as productive work, and that the women's knowledge of seed and food has been discounted as knowledge.

Agarwal (2020) furthermore shows that the autonomy of women is further limited in rural family enterprises. Women have limited decision-making power in the enterprise and often do not have the option to work independently (i.e. outside the family enterprise), which allows them to earn money and control these earnings, giving them bargaining power within the household.

Following this same vein, Federici (2005, p. 217) writes that "land is the material basis for women's subsistence work, and the main source of 'food security' for millions of people across the planet", pointing towards the problematic effects of lack of female landownership and the consequences for their subsistence farming practices.

What underpins the above issues is the impact of colonialism, agrarian change, capitalism, commoditization and globalisation, altogether resulting in (global) industrial farming with has as negative consequences that women's labour in farming and food systems becomes invisible; land ownership has become an problem for many women; and thereby subsistence farming and seed sovereignty vanish. Many of the above mentioned authors therefore point to the need for eco-feminism (Shiva and Mies, 2014), which can been seen as a form of resistance to the impact of the colonialism, globalisation, industrial farming, etc. It gives way to ecological sustainability, care work, biodiversity and subsistence farming.

Feminist approaches to AI

Donna Haraway's iconic 'A Cyborg Manifesto' (1985) lays the foundations for discussing feminist approaches to AI. She argues that the boundaries between human, animal, and machine are breaking down, and the cyborg is a symbol of this new hybrid reality. She uses the cyborg as a metaphor for rethinking identity and feminism without relying on fixed categories like gender or nature. Instead, she encourages building flexible, crossboundary alliances in a world shaped by technology. In the context of AI, these blurred boundaries create new spaces as categories are no longer fixed: AI tools and voices become genderless, and the distinctions between knowledge workers and machine workers are also less clear-cut. Thus, AI potentially expands the spectrum of identity and action, allowing for collaboration with AI, through different forms of community building, and communicating and sharing the work between human and non-human agents.

However, as Haraway also argued, technology is not neutral. Building on this idea Noble (2021) emphasises that the design and deployment of digital technologies come with hidden costs (ethical, social, environmental, and political). Because these systems determine what information people see, they shape opportunity, knowledge, and public perception. Therefore, she calls for greater transparency, interdisciplinary oversight, and ethical responsibility in tech development, pushing for technologies built in service of the public rather than corporate power. In her empirical work, she shows that search engines and digital platforms can reproduce racist and sexist stereotypes, particularly harming women and girls of colour (Noble, 2018).

Benjamin (2019) continues on this point as she shows how racism is not only embedded in social institutions, but also encoded into the design of modern technologies. For example, AI may reinforce discriminatory patterns under the guise of objectivity (Benjamin. 2023). Empirically, she points out that the commonly used health care algorithm in the US structurally underestimates the needs of black patients because it is biased to use healthcare costs as a proxy for health care needs. As black patients historically receive less medical spending overall, this design choice meant black patients ran much higher risks than white patients (Benjamin, 2019).

Eubanks (2018) also shows that automated decision-making systems used in welfare, housing, and child protection do not eliminate human bias, but instead encode and intensify longstanding inequalities, disproportionately harming poor and marginalised communities. She argues that these systems reproduce discriminatory assumptions, turn social services into surveillance regimes, and create opaque and punitive digital records that follow individuals across institutions. Rather than delivering fairer outcomes, automated systems often deny essential support, entrench racial and economic disparities, and shift public policy toward austerity and social control. She demonstrates how these systems act as "digital poorhouses," profiling, policing, and punishing the poor under the guise of efficiency and neutrality (Eubanks, 2018).

Eubanks (2007) shows that the problems caused (in part) by digital technologies, creating so-called divides (i.e. digital technology have and have-nots), are not solved through more access to digital

technologies by the have-nots. This "distributive paradigm" obscures structural inequalities and the ambivalence people feel toward technology, limiting the kinds of solutions imagined. For example, by centring on how lowincome women actually experience and interact with digital systems in their daily lives, Eubanks shows that digital equity must address power, surveillance, and lived experience, not just access (Eubanks, 2007).

Suchman (2020) also argues innovation should not be centred around a few (often male, elite) designers, instead emphasising the invisible, collaborative everyday practices, and often feminised labour required to make technological systems actually work. She continues that agency is not a fixed attribute of either humans or machines, but something that emerges through ongoing relations at the human–machine interface. According to her, the agency should be reframed as distributed, contingent, and relational. However, Suchman (2023) warns that AI has come to be treated as a stable, selfevident singular object with agency. She calls for destabilising AI in order to examine how AI is continuously constructed and how its power is reproduced. Thus, she proposes a feminist reimagining of technology design, one that recognises diverse forms of expertise, questions dominant notions of innovation, and opens space for alternative, more socially just relations with machines (Suchman, 2020).

Discussion and conclusion

As the agri-food sector is already shaped by longstanding power imbalances, gendered divisions of labour, and structural inequalities, the likelihood of gendered AI issues arising is high and apparent. The feminist scholars Agarwal, Shiva, and Federici show that women's contributions, especially unpaid, subsistenceoriented, or carerelated labour, have historically been rendered invisible, devalued, or excluded from official data and resource allocations.

When AI systems enter this context, women risk a further digitalisation and amplification of these inequalities. For example, if AI models are trained on data that already excludes women's labour or misrepresents women farmers' knowledge, the resulting technologies will reproduce those biases. Similarly, if AI systems are developed without attention to women's limited access to land, training, or technologies, the benefits of agricultural AI will accrue mainly to those who already hold resources. Following Noble, Benjamin, and Eubanks, this means that agricultural AI may embed hidden ethical, social, and political costs, i.e., algorithmic decisions about credit, land access, resource allocation, or crop recommendations could reinforce discriminatory structures under the guise of efficiency or neutrality.

Conversely, gendered agri-food issues will also arise in AI, because agriculture remains one of the most materially embedded, ecologically dependent key areas of society. As feminist agrarian scholars argue, industrial farming, globalised food systems, and colonial histories shape what knowledge counts, whose labour is recognised, and who controls natural resources. When AI systems draw on agricultural datasets shaped by these histories, e.g., yield records that reflect land dispossession, productivity metrics that ignore subsistence work, or seed databases built on corporate intellectualproperty regimes, the resulting AI models can become complicit in the same extractive, commodifying logics. The epistemic issues highlighted by Shiva and Federici, where women's local agricultural knowledge is discounted, mirror the epistemic issues Noble and Benjamin identify in AI, where marginalised knowledge is excluded from training data. This means that agricultural AI may continue to privilege industrial, input-intensive, corporate farming paradigms while erasing the ecological, communal, and subsistence-oriented agricultural practices central to eco-feminist visions of sustainability.

These two domains interact deeply because both agriculture and AI are sociotechnical systems shaped by everyday practices, power relations, and histories of inequality, as Suchman emphasises. Neither technology nor farming practices are neutral: both are coconstructed through relationships, labour, and

situated knowledge. If AI is layered onto agri-food systems without recognising the gendered, colonial, and capitalist structures that have shaped those systems, AI will automate precisely the injustices that feminist agrarian scholars critique. At the same time, the introduction of AI into agri-food reshapes social relations: it changes who is recognized as a knowledge holder, who is considered an innovator, and who gains or loses agency in decisionmaking. Drawing on Haraway and Suchman, we can see that assemblages of agri-food and AI redistribute agency across human and nonhuman actors, potentially opening up hybrid forms of identity, collaboration, and resistance, but only if designed with a feminist, relational, justicecentred lens.

To conclude, AI ethics issues will arise in agriculture because AI reproduces the structural biases already present in agri-food systems. Agri-food issues will arise in AI because the data, values, and knowledge embedded in agricultural practices become part of AI's computational logic. Their interaction is therefore reciprocal and mutually constitutive. A feminist perspective, one attentive to distributed agency, invisible labour, and the need for ecological and social justice, is essential for ensuring that AI in agri-food does not deepen inequality, but instead contributes to more equitable and sustainable food futures.

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Non-economic values and climate loss and damage: the case of traditional agricultural practices

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Abstract

Climate loss and damage become increasingly severe. Much is non-economic and can only be addressed if the voices of the people affected are included in the policy process. However, the ethical literature engages with how such inclusion should be designed only insufficiently. To address this gap, the paper presents a typology of ideal types of inclusion processes. This typology is intended to be a tool that highlights potential value conflicts and trade-offs when choosing a particular inclusion process. As proof of concept, the typology is applied to the case of the loss of traditional agricultural practices due to climate-induced displacement.

Keywords: climate change, non-economic loss and damage, compensation, procedural justice

Introduction

The impacts of climate change become increasingly severe. As a result, many humans are suffering from adverse consequences. Some of these impacts, non-economic loss and damage (NELD), cannot be measured or addressed with monetary means. The climate ethical literature argues that to remedy these impacts, the value judgments of the people affected by NELD should be included in loss and damage policy (Page and Heyward, 2016; Wallimann-Helmer, 2015). However, beyond the argument that inclusion is important, engagement with how such inclusion should be designed is limited.

This paper presents a typology of ideal types of inclusion processes for loss and damage policy. This typology can help to highlight the tensions that may arise between the different values that underpin particular inclusion processes. This allows some of the trade-offs that need to be made when designing inclusion processes for loss and damage policy to be illuminated without prescribing a single solution for all cases. As proof of concept, I apply the typology to the case of the loss of traditional agricultural practices due to climate-induced displacement.

First, I begin by introducing NELD. Second, I show why it is important that the voices of the people affected are considered in compensatory loss and damage policy. Third, I introduce my typology. Fourth, I show how this typology can be applied.

Non-economic loss and damage

In loss and damage policy, two kinds of climate impacts are distinguished: economic and non-economic loss and damage (NELD). Economic loss and damage are generally understood to be adverse impacts of climate change to goods that are traded on markets, therefore have an economic value, for example a car. NELD is considered to comprise the adverse impacts of climate change to goods that are not normally traded on markets and thus that do not have an economic value, such as cultural practices (UNFCCC, 2013).

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However, this distinction is problematic because it does not take into consideration that goods traded on markets can also have non-economic value (Tschakert et al. 2019). For instance, the house one calls home has a price on a market but is also non-economically valuable as a home. Furthermore, economic impacts, such as the loss of a particular occupation, can lead to non-economic impacts, such as a loss of psychological well-being. Moreover, the ability to engage in a certain occupational practice, for example traditional agriculture, may also hold non-economic value for those engaged in it (Abu et al., 2024).

For these reasons, I do not focus on goods in this paper but on the value that these goods hold. I assume that goods can have both economic and non-economic value (Marx, 1969). They have economic value if they are traded on markets. And they have non-economic value if they are valued by people aside from their function as commodities on markets, for instance a house as a home in contrast to a house as a capital investment (Kräuchi and Walliman-Helmer 2024).

Thus, economic and non-economic loss and damage can be defined as follows: economic loss and damage occurs when climate change adversely impacts economic value, for instance by destroying the commodity value of infrastructure. NELD occurs when climate change adversely effects non-economic value, for instance by destroying a house valued as a home. NELD is therefore always established in relation to a value held by particular people. In the next section, I discuss what this implies from an ethical perspective.

Compensating loss and damage

Generally, the occurrence of any loss and damage is understood to be an injustice. The people that typically suffer from climate loss and damage are neither historically responsible for climate change nor in a position to deal effectively with its consequences (IPCC, 2022). Loss and damage predominantly affect poor people in the so-called Global South. Hence, the international community is generally understood to bear a moral obligation to address loss and damage, including NELD (García-Portela, 2025; Page and Heyward, 2016; Wallimann-Helmer, 2015, Wallimann-Helmer et al., 2019).

So far, the moral obligations arising from climate loss and damage have often been articulated in terms of compensation (Düvel and García-Portela, 2024; Page and Heyward, 2016; Wallimann-Helmer, 2015). Those suffering from loss and damage are owed compensation for these impacts either by those who caused the impact or by those most able to assist.

In these compensatory approaches, NELD, especially non-economic loss, is a particularly problematic case: because there is no obvious monetary equivalent to the value impacted, compensating it becomes difficult. It is argued that because of this, the people suffering from NELD need to be included in the process of compensation because they may be able to say what kind of good could rectify the well-being they formerly derived from the non-economic value (Goodin, 1989; Page and Heyward, 2016; Wallimann-Helmer, 2015).

A typology of inclusion processes

The compensatory approaches sketched above give two main reasons why it is important to include the people affected in loss and damage policy. Firstly, there are epistemic considerations: these people hold the information needed to calculate the appropriate compensation (Goodin, 1989; Page and Heyward, 2016; Wallimann-Helmer, 2015, Wallimann-Helmer and Kräuchi 2025). Secondly, people should be included because compensation in the end is about respecting autonomy (Heyward and Ödalen 2016; Wündisch 2021). If it is impossible to respect the autonomy of people by giving back what they had before the loss occurred, they should be able to have a choice in how they are compensated and preserve

their autonomy through this choice. I take these two principles as the starting point for my typology of inclusion processes.

I begin by considering the epistemic principle. People affected by NELD should be able to accurately provide the information needed to assess the non-economic value impacted by climate change. Hence, any inclusion process that is supposed to satisfy this demand needs to be epistemically adequate for its purpose. These can formally be defined as follows: An inclusionary process for loss and damage compensation policy is epistemically adequate for purpose if, and only if, it accurately represents the non-economic values impacted by climate change.

Although this principle appears quite clear intuitively, it can be interpreted in several significantly different ways, and substantial tension can arise between these interpretations. First, tension may arise about how accurate representation can be understood. Some people may be concerned that people misrepresent or overrepresent the values they hold and thus distort the objectivity of the processes (McShane, 2017; Newey, 2016). From such a point of view, combining local knowledge with expert assessment will be important to safeguard objectivity. Conversely, others may be concerned that insufficiently respecting people's value judgments could distort the processes and may expose these people to epistemic injustice (Fricker, 2007; Longino 1990). From this point of view, control over the epistemic policy process should be given entirely to the people affected. Second, the principle above leaves unclear whether individuals or groups should be included in the processes. It may be argued that individuals are the valuers; thus, it is primarily they who should be included (McShane, 2017). Such a position would seek to ensure that individuals can voice their judgments as uninterruptedly as possible. Conversely, it may be claimed that values emerge in social groups, and thus it is central for such groups to be included in the processes (Schlosberg, 2012). Hence, groups would need to be the protagonists in the epistemic processes.

I now turn to the autonomy principle. People who suffer from NELD are disturbed in their chosen life plans. Thus, to respect their autonomy, they should be able to decide autonomously how to continue their lives after the injury occurred. Formally, an inclusionary process for loss and damage compensation policy respects the autonomy of people affected by NELD if, and only if, the process allows them to decide how to continue living their lives.

Again, this principle is vaguer than it may initially appear. First, what allowing people to decide how they continue their lives means may remain unclear. Proponents of a strong view of autonomy may believe that such decision rights should be quite expansive and are only allowed to be constrained if they violate fundamental rights of other people (Nozick, 2013). A policy process building on this conception will leave ample space for individual choice. Conversely, others may be concerned that a strong autonomy-based approach will allow people to choose more than they deserve (Dworkin, 1981). Hence, such a position will be more focused on what restrictions may legitimately be placed on choice by other normative demands and will, hence, leave less room for choice than the first interpretation. Second, the tension between individual and group emerges also emerges in this case. The most important choice to respect may be argued to be individual choice (Berlin, 1997). A process building on this conception may need to protect individual choice against group influences. Conversely, collective self-determination may be argued to be key, and hence groups as a whole should be able to decide (Pettit, 2003). Thus, policy processes guided by this ideal need to ensure that groups can express their collective decisions adequately.

Furthermore, tension exists not only between the interpretations of the two normative principles but also between the principles. If inclusion is driven by epistemic reasons, the accuracy of knowledge about non-economic losses and damages becomes central. The aim of the compensatory project is to replace the originally held value as completely as possible. If respect for autonomy is the underlining value of

the compensatory project, the aim of the project is to secure the autonomy of the people involved. Therefore, whether what the people choose is close to what they held before loss and damage occurred is only of secondary importance.

Following these remarks, the typology of inclusion processes for loss and damage policy can be organized according to the processes' normative aims. First, one can generally distinguish between processes that seek epistemic adequacy and processes that seek respect for autonomy. Second, within epistemically focused processes, one can distinguish between processes that understand ideal epistemic processes as something external and expert driven, and processes that understand this ideal as governed by the value judgments of those affected. Third, within autonomy-focused processes, one can distinguish between processes that emphasize the importance of constraints on autonomy and those that emphasize the free decision of those affected. Finally, for all options, one can distinguish between approaches that focus on individuals and approaches that focus on groups (see Table 1).

Of course, these are ideal types. In reality, combinations of ideal types are possible. However, as the discussion before highlights, whenever such a combination occurs, some of the values underlining the pure ideal are lost. For example, if one combines Choice Power with Value Judgment, a compromise between both will be necessary. Although in both cases, the people affected by loss and damage take centre stage, they do so in different ways. Processes that focus on Value Judgement still prioritize the accuracy of values and compensation that is as close to the original as possible. Conversely, processes that focus on Choice Power prioritize the free choice of people affected without being much concerned with the accuracy of the values included or whether compensation comes as close to the originally held value as possible. Hence, a combination of the two needs to make a trade-off between maximizing the free choice of the people affected and allowing them to represent their lost value as accurately as possible.

It is beyond the scope of this paper to investigate all the detailed reasons to prioritize one of the ideal types over the other. The typology is intended as a tool to highlight the different values underlining types of inclusion processes and the trade-offs that may occur between them. In the next section, I briefly apply the typology to loss of agricultural practices due to climate-induced displacement.

Applying the typology to the loss of traditional agricultural practices

Climate change impacts many environmental conditions that influence the success of agricultural practice. Variations in weather patterns may impact irrigation. Temperature rise may impact which crops can be grown. Desertification may impact soil capacity. In some cases, traditional agricultural practices

Table1. Typology of inclusion processes

	Epistemic Adequacy for Purpose		**Respect for Autonomy**	
	External Knowledge	*Value Judgment*	*Additional Considerations*	*Choice Power*
Individuals	Individuals as informants for external epistemic process	Individuals as main source of knowledge.	Additional normative considerations take priority over individual choice.	Individual choice takes priority over additional normative considerations.
Groups	Groups as informants for external epistemic process	Groups as main source of knowledge.	Additional normative considerations take priority over group choice.	Group choice takes priority over additional normative considerations.

may be able to adapt to the changing environment by changing irrigation patterns, using other varieties, and employing fertilizers. In other cases, they will encounter limits to adaptation (Dow et al., 2013). In such cases, people engaged in these practices will be affected by loss and damage.

A drastic case of loss and damage in such cases is displacement. When the environmental conditions of a place degrade too far, people may be forced to relocate to find new livelihoods (Cattaneo et al., 2019). In some cases, whole communities need to relocate because the place where they live has become unsafe and is no longer able to provide them with what they need to sustain their livelihoods. For example, parts of the village Keta, in Ghana, were relocated because of the threat of sea-level rise and the reduced opportunities of the villagers to sustain their lives through fishing (Abu et al., 2024).

The people displaced in such cases suffer from NELD because they lose connection to their traditional forms of agriculture, which can hold significant value for them (Abu et al., 2024). Hence, from the compensatory approach developed here, they should receive a remedy for the impacts incurred. Moreover, because non-economic values are affected, the people affected need to be included in the loss and damage policy processes.

Depending on the ideal type of inclusionary process that is chosen, quite different concrete policies will be implemented. For instance, an epistemic approach to compensating loss and damage in this case will require that people are compensated in kind as much as possible. This may imply that where possible they can continue their traditional forms of agriculture on new territory. Hence, it will be important to include these people in a way that provides adequate information about which territories may be suitable for reinstating their agricultural practices. Conversely, if the loss and damage policy focuses more strongly on respect for autonomy, it is more important that these people can choose a new way of life than that they are accurately compensated. Hence, a process guided by this ideal may be more transformative and may imply determining how people would like to live together without focusing on their tradition too much.

Moreover, if a general approach is chosen, the more fine-grained ideal types may help to spell out a more detailed approach to inclusion. For instance, if the general aim is to focus on autonomy, and it is further decided that individual choice is important, a solution may be to implement a labour migration policy that allows individuals to move as they prefer to occupations close to their former occupations or to new ones. Conversely, if the focus is more on group choice, a planned community relocation policy may be implemented in which the people affected can decide collectively on what to do and where to move.

Of course, more arguments need to be provided for why one ideal type should be chosen over the other. These arguments may also depend on the broader context in question. Nonetheless, the typology helps to highlight which options are possible and what kind of values are embedded in these options. Thus, it can help make such planning processes more transparent.

Conclusion

In this paper, I followed the argument that to address NELD, the people affected need to be included in the loss and damage policy processes. I presented a typology of normative ideals that could guide such inclusion processes. This typology highlights various potential ideal types of inclusionary processes by illuminating the values that underpin them. Although the typology does not prescribe which ideal type to choose, it can help such a decision process by showing the tensions between the underlining values and the trade-offs that need to be made between them. As proof of concept, I applied the typology to the loss of traditional agricultural practices due to climate change induced displacement.

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Postcolonial development of colonial red cattle: livestock diversity and market selection

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Abstract

The purpose of this paper is to establish how Korean cattle, imported in large numbers to the colonial metropolis during the colonial period, were received in post-war Japan, and to explore how they came to be recognised as a distinct foodstuff, thereby contributing to the diversity of livestock.

When Korea became a Japanese colony, tens of thousands of red cattle, mainly females, were exported from Korea to Japan every year. They became widespread as draught animals for agricultural work, supporting Japanese rice cultivation; where their strength waned, they were slaughtered to fill the stomachs of the Japanese people, serving as an important source of animal protein. Even after the collapse of the imperial order, Korean red cattle remained in Japan and continued to be an indispensable presence in rural areas; consequently, Japan's period of rapid economic growth dealt a severe blow to the red cattle industry. With the mechanisation of agriculture, their importance as draught cattle diminished, and the red cattle lost their competitiveness in this role. At the same time, as beef consumption rose due to rising incomes among the Japanese, the fatty texture of the meat became popular, and during grading, black cattle – which possess large amounts of fat – came to be favoured as beef cattle. Consequently, red cattle lost their market competitiveness and, facing intense pressure from black cattle and imported beef, their numbers declined sharply. That said, as excessive fat intake is now recognised as having a negative impact on health, the nutritional merits of red cattle are being re-evaluated, and they are attracting renewed attention as beef cattle. Thus, through the post-colonial development of colonial cattle, the diversity of livestock has changed significantly under the influence of shifts in the market economy driven by changes in the role of livestock and rising national income; however, new shifts in consumer preferences are now prompting a re-evaluation of the status of red cattle.

Keywords: Japanese cattle, beef market, assessment criteria

Introduction

Japan was the first country in East Asia to achieve modernisation, and through the Sino-Japanese and Russo-Japanese Wars, it joined the ranks of the imperialist powers. The Japanese Empire established a territorial sphere comprising a long, narrow chain of islands stretching from the Kuril Islands and Sakhalin through the Japanese archipelago to Okinawa, and further to Taiwan and the Ogasawara Islands, as well as a continental territory extending from the Korean Peninsula to Manchuria. Within this realm, colonial Korea was reorganised as a supply base for the Japanese mainland, providing primary commodities such as foodstuffs. Whilst rice was the principal export, Korean cattle were equally essential for agriculture in Japan. It can be argued that the export of cattle, whilst placing pressure on agricultural production in colonial Korea, served to strengthen the agricultural foundation of the Japanese mainland as the colonial power.

Whilst Japanese cattle were predominantly black-haired, the majority of Korean cattle were red-haired. Korean cattle had been imported from Korea even before the colonial period; not only were they

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cheaper than Japanese cattle, but they were also larger in stature and more robust, making them highly resistant to disease. They could endure severe cold, intense heat, wind and rain, as well as a coarse diet, thereby reducing the labour required for their rearing and management. They were put to work in tasks ranging from ploughing to cultivation, weeding, threshing and transport, and were also used for manure production, which resulted in good fattening and fertility. When they became too old to be suitable for farm work, they were slaughtered and became a source of protein for the Japanese people (Lim 2019).

This paper therefore seeks to establish how Korean cattle, imported in large numbers to the colonial metropolis during the colonial period, were received in post-war Japan, and to explore how they were re-recognised as a distinct food ingredient, thereby contributing to the diversity of livestock.

From Korean cattle to Japanese red cattle

The number of draught cattle fell to 1.82 million in 1946 due to the effects of the war. This represented a decrease of 15 per cent compared with the 1944 figure, and the situation was such that an urgent need was identified for an increase in the number of cattle. Consequently, as part of the Five-Year Plan for Livestock Promotion (1947–52), which aimed to restore livestock numbers to their pre-war peak, the intention was to increase the draught cattle population to 2.2 million head. The decision was taken to increase the population of beef cattle in order to promote the industry and ensure the security of meat and leather resources (General Affairs Division 1972, 21-32). This policy was based on economic and efficiency considerations relating to agricultural production as a whole. It viewed cattle purely as a source of traction, similar to a tractor, and was designed to increase agricultural production. The measures implemented included the establishment of designated breeding zones for cows, the promotion of artificial insemination, and the implementation of special measures to ensure the provision of feed for those managing breeding cows. In addition, there was an emphasis on the enhancement of breeding practices in key production regions, alongside the identification and establishment of new suitable areas for agricultural development. This was accompanied by the promotion of pasture utilisation and the conversion of forested land into agricultural domains. In addition, The Ministry of Agriculture and Forestry (MAF) strived to disseminate techniques for the training and utilisation of cattle, with a view to preventing miscarriages and tick-borne fever. Furthermore, the resumption of imports of Korean cattle and the establishment of a registration association for Japanese cattle were considered.

Following the Second World War, the importation of Korean cattle had been completely halted, and the trend towards switching from horses to cattle – which had begun in the Tohoku region and spread nationwide – began to manifest itself in a surge in demand for brown-haired Japanese cattle. Concurrently, within the context of the establishment of independent smallholder farms following the land reform, farmers' attention was directed towards the red cattle for working stock, thereby further accelerating this trend. In the context of the prevailing social climate of the time, which espoused the sentiment that "as long as you produce, and as long as it has four legs, you can make a fortune," there was an acute shortage of draught cattle, so the more red cattle that farmers could produce, the greater their guaranteed profitability would be. It is unsurprising that in prefectures such as Kumamoto, which held the position of supplying breeding stock to the whole country, a profound sense of responsibility weighed heavily upon those involved (Kuwahara 1962, 4-11). Red cattle exhibited superior performance in agricultural work when compared to black cattle, while also being more cost-effective (Okamoto 1962). Consequently, as demand for brown Japanese cattle increased, it became imperative to enhance their market value in conjunction with the expansion of the brown Japanese cattle population.

Consequently, in April 1952, the Japanese Red Cattle Registration Association (JRCRA) was established, with Kumamoto and Nagasaki Prefectures as its founding members. The establishment of branches in 13 prefectures across the Tohoku, Kanto, Koshinetsu and Kyushu regions resulted in a significant

increase in membership, surpassing 60,000 individuals. The association's primary objectives included the revision of judging standards for the Brown Japanese breed, the streamlining of the scoring system, and the registration of blood types. The association proposed the organisation of pedigree cattle shows featuring parent-and-calf pairs, and the inaugural Japanese Brown Cattle Pedigree Show was held in Kikuchi, Kumamoto Prefecture. It was during this period that Kumamoto Prefecture began to function as a supplier of red cattle.

In considering the development of the red cattle breed in Kumamoto Prefecture, it is important to acknowledge the role of the government in promoting livestock farming. From approximately 1881 to 1887, philanthropists made significant efforts to enhance the red cattle breed by utilising Devon breed bulls, which were derived from the Korean strain of red cattle. However, these efforts were discontinued because the resulting cattle became too large and unsuitable for draught work. Subsequently, in 1900, the government established a policy to improve Japanese cattle through crossbreeding with foreign breeds. From then until the 1910s, several foreign breeds, including Simmental and Brown Swiss, were used to improve the red cattle. In particular, from 1922 onwards, the breed was imported directly from Switzerland, and improvement was pursued exclusively through crossbreeding with Simmental. Consequently, under the explicit breeding objective of producing economical draft and beef cattle with increased body size and a uniform brown coat colour, whilst maintaining a bloodline percentage of 25% or less, repeated selective breeding was carried out (Aso Branch 1990, 5-12). This endeavour, spearheaded by government research institutes, culminated in the meticulous development of the ideal dual-purpose cattle with brown hair. The cattle were then distributed to private livestock farmers.

In 1923, a standard body type for Higo cattle was established, and efforts were made to improve the breed by introducing registration regulations and judging standards. However, these efforts did not yield particularly favourable results. In 1933, a comprehensive revision of the standard body type and evaluation criteria was initiated, thereby laying the foundation for subsequent advancements. By 1940, the Imperial Livestock Association (formerly the Central Livestock Association), which functioned as the central registration body at the time, had established evaluation criteria for the Japanese red cattle breed that were common to both Kumamoto and Kochi Prefectures. Subsequently, in 1944, Japanese cattle 'Wagyu' were recognised as a fixed breed, and the cattle of both prefectures came to be collectively referred to as the Japanese red cattle breed (Uesaka 1956, 33-34). This breed was created by the state through a process of cross-breeding Korean cattle with Western breeds, followed by repeated selection, with the aim of producing a distinctly Japanese breed. Subsequent to the war, the JRCRA spearheaded the initial revision of the judging standards in 1957, which emphasised that the breed should be 'docile in nature, robust in constitution, highly efficient in feed utilisation, strongly adaptable to the environment, and possess vigorous fertility and the ability to produce multiple calves. In order to be effective in the role, the candidate should be able to demonstrate strength, speed and endurance. As a meat breed, they should be characterised by early maturation and rapid fattening, coupled with excellent meat quality and high meat yield." These criteria were established in 1957 following a public hearing involving the Central Examination Committee, the Live Cattle Research Association, and the Eastern and Western Regional Committees (Japanese Red Cattle Registration Association 1982, 22-31). This represented a fundamental shift in emphasis from the primary focus on draught use to the prioritisation of meat production capacity. Subsequent revisions were made as necessary to ensure the continued efficacy of the initiative.

Consequently, while the red cattle's popularity persisted as draught cattle and exceeded 20% in the late 1950s, the market surrounding the cattle trade underwent substantial changes.

An evaluation of the market and the prospects for the survival of red cattle

Following the implementation of the Five-Year Plan for Livestock Promotion, there was a steady increase in the number of draught cattle. However, with the development and widespread adoption of agricultural machinery such as tillers and tractors, red cattle were no longer regarded as draught animals but were reclassified as beef cattle. Concurrently, the period of accelerated economic growth commenced, characterised by an increase in the average income of the Japanese population and heightened demand for meat. This precipitated a transition from draught cattle to beef cattle.

As previously stated, the evaluation standards underwent a revision that placed greater emphasis on characteristics relevant to meat production. However, given that 'the shortage of beef cattle had already become a problem for the relevant authorities', meat-type conformation was further taken into account, and the evaluation standards were revised in 1962. The emphasis placed on body volume and growth is indicative of the close relationship between these factors and meat-producing capacity or productivity. By 1966, in response to the prevailing trend of shifting from draught to beef cattle, all sections relating to draught capacity as a breeding objective were removed. In relation to the standard conformation, a comprehensive review was conducted by the JCRCA's Central Review Committee with the objective of aligning it with the revised strategic direction, which reflects changes in demand for beef. This entailed a streamlining of the standard conformation criteria, focusing on key performance indicators such as body weight, height, and chest circumference ratio. Concurrently, the criteria for the supplementary point assessment underwent a comprehensive revision. During the fourth revision of the evaluation standards in 1970, the direction towards beef cattle was established, taking into account the practices of the carcass trade (Japanese Red Cattle Registration Association 1982, 22-31).

Concurrently, studies into direct and indirect methods of testing for meat production capacity were conducted from the early 1960s onwards, with the objective of enhancing the selection of breeding stock from the conventional focus on conformation to a system based on meat production performance test results. These methods were implemented in the 1967 and 1968 financial years, respectively, and played a significant role in the early improvement of meat production traits. The Breeding Stock Production Base Development Project was initiated in the 1970 financial year as part of a national breeding programme. This process entailed the deliberate mating of superior cows, the selection of top-tier sires from the resulting male calves through meat production ability testing, and the utilisation of female calves to replenish the foundation herd. Consequently, the enhancement of meat production capacity has been encouraged through the utilisation of this approach (Okamoto 1962, 31-54). The implementation of government policy was predicated on the objective of augmenting meat production capacity.

As demonstrated in Figure 1, the population sizes of both black and red cattle exhibited an increase until the early 1950s. However, with the advent of agricultural machinery and the subsequent obsolescence of draught cattle, the number of cattle kept underwent a precipitous decline, a trend that persisted until the early 1970s. The mechanisation of agriculture and the transition to large-scale livestock farming have resulted in the separation of cattle from farmers' daily lives as working partners. Consequently, the way of life in which humans and livestock once lived together as 'family' and learned about the cycle of life and death has been lost, creating a significant cultural divide between humans and livestock. Consequently, the number of red cattle declined even more sharply. The population of black cattle exhibited fluctuations over time, yet demonstrated an increase in the long term. Conversely, the population of red cattle underwent a precipitous decline, reaching mere tens of thousands and constituting a mere 1% of the total cattle population. This phenomenon is hypothesised to be the result of competition between black and red cattle, as well as the commencement of beef imports from overseas, which experienced a significant increase following the liberalisation of beef imports in 1991. It is important to note that,

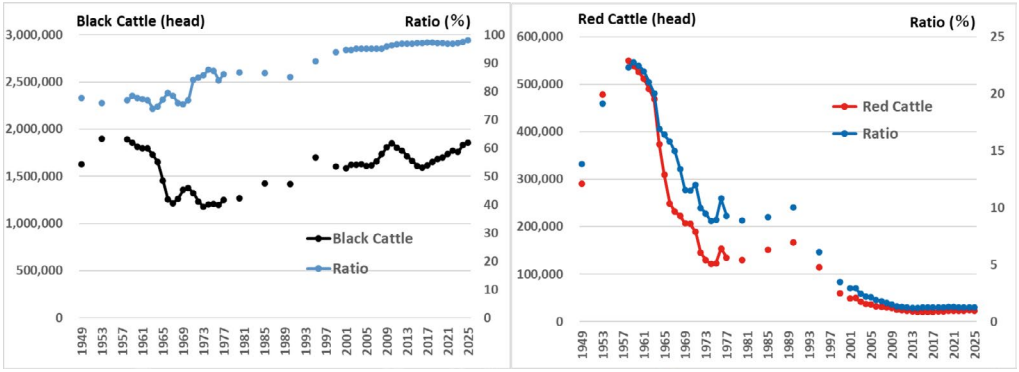


Figure 1. Number of red and black cattle in Japan. Sources: Livestock Bureau annual editions; Statistical Survey Division annual editions; Uesaka 1956, 16; National Beef Cattle Association 1978; Inoue 1993, 67; Matsukawa 2010, 72-77; Statistics Bureau 2026.

even within the same market environment, black cattle have gained momentum for recovery. However, it is pertinent to consider whether red cattle are destined to follow a path of decline.

The Japanese black cattle breed is renowned for the quality of its fattened beef. While it is only natural for fattening farmers to pay a higher price for calves of breeds expected to fetch high selling prices, breeds with higher calf prices tend to yield greater profits from calf production if production costs are similar. This leads to an increase in the number of cattle raised. The Japanese black cattle breed was high-priced and profitable due to its high market value, whereas the red cattle breed can be described as intermediate between high-price and low-production-cost types. In other words, it offered reasonable price potential while also being able to withstand extensive grazing-based management to a certain extent (Inoue 1993, 66-68). Consequently, in the case of black cattle, modern livestock farming systems – which prioritise efficiency and mass production and involve rearing livestock at high densities in confined spaces – have become the norm. Conversely, the practice of grazing red cattle on pastureland persists to the present day.

In April 1988, the 'Beef Trading Standards' were revised, moving from a comprehensive evaluation system to separate systems based on 'Yield Grade' and 'Meat Quality Grade'. This introduced a 15-tier rating system ranging from A-5 to C-1 (Japan Meat Grading Association 2026). The aim at that time was to differentiate imported beef by 'refining the marbling – a characteristic unique to Japanese cattle, particularly the black breed.' As can be seen in Table 1, while black cattle cannot be said to be superior to other breeds in terms of growth potential, they are the finest among Japanese domestic cattle in terms of marbling and intramuscular and subcutaneous fat (Inoue 1993, 66-68). Consequently, alongside promotional efforts and in response to consumer preferences favouring marbling over lean meat, breeding improvements centred on black cattle were undertaken while controlling their feed simultaneously. In particular, as oleic acid has a low melting point and imparts a smooth texture, and as high levels of it enhance flavour, the oleic acid content of beef fat was recognised as influencing palatability. Consequently, great importance was placed on producing beef with fine, abundant marbling. In this regard, as red cattle are inferior in terms of marbling, the shift towards rearing black cattle, which command the highest prices in the beef market, was inevitable. The cattle industry has undergone significant changes in response to shifts in the role of livestock and the transformation of the market economy, driven by rising national income. This has resulted in a notable shift towards a single breed of cattle, namely the black cattle. Consequently, livestock diversity has been jeopardised, and modern

livestock systems – which prioritise efficiency and profitability by rearing animals at high densities in confined spaces – have become the norm.

However, it has been demonstrated that excessive daily consumption of heavily marbled meat has been associated with an increased risk of obesity, lifestyle-related diseases, indigestion and cardiovascular disease. Of particular concern is the issue of excessive intake of 'saturated fatty acids' and systemic inflammation caused by the accumulation of visceral fat. In this regard, red cattle beef has come to be recognised as a healthy food option because, unlike black cattle beef, it is not greasy; it is low in fat yet rich in high-quality protein, iron and taurine, which aids in recovery from fatigue. Due to its rarity, the focus in the foodservice industry has been on its consumption, resulting in a supply deficit (Ozaki 2026). In light of the prevailing trend towards health consciousness among the general consumer population, there is a strong probability of an increase in the consumption of red cattle.

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Perception bias in assessing rodent welfare during euthanasia and anaesthesia

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Abstract

Although euthanasia is routine in animal experimentation, its welfare implications, particularly for commonly used methods such as carbon dioxide (CO_2), remain debated. Euthanasia has also been described as being ethically challenging for those who perform it and linked to moral distress and compassion fatigue. Next to perceived unjustified reasons of killing (e.g., surplus animals), the welfare of rodents and uncertainty about the level of suffering also adds to uncertainty in decision-making and subsequently in ethical uncertainty.

Animal welfare is a key criterion for evaluating euthanasia methods; however, prior work by Baker & Hickman (2018) showed that welfare assessments of mice can be influenced by contextual framing, with identical videos interpreted differently when presented as anaesthesia versus euthanasia. Their findings have been described as perception bias when evaluating rodent welfare. Such perception bias may compromise objective welfare assessment during euthanasia. The aim of this pilot eye-tracking study was to investigate the presence of perception bias in evaluations of mouse welfare, the areas of visual attention of the mouse body and simultaneously gain insights into the reasoning of the observers.

35 professionals viewed four short videos depicting either anaesthesia or euthanasia of mice in a randomized cross-over design. During video observation, participants verbalized their interpretations using a think-aloud protocol. After each video, participants rated rodent welfare on four 0–9 Likert-scale items assessing fear/escape behaviour, respiratory distress, and overall distress. Quantitative data, including ratings, were analysed using linear mixed-effects models. Qualitative data were analyzed by thematic coding. Eye-tracking data were analysed descriptively, using dwell time as a proxy for attention to body regions relevant to welfare indicators and to distractors.

Euthanasia was rated as significantly more distressing than anaesthesia. Importantly, anaesthesia videos that were incorrectly framed as euthanasia were rated as significantly more distressing than the same anaesthesia videos when correctly framed. This indicates the presence of systematic bias. In contrast, eye-tracking results showed that participants focused on similar body regions across conditions, suggesting that contextual framing influenced interpretation rather than visual attention. Qualitative findings supported this pattern: participants particularly highlighted the difficulty of distinguishing escape or fear-related behaviour from exploratory actions, and they also described respiratory and grimace-based indicators as difficult to interpret in isolation.

The findings of our pilot study indicate the potential of a perception bias when aiming to assess rodent welfare during euthanasia. It is unclear if this perception bias is associated with demographic factors or could be mitigated by specific training. It also became evident that the classical welfare assessment tools, i.e., grimace face scale, are typically not designed for welfare assessment during euthanasia.

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Introduction

In laboratory animal science, euthanasia is routine but remains ethically contested because different methods may differ in their impact on animal welfare. For example, carbon dioxide (CO_2), one of the most used methods for rodents, has been widely debated due to concerns about potential distress prior to loss of consciousness. Alternative approaches, such as anaesthesia with isoflurane followed by CO_2 exposure, have been proposed to mitigate these effects. However, current evidence does not clearly support one method over another. Both CO_2 and inhalant anaesthetics induce substantial physiological and behavioural changes and may themselves alter the animal's state prior to death (Tobar Leitão et al., 2021). As a result, no approach can be unequivocally identified as least distressing.

Since animal welfare is a key criterion for selecting euthanasia methods within the 3Rs framework, determining the "best" method depends on how suffering is assessed. Yet welfare assessment during euthanasia is inherently difficult. Behavioural and physiological indicators of distress are often ambiguous and context dependent. For example, responses such as ataxia, immobility, laboured breathing, or escape-related behaviours are observed during CO_2 exposure but may also occur during sedative or anaesthetic states, complicating their interpretation (Rodriguez-Sanchez et al., 2021).

When indicators are ambiguous, their interpretation necessarily depends on contextual information. Under these conditions, identical behavioural cues may be interpreted differently depending on framing, giving rise to perception bias. Such uncertainty may affect not only welfare evaluations but also add to the perceived stress and moral burden of personnel performing euthanasia. The challenge is therefore not only to identify the least harmful euthanasia method, but also to understand how uncertainty in interpreting animal suffering shapes both welfare assessments and the burden experienced by those who perform it. The present pilot study therefore examined whether welfare evaluations of rodents by professionals working in animal experimentation are systematically biased by contextual framing, and how such bias is reflected in visual attention and observer reasoning.

Methods

Video stimuli

Four video stimuli depicted mice undergoing routine euthanasia procedures. Euthanasia was performed using one of two routinely approved protocols: a) direct euthanasia with carbon dioxide (CO_2), or b) induction of general anaesthesia with isoflurane followed by CO_2 euthanasia.

No animals were euthanized specifically for the purpose of this study, and no additional procedures were. All procedures were conducted under existing animal licenses and followed institutional and national animal welfare regulations. These videos varied by procedure type (pre-euthanasia anaesthesia versus direct euthanasia) and rodent coat colour (black vs white). All 4 videos run for the same length of time (75s). The selected videos did not depict unusually severe or graphic scenes and reflected typical events observable during routine laboratory euthanasia and anaesthesia procedures. Each video was presented with either a correct or incorrect framing label (i.e., anaesthesia or euthanasia).

Participants

A total of 36 volunteers were recruited. Inclusion criteria were: 1) authorization to conduct animal experimentation in Switzerland, and 2) prior experience with rodent anaesthesia and euthanasia. One participant was later determined to be ineligible and excluded entirely. All remaining 35 participants completed the study protocol. The study protocol was approved by the the Ethics Committee of the Faculty of Medicine, University of Zurich and all participants provided written informed consent prior to participation.

All participants watched the videos while wearing eye-tracking devices and completed the distress-rating tasks. For eye-tracking analysis, calibration quality was assessed post hoc. Seven participants were excluded due to insufficient calibration accuracy, leaving a final eye-tracking sample of 28 participants. Survey and think aloud interview data from these excluded individuals were retained for non–eye-tracking analyses where appropriate. Participants received monetary compensation for their time.

Procedure

All components of the study-eye-tracking, distress ratings, and qualitative interviews-were conducted in parallel within a single laboratory session. Experiment conducted individually with participants in a controlled laboratory environment. Seating distance, screen position, and ambient lighting were standardized across sessions.

After eligibility screening and completion of demographic questions in LimeSurvey and prior to the start of video observations, eye-tracker calibration was performed. Calibration consisted of a three-point triangular calibration procedure, during which participants were instructed to sequentially fixate on three predefined points displayed on the screen.

Participants viewed four videos according to their assigned AB/BA cross-over sequence, differing only in the order of the actual procedures viewed, while the framing sequence was held constant across groups. This design allowed each participant to serve as their own control and controlled for period and fatigue effects. Rodent coat colour (black vs white) was not counterbalanced across experimental periods but was included as a fixed effect in all statistical models**.** During video presentation, participants wore the eye-tracker and were instructed to verbalize their thoughts continuously using a concurrent think-aloud procedure, describing what they observed in real time.

Immediately after each video, participants completed ordinal Likert-scale ratings evaluating rodent welfare on four indicators: escape behaviour, fear behaviour, respiratory distress, and overall distress. Ratings were provided on a 0–9 Likert scale (0 = none, 9 = extreme), adapted from established welfare assessment instruments (Baker & Hickman, 2018).

After completion of all four video observations and their associated ratings, participants took part in a final retrospective talk-aloud interview. This semi-structured interview explored participants' reasoning strategies, confidence in welfare assessment, perceived ambiguity in the videos, and criteria used to distinguish anaesthesia from euthanasia.

All verbal data (concurrent think-aloud and final talk-aloud interviews) were audio-recorded. Recordings were anonymized and transcribed verbatim using a locally run automated transcription system.

Eye-tracking data acquisition and areas of interest

Eye-tracking binoculars continuously recorded gaze position, fixation duration, saccades, and pupil diameter during video viewing. Areas of interest (AOIs) were predefined a priori based on a behavioural ethogram relevant to rodent anaesthesia and euthanasia (Rodriguez-Sanchez et al., 2021) and were mapped to specific anatomical regions associated with observable welfare indicators. Dwell time to specific AOIs were extracted from eye-tracking data. Dwell time was defined as the total duration of gaze within an AOI and was expressed as a proportion of total viewing time per trial. It was used as an indicator of the relative allocation of visual attention across body regions.

Qualitative data analysis

Think-aloud and interview transcripts were first entered to Excel then analysed using conventional inductive content analysis with MAXQDA 2022 (VERBI Software, 2021). Thematic coding focused on attentional allocation, behavioural interpretation, welfare assessment heuristics, and criteria used to distinguish anaesthesia from euthanasia. Coding was performed independently and iteratively refined.

Sample size estimation

Based on the study Baker and Hickman (2018), we determined cohen's d, the effect size, to detect a difference in the rating of mice welfare depending on the context (framing: anaesthesia vs. euthanasia) for Pentobarbital, Isoflurane, 30% and 70% CO2. The corresponding cohen's d values were: 0.693, 0.596, 0.499, 0.765. Based on G*Power, assuming an effect size of 0.5, an alpha of 0.05 and a power of 0.9, a total sample size of 28 is needed.

Statistical analysis

All analyses were conducted in R (R Core Team, 2025). Data were anonymized prior to analysis.

Distress ratings were analysed using linear mixed-effects models fitted with the lme function in R. Fixed effects included actual procedure (anaesthesia vs euthanasia), framing label, their interaction, experimental group, distress question, and demographic covariates (gender, years of experience, and frequency of performing rodent procedures).

Eye-tracking data were analysed descriptively (no inferential statistical testing conducted at time of writing), using dwell time to characterise patterns of visual attention across conditions and to assess whether contextual framing influenced the allocation of attention to behaviourally and physiologically relevant regions.

Results

Perceived distress ratings

Euthanasia videos were rated as more distressing than anaesthesia videos. Importantly, for the same videos, incorrect framing systematically shifted distress ratings: for example, the video depicting black mice euthanasia was rated lower when incorrectly framed as anaesthesia (μ= 5.4 [4.4; 6.3]) compared to when correctly framed as euthanasia (μ = 7.3 [6.6; 8.1]), while the video depicting a white mice anaesthesia was rated higher when incorrectly framed as euthanasia (μ = 6.1 [5.1; 7.1]) compared to when correctly framed as anaesthesia (μ = 5.4 [4.5; 6.3]).

This pattern is supported by the mixed-effects model, which revealed a significant main effect of procedure (i.e., anesthesia vs euthanasia) (β = -0.22, 95% CI [-0.38, -0.06], p < .01) and a significant Procedure*Framing interaction (β = -0.33, 95% CI [-0.54, -0.12], p < .01) , while the effect of framing (i.e., correct vs incorrect) was not statistically significant (β = 0.19, 95% CI [-0.02, 0.36], p = .064). The interaction indicates that the effect of the actual procedure on distress ratings depended on whether the procedure was labelled correctly. Specifically, under correct framing, euthanasia was rated as more distressing than anaesthesia, whereas under incorrect framing this difference was attenuated. Together, these findings indicate the presence of a biased perception in welfare evaluations.

Post-hoc pairwise comparisons using Tukey-adjusted contrasts were performed to examine differences between the four distress indicators assessed in the survey: escape behaviour, fear behaviour, respiratory distress, and overall distress. The comparisons revealed systematic differences between the distress indicators. Ratings for respiratory distress and overall distress tended to be higher than ratings for behavioural indicators such as escape or fear behaviour. In contrast, escape behaviour and fear behaviour showed more similar rating patterns and were generally evaluated as less severe across videos.

These differences suggest that participants may rely more strongly on physiological indicators, such as breathing irregularities, when judging the level of distress in rodents. Behavioural indicators, particularly escape and fear behaviours, appeared more ambiguous to observers and may therefore contribute less consistently to overall welfare assessments.

This interpretation is consistent with qualitative findings from the think-aloud interviews, in which participants frequently reported difficulties distinguishing exploratory movements from escape behaviour and expressed uncertainty when interpreting subtle behavioural signs.

Dwell time

Descriptive AOI summaries indicated that attention allocation was not evenly distributed across body regions but concentrated on specific areas. Across all conditions, the cranio-cervical region consistently received the greatest proportion of viewing time. For anaesthesia videos, cranio-cervical dwell time was 28.3% under correct framing and 29.2% under incorrect framing, while for euthanasia videos it was 26.4% under correct framing and 25.7% under incorrect framing. Similarly, attention to the forelimbs remained stable across framing conditions (anaesthesia: 14.2% correct vs 14.0% incorrect; euthanasia: 17.5% correct vs 15.3% incorrect).

For distractor regions, attention was generally low but varied across conditions. For distractors, when identical anaesthesia videos were framed incorrectly as euthanasia, dwell time was lower (0.4%) compared to correct framing (1.7%). Similarly, for euthanasia videos, distractor engagement was lower when framed incorrectly as anaesthesia (1.7%) compared to correct framing (2.7%). In contrast, attention to task-relevant regions such as the cranio-cervical area remained stable across framing conditions.

This pattern indicates that framing did not produce a systematic shift of attention toward or away from relevant body regions. Instead, attentional allocation remained largely stable, with only modest differences in distractor engagement depending on framing.

Discussion

Our pilot findings provide evidence for a meaningful perception bias in rodent welfare evaluations: contextual framing systematically shifted distress ratings., these findings suggest that perception bias

primarily operates at the level of evaluation and interpretation rather than through a systematic alteration of early visual processing.

Descriptive eye-tracking results showed that participants consistently focused on task-relevant regions, particularly the cranio-cervical area, irrespective of how the videos were framed. When identical videos were presented under different contextual labels, dwell time in these regions remained highly stable, suggesting that observers attended to similar visual information across conditions. Differences in attention were limited to low-salience regions such as distractors, where only modest variations were observed.

Qualitative findings supported this interpretation. Participants highlighted the difficulty of distinguishing escape or fear-related behaviour from exploratory actions and reported uncertainty when interpreting respiratory and grimace-based indicators in isolation. This ambiguity in behavioural and physiological cues may provide a basis for interpretative bias, particularly under conditions where contextual information frames expectations about the procedure.

Taken together, these results suggest that perception bias arises not from differences in visual attention, but from the interpretation of ambiguous cues under contextual uncertainty. Observers appear to attend to similar features of the stimulus but rely on contextual information to resolve ambiguity when forming welfare judgments.

By including the perspectives of personnel alongside animal welfare outcomes, this study contributes to a broader perspective on euthanasia, emphasizing how uncertainty in interpreting animal distress can shape welfare assessments and the experiences of those who perform them.

Although the observed effects on distress ratings appear meaningful, this was a pilot study, and their magnitude and generalizability remain uncertain. It is not yet clear whether perception bias is associated with demographic or professional factors, such as role, experience, or frequency of performing euthanasia, nor whether it could be mitigated by specific training. Future research should address these questions directly.

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Section 5.
Ethical food consumption and governance

Are people's cooking skills constraining their ability to consume more plant-rich foods?

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Abstract

Rationale and aims: Global food systems contribute about one-third of anthropogenic greenhouse gas emissions, making a shift toward plant-based diets essential. Although many individuals express willingness to reduce meat consumption, population-level declines remain modest. A possible barrier is low confidence in preparing plant-rich meals. This study develops a measure of Self-efficacy for Cooking Plant-rich Meals (SCPM) and examines its association with plant-rich eating. Methods and materials: We used questionnaire data from a representative sample of parents in four Danish municipalities, recruited via a lottery draw from all families with children. Data were collected in June/July 2025 (n = 4,908). We developed a novel SCPM measure (four Likert-scale items) inspired by the validated Cooking and Food Provisioning Action Scale. Plant-rich eating was assessed using two measures: (1) whether meat was consumed at yesterday's dinner and (2) meat intake in grams, based on a recently developed Swiss measure. Findings: The SCPM showed very good psychometric properties (Cronbach's $\alpha = 0.907$). SCPM was negatively associated with meat intake in grams ($p < 0.001$; Spearman's $r = -0.402$): individuals with very high SCPM consumed almost 50% less meat (in grams) than those with very low SCPM. SCPM was also negatively associated with meat consumption at yesterday's dinner ($p < 0.001$; Spearman's $r = -0.197$) approximately 70% of participants with very high SCPM ate meat at yesterday's dinner, compared to about 89% among those with very low SCPM. Restricting the analysis to participants who reported actively reducing meat consumption (n = 1,928), SCPM still significantly influenced the likelihood of plant-rich eating (meat intake in grams: $p < 0.001$; Spearman's $r = -0.203$; meat at yesterday's dinner: $p < 0.01$: Spearman's $r = -0.072$).

Conclusions: Confidence in cooking plant-rich meals strongly predicts lower meat intake, even among reducers, highlighting a key behavioural barrier. Policies that build practical skills, e.g., community cooking classes, school curricula, and workplace programmes, could accelerate dietary shifts.

Keywords: green transition, meat reduction, dietary self-efficacy, CAFPAS-short, Denmark

Introduction

Global food systems are responsible for about onethird of all human generated greenhouse gas emissions, highlighting their substantial role in driving climate change. Because a large proportion of these emissions stems from livestock production, land use, and resourceintensive supply chains, researchers and policymakers increasingly emphasize the need for dietary transitions (Crippa et al., 2021). A shift toward more plantbased eating patterns is therefore viewed as a crucial strategy for reducing environmental pressures, lowering emissions, and supporting a more sustainable global food future (Rodés-Bachs et al., 2026).

Many people express a willingness to reduce meat consumption in Western countries (Dagevos, 2021). In Denmark, for instance, several studies have shown that more than 40% of the adult population report

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that they have reduced, or are planning to reduce, their meat intake (Halkier and Lund, 2023; Hielkema and Lund, 2021). It could therefore be expected that these consumers' efforts would be easily discernible as a population-level decline in the intake of meat. Yet, this is not the case, as the most recent national dietary survey with data collected in 2021-2024 shows that adult Danes eat just as much meat today as they did approximately 10 years earlier (DTU Fødevareinstituttet, 2026).

Several reasons for this population-level lack of decline in meat intake can be raised. Many of those who are not trying to reduce their meat consumption consider meat to be necessary and normal, and a natural part of life (Piazza et al., 2015) and they may experience little persuasion and social pressure from personal networks to make a change (Lund and Halkier, 2024). But even among some of those who are trying to cut down on meat, this food group is likely to be experienced as a pleasure to eat making it difficult to change their actual behaviour because of hedonistic cues (Graça et al., 2015). Another direction of research has made it clear that there are many practical obstacles in everyday life that hamper people's ability to cut down on meat in practice (Halkier and Lund, 2023; Lopez et al., 2023; Van Hoeven et al., 2024).

In this paper, we focus on one such practical aspect of daily life, namely a lack of confidence in preparing plant-rich meals. To do this, we first developed a novel measure of self-efficacy for cooking plant-rich meals (SCPM). Secondly, we examined its association with plant-rich eating.

To develop the novel measure, we took our point of departure in the Cooking and Food Provisioning Action Scale (CAFPAS). This is a validated questionnaire-based tool for measuring food agency. It represents an individual's ability to make and achieve food-preparation and -provisioning goals through three constructs: self-efficacy, attitude, and structure (Lahne et al., 2017). When developing the SCPM, we focussed on the self-efficacy construct from CAFPAS, as this construct covers an individual's general ability to prepare food. A person's ability is also pertinent for plant-rich cooking, and the construct can be readily modified to model an individual's ability to make plant-rich foods. In contrast, the attitude and structure constructs are generic dimensions of food agency. Thus, the attitude construct maps an individual's overall interest and willingness to invest time in cooking, while the structure construct maps constraints in everyday life.

Methods

Data

Data for this paper come from a questionnaire study comprising a representative sample of individuals in four Danish municipalities, recruited via a lottery draw from a sample frame comprising all adult individuals from families with children. Data were collected in June/July 2025 by Statistics Denmark. In two-parent households, only one parent was invited. In total, 17,072 individuals were invited, and 4,908 completed the questionnaire (response rate: 29%).

Materials and measures

We issued the brief version of the CAFPAS to the respondents, where the three constructs self-efficacy, attitude, and structure are measured using eleven items (Karlsson et al., 2023). To ensure conceptual equivalence, the eleven items were translated from English to Danish and back-translated to English, after which the resulting items were checked for equivalence with the original English version.

To develop the SCPM measure, four new items were developed and issued to the respondents with the aim of measuring SCPM. These items were highly similar to the four items of the self-efficacy scale of the

CAFPAS, as they only involved adding "plant-rich" to the original formulations. For instance, one of the self-efficacy items, "In preparing food, I can solve most problems with enough effort" was reformulated to "In preparing plant-rich food, I can solve most problems with enough effort".

Two measures aimed at evaluating the respondent's propensity to eat plant-rich foods were employed. The first measure probed the respondents about the food they ate at yesterday's dinner. The respondents were asked to select all food groups that they ate, including a range of meat types. Based on this, a binary measure was developed indicating whether meat was consumed (no meat=0; meat was consumed=1). For the second measure, we replicated a recently developed Swiss approach (Strässner and Hartmann, 2023, where meat intake in gram is calculated by first asking respondents about how often they consume dishes with meat, after which the respondents are asked to point out how much meat they eat in grams using a combined visual scale and verbal specification. After this, the respondents are asked about how often they consume processed meat spreads such as sausages and ham, after which they once again were asked to point out how much meat they eat in grams using a combined visual scale and verbal specification. In the end, frequency of eating unprocessed and processed meat was multiplied with the indicated meat portion size and converted into grams of meat per week.

Data analysis

Confirmatory factor analysis was carried out using the 11 CAFPAS items and the four SCPM items as input variables. We examined the fit of a model with the four predefined latent constructs using the root mean squared error approximation (RMSEA) (Steiger, 1990) and the comparative fit index (CFI) (Bentler, 1990). A RMSEA value below 0.08, and a CFI of 0.95 or more, were considered acceptable. We also report Cronbach's alpha for each latent construct.

To study whether SCPM is associated with meat intake, two different regressions were run. For the outcome variable, *meat consumed at yesterday's dinner*, a multivariable logit regression analysis was conducted, and odds ratios (OR) were reported. For the outcome variable, *gram intake of meat*, a multivariable linear regression analysis was conducted.

Spearman's correlation coefficients were calculated to evaluate whether SCPM is also associated with meat intake among people who are actively reducing meat consumption (n = 1,928).

Results

Results from the confirmatory factor analysis (CFA) are presented in Table 1. Respondents who indicated that they never cook meals at home, or that they never prepare a plant-rich meal, are not included in the CFA, leaving a sample size of 3863 for this analysis. The CFA results suggested that the specification into the four predefined constructs returned an acceptable model fit (RMSEA: 0.065; CFI 0.959). Further, all constructs exhibited at least good internal consistency, with all Cronbach's alpha values >0.70. Specifically, for the SCPM construct, Cronbach's alpha was 0.907, which suggests that this latent construct has very good reliability.

Table 2 presents outputs from two multivariable regressions, where SCPM, the three CAFPAS scales (self-efficacy, attitude, structure), the respondent's gender, and educational level were inserted as predictors. We focus on the SCPM and treat all other predictors as control variables. Note that the SCPM was inserted as a categorical predictor, so that respondents who never prepare a plant-rich meal (and thus did not respond to the four CAFPAS items) could be included in the analysis. The five other categories from "very low" to "very high" SCPM were divided into quintiles.

Table 1. Results from confirmatory factor analysis (standardised factor loadings are reported in cells) (n=3863)

Question formulation	Self-efficacy	Attitude	Structure	SCPM
When preparing food, I am confident that I can deal with unexpected results.	0.661			
When preparing food, it is easy for me to accomplish my desired results	0.762			
In preparing food, I can solve most problems with enough effort.	0.811			
I am comfortable preparing food.	0.752			
For me, cooking is just something to get through as quickly as possible.		0.789		
Compared to other activities, Cooking brings me little enjoyment.		0.804		
I prefer to spend my time on more important things than food		0.847		
I feel like cooking is a waste of effort		0.742		
I have a hard time finding enough time to prepare the food I'd like to eat			0.760	
My social responsibilities prevent me from having the time to prepare meals.			0.726	
My job responsibilities prevent me from having the time to prepare meals.			0.724	
When preparing plant-rich food, I am confident that I can deal with unexpected results.				0.837
When preparing plant-rich food, It is easy for me to accomplish my desired results				0.912
In preparing plant-rich food, I can solve most problems with enough effort.				0.919
I am comfortable preparing plant-rich food.				0.892
Cronbach's alpha	*0.827*	*0.875*	*0.778*	*0.907*

Model fit results: RMSEA 0.065 (90% CI: 0.062 – 0.068); CFI: 0.959

All questions had response options ranging from 1: Completely disagree to 7: Completely agree.

SCPM: Self-efficacy for Cooking Plant-rich Meals

Table 2 reveals that SCPM is clearly associated with meat consumption. Higher SCPM results in lower gram intake of meat. For instance, individuals with very high SCPM (coeff.=-60123.23***) consumed approximately 50% less meat (in grams) compared with those who never prepare a plant-rich meal and those with very low SCPM. Similarly, SCPM predicted propensity to consume meat at yesterday's dinner. Individuals with very high SCPM had a lower propensity (OR=0.17) to eat meat for dinner compared with respondents who never prepare a plant-rich meal (the baseline). Specifically, 70% of participants with very high SCPM ate meat at yesterday's dinner, compared to about 89% among those with very low SCPM, and 91% of those who never prepare a plant-rich meal.

For the entire sample, the strength of the negative association between SCPM and gram meat consumption was medium to strong ($p < 0.001$; Spearman's $r = -0.402$). The strength of the association between SCPM and having meat for yesterday's dinner was small to medium ($p < 0.001$; Spearman's $r = -0.197$). Even when we restrict the analysis to individuals who reported actively reducing their meat consumption (n = 1,928), we still identified statistically significant associations, albeit at a lower level of strength: SCPM and meat intake in grams: $p < 0.001$; Spearman's $r = -0.203$. SCPM and meat at yesterday's dinner: $p < 0.01$; Spearman's $r = -0.072$.

Discussion

In Denmark, many people are critical of how animals are treated in livestock farming (European Commission, 2015), and concerns about global warming are widespread. In this study, for example, 70% reported being concerned about global warming, more than 60% agreed that plantrich foods are

Table 2. Results from two multivariable regressions examining predictors of gram intake of meat and whether meat was consumed for yesterdays' dinner

Predictor	Weekly intake of meat in gram Unstd. coeff.	Meat consumed for yesterday's dinner Odds Ratio
SCPM (baseline: Never prepares a plant-rich meal)	1	1
Very low SCPM	-50.81 (26.09)	0.94 (0.155)
Low SCPM	-214.25 (26.08) ***	0.72 (0.116) *
Medium SCPM	-355.22 (26.24) ***	0.39 (0.059) ***
High SCPM	-408.63 (26.42) ***	0.27 (0.039) ***
Very high SCPM	-601.23 (27.87) ***	0.17 (0.027) ***
Self efficacy	67.07 (12.43) ***	1.50 (0.091) ***
Attitude	-2.50 (7.96)	0.96 (0.039)
Structure	-11.60 (7.42)	1.04 (0.039)
Sex (baseline: Male)		
Female	-229.39 (16.57) ***	0.91 (0.079)
Educational level (baseline: Primary school)	1	1
Upper sec. education, vocational education	54.08 (29.12)	1.56 (0.223) **
Shortcycle and medium-cycle higher education	-12.28 (28.72)	1.56 (0.218) ***
Bachelor's, longcycle higher education, PhD	-98.91 (31.32) **	1.21 (0.180)
Constant	1281.28 (32.53) ***	7.96 (1.404) ***
Model fit results	F(12, 4851)=86.85; Omnibus p-value<0.001; adj. R2=0.1748; n=4864;	Log likelihood = -2087.8; LR chi2(12) = 281.62; Pseudo r= 0.063; n=4728

*** p < .001; ** p < .01, * p < .05

SCPM: Self-efficacy for Cooking Plant-rich Meals

more climatefriendly than meat, and a similar share stated that they feel a personal responsibility to choose foods that minimize their carbon footprint.

Yet translating this ethical awareness into everyday behaviour can be challenging. Earlier qualitative evidence has documented that limited cooking skills are a major obstacle to adopting a plantbased diet (Reipurth et al., 2020; Yang et al., 2025). The present study similarly highlights that practical cooking competencies play a central role in enabling more plantrich eating patterns. The clear association between SCPM and both meat intake in grams and the likelihood of having eaten meat at yesterday's dinner suggests that confidence in preparing plantrich meals is a key behavioural mechanism underpinning successful meat reduction. Moreover, the graded relationship across SCPM categories – with those highest in self-efficacy consuming nearly 50% less meat – underscores the potential publichealth and sustainability impact of strengthening cooking abilities.

At a societal level, this implies that structural and informational interventions may be insufficient unless paired with skillbuilding initiatives. Policies such as communitybased cooking programmes, school curricula that include plantrich cooking, or workplace initiatives could help reduce practical barriers. Future research should examine how improvements in SCPM translate into longterm dietary change and whether targeted interventions can effectively lift lowconfidence groups. Overall, the study demonstrates

that enhancing individuals' practical competencies may be a critical, yet currently overlooked, lever for accelerating the transition to more sustainable diets.

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Digitalization, shame, and the ethics of animal agriculture

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Abstract

Digital technologies and AI systems are increasingly promoted to optimize livestock management, improve efficiency, and support animal welfare. Through continuous data collection and automated decision-making, they reduce direct contact between farmers and animals. Yet this distance may deepen human–animal alienation. When digital tools mediate encounters, they risk dulling moral perception and weakening emotional responsiveness. We argue that this threatens a key moral resource: shame. As a reflexive affect that reveals one's participation in harm and prompts ethical reflection, shame sustains accountability. In animal agriculture, it signals recognition of animals as moral subjects. While it may bring practical gains, digitalized management risks obscuring suffering and eroding the affective foundations of moral responsibility.

Keywords: animal ethics, smart farming, AI automation, alienation, shamelessness

Introduction: smart farming and the dulling of morals

New technologies and tools have always played a central role in farming and food production. Today, however, the growing integration of digital tools is driving a structural transformation that some scholars describe as a 'fourth agricultural revolution' (Lejon and Frankelius, 2015). This emerging phase – also referred to as 'agriculture 4.0' (Rose and Chilvers, 2018) – is characterized by increasing automation and the extensive use of information and communication technologies, particularly large-scale data collection and analysis ('big data') (Wolfert et al., 2017), to organize and manage food production. Accordingly, it is also described using terms such as 'digital agriculture', 'e-agriculture', and 'smart farming'. In the context of animal agriculture, which is the focus of this paper, this model of digital and automated farm management is commonly referred to as Precision Livestock Farming (PLF) (Wathes et al., 2008; Bos et al., 2018).

Examples of PLF technologies include robotic systems used for automated milking, herd management, and the collection of 'layers' (eggs laid outside designated nest boxes). A wide range of sensors is also employed to monitor and control the production environment, including light, temperature, humidity, and the automated opening and closing of gates. Additional sensors support fattening control, feed optimization, and automated feeding systems. PLF technologies are increasingly used for animal health monitoring as well: sensors can detect parasites, ulcers, and injuries, and may help predict or prevent diseases – for example through automated pain detection and the dispensing of medication. Cameras and other monitoring tools analyse animal behaviour and identify deviations from expected patterns. Furthermore, physiological sensors collect detailed data on animals, including acoustic signals, cortisol and glucose levels, body weight, growth rate, and mortality. Some systems are even designed to interact directly with animals through sound or electric impulses. Ultimately, the objective of PLF is the full automation of livestock management, minimizing or eliminating the need for continuous human observation and intervention.

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Smart farming technologies offer several advantages for human stakeholders, including improved management and efficiency, increased productivity and profitability, reduced production costs, and the potential to limit environmental impacts while promoting sustainability. At the same time, nonhuman animals themselves may also benefit from digitalization and automation through real-time monitoring of their health and welfare. For instance, the early detection of diseases and injuries can enable faster intervention, potentially reducing pain and suffering. Moreover, removing humans from certain stages of the production process may reduce the risk of the sadistic brutality toward animals that has occasionally been documented among factory farm workers (Singer and Tse, 2023).

However, this transformation is not merely technical but also normatively charged, giving rise to a range of ethical challenges (e.g., Bos et al., 2018; Hagendorff, 2022; Singer and Tse, 2023; Coghlan and Parker, 2023; Bossert and Coeckelbergh, 2024; Santana et al., 2025; Giersberg, 2026). In this paper, we focus on one particular ethical concern: the erosion of a specific moral resource in human-animal relations – namely, shame – brought about by digital mediation. By further distancing humans from nonhuman animals, smart farming risks dulling, or even erasing, our awareness of the ethical costs associated with animal agriculture.

Digitally mediated management and moral distancing

Coghlan and Parker (2023) have proposed a systematic framework for considering various possible AI harms to animals. However, an assessment of the use of digital tools in the context of animal agriculture must additionally consider potential normative impacts on the *relations* between animals and humans. Our claim is that AI can negatively impact human-animal relations themselves: by alienating humans and animals, a moral distance is created that risks blinding humans to the animals' ethical concerns. In this way, shame as a critical moral resource in the face of anthropogenic animal suffering will be eroded.

The risk of alienation through PLF has already been noted. Whereas Stuart et al. (2013) have applied a Marxian framework to the dairy sector to analyse cows' alienation in terms of the estrangement from their product, productive activity, species being, and fellow animals, we want to shed light specifically on the alienating effects of digital management on the relation between humans and animals (cf. Bossert and Coeckelbergh, 2024). These effects start to become apparent once the use of digital tools in PLF is put into a bigger perspective. One express purpose of using these tools is to replace human keepers with machine intelligence, promising to 'preserve farming while recreating an artificial version of the semi-mythic image of the good steward caring for their animals' (Werkheiser, 2018, p. 185). However, removing human expertise might harm animal welfare (Ryan and Bossert, 2026; Bos et al., 2018), and, if farmers have special obligations to their animals (cf. Palmer, 2007; 2010), it might also lead to the farmers' failure to uphold their special duties (Werkheiser, 2018, p. 190).

Moreover, the use of digital management in PLF is primarily driven by economic concerns which put pressure on farmers to increase production efficacy (Coghlan and Parker, 2023). If automated systems 'answer a desire to increase productivity' (Cornou, 2009), then AI might help to answer it even better. But economic interests may conflict with the animals' interests, meaning that digital systems employed with an eye toward maximizing productivity 'may thus miss signs of poor welfare, further estrange humans from animals, and compound the objectification of animals' (Coghlan and Parker, 2023, p. 24; cf. Werkheiser, 2018). With PLF increasingly monitoring animals, they get reduced to 'a collection of data points' or 'to numbered units that are differentiated, but not individualized' (Werkheiser, 2018, p. 193). Consequently, the animal is no longer seen 'as a whole' (Cornou, 2009). This means that animals are rendered increasingly machine-like, and, crucially, this 'de-animalization', through which 'animals become living parts of machinery', might not only prevent animals from leading a good life, but also exasperate 'ethical blindness': 'By producing pigs in a barren environment where the animals have no chance to actually

present themselves as anything other than bioreactors growing meat, we thus lose sight of the ethical aspects of surgically adapting the animal to fit into the production system' (Harfeld et al., 2016, p. 416). Ultimately, the promises of digitally mediated (so-called) 'care' evaporate, when care no longer means responding to the animals' ethical concerns but rendering them cogs in a profit-maximizing machine.

Shame as a moral resource

By prompting us to see the animals as nothing but units of production and thereby further alienating humans and animals, the use of digital management in PLF erodes shame as an important moral resource in human-animal relations, instead fostering a climate of shamelessness that risks locking in harms and reinforcing an already harmful system.

Shame is an emotion that is notoriously difficult to pin down, with a clear-cut definition that would capture all its various possible manifestations being unlikely to come by (Zahavi, 2014). Still, there is a consensus on certain of shame's features. Firstly, shame is tightly connected to identity. While both guilt and shame can indicate (the perception of) a moral failure, guilt is usually taken to be about something one has *done*, whereas shame, more fundamentally, concerns who one *is*. Accordingly, someone who is overcome by shame might ask *What kind of person does this make me?*, where 'this' typically refers to violating a social norm or failing to live up to a value. Secondly, although shame has had a bad reputation for a long time, with psychological studies concurring on its damaging nature, the picture has recently become more complex. Shame is no longer unilaterally understood as bad. Rather, it has been (re-) evaluated as a central moral emotion. On this newer view, shame is not something we should collectively seek to overcome, for we could not do so without fundamentally disfiguring human morality itself. The capacity for shame testifies to our shared moral bond, and a liability to shame is intrinsically related to our moral concern for others. What makes a liability to shame morally constructive is that it is constitutive of our respect for others such that 'a liability to respect and a liability to shame are two sides of one coin' (Thomason, 2018, p. 156). Essentially, to have a liability to shame means understanding that one does not act in a moral vacuum and that one's self-conception is put in check, on all sides, by others to whom one holds oneself accountable. Conversely, to consider oneself morally autonomous is to be shameless (Fumurescu, 2022). In contrast, for those who are liable to it, shame instantiates a 'reciprocal structure' of respect (Williams, 2008, p. 84). This reciprocal structure of shame is tripartite: 'I am ashamed *of* myself *before* the Other' (Sartre, 2021, p. 371). This makes shame a fundamentally social emotion that can make us aware of the moral demands that the fact of sharing a world – of sharing an *ethos* – with others puts on our shoulders.

Importantly, animal others are also part of our shared world. If shame can serve as a moral compass in intraspecies relations, it can also alert us when something goes wrong in our relations to animals, attesting to a human-animal bond precisely by signalling its brokenness. However, the possibility of such an experience depends on relating to animals not as objects but as moral subjects (either in the sense of moral agent or patient) to whom we feel accountable. The suffering animal is encountered as a some*one* rather than a some*thing* who makes a moral claim on us, destabilizing thereby a sense of subjectivity predicated on human exceptionalism. It is on that condition that shame may arise as a response to animal suffering. What it points to – more so than any specific transgression against a moral subject – is the fact that we have not even recognized the animal as a moral subject in the first place.

Digitalization and the erosion of shame

With this account of shame in view, we can see how 'smart farming' may undermine the conditions under which shame arises in response to animal suffering. These systems do not merely reorganize agricultural work; they also transform what Thompson (2021) calls the 'ethics of husbandry', that is, the ways in

which humans encounter and relate to the animals whose lives they manage. By filtering perception, redistributing agency, and normalizing technologically mediated management, digital infrastructures can make the suffering of animals less experientially present. The result is not the disappearance of responsibility, but a weakening of the emotional conditions through which responsibility for animal suffering is experienced.

One key mechanism is the reduced perceptual salience of suffering. In smart farming environments, interactions with animals increasingly occur through data streams, dashboards, and automated alerts. Instead of encountering animals directly – their bodies, movements, distress, or vulnerability – farm workers often encounter indicators: productivity metrics, health scores, behavioural flags, or temperature deviations. The animals themselves recede behind these representations (Bos et al., 2018; Tuyttens et al., 2022). When a cow appears primarily as a dataset or a pig as a behavioural metric, the sensory immediacy through which suffering might otherwise become apparent is diminished. The moral shock that may arise from witnessing a suffering animal face-to-face is replaced by the neutral language of system outputs. As a result, the emotional triggers that often give rise to shame are weakened.

A second mechanism lies in the fragmentation and opacity of agency within digitalized farming systems. Decisions affecting animals – such as feeding regimes, breeding cycles, or health interventions – are increasingly shaped by complex technological infrastructures. Algorithms generate recommendations, automated devices implement routines, and decision-making authority is distributed across a range of actors, including designers, engineers, managers, and data providers. Within such arrangements, it becomes more difficult for any single individual to perceive themselves as the direct author of harm experienced by animals. Responsibility becomes structurally diffused across technical layers and organizational roles (Werkheiser, 2020; Papakonstantinou et al., 2024). While accountability may still exist in principle, the psychological experience of causing an animal's suffering becomes less clear. Without a sense of personal involvement, the affective experience of shame is less likely to arise.

Smart farming technologies can also reframe animal suffering as a technical rather than a moral problem. When harmful outcomes occur – such as injuries, stress, or deaths – they are frequently interpreted through the language of system malfunction: sensor failure, incorrect predictions, or model error. This technical framing shifts attention away from the ethical significance of the animals' suffering and toward questions of system performance and optimization. The suffering animal becomes evidence of a malfunctioning system rather than a victim of morally troubling practices. Although such technical analysis may help diagnose operational problems, it can simultaneously dull the moral resonance of the event. When harm appears primarily as an engineering issue, the emotional dynamics associated with moral failure – including shame in response to the suffering of animals – are less likely to be activated (Bos et al., 2018; Giersberg, 2026).

Digitalization therefore reshapes the affective environment within which responsibility is experienced. Smart farming risks creating conditions in which it becomes structurally more difficult for individuals to feel shame in response to animal suffering.

Conclusion: shamelessness as a structural risk

The erosion of shame in smart farming is not a matter of individual moral failure but follows from the structural design of digitally mediated, industrial systems of production. Within such systems, shame steadily loses its regulatory force. What emerges instead is a form of systemic shamelessness: a condition in which harmful practices can persist and expand without provoking meaningful moral discomfort. Shamelessness thus becomes a structural risk that enlarges the moral invisibility of animal suffering while stabilizing forms of production that should, by any serious ethical standard, remain deeply troubling.

As human contact with animals diminishes, the emotional and moral feedback that might once have triggered discomfort or compassion fades with it. Under these conditions, it becomes increasingly difficult to imagine moral concern emerging either from farmers themselves or from the wider public. Indeed, these systems may not simply transform existing agricultural roles; they may replace them altogether. Traditional farmers risk being displaced by engineers, data analysts, and managerial staff who encounter animals primarily through interfaces, dashboards, and performance metrics rather than through embodied care (Werkheiser, 2020; Coghlan and Parker, 2023). Meanwhile, the fundamental aim of smart farming remains unchanged: the profitable production of animal products. Digital tools deployed in this context do not question this objective. On the contrary, they enable ever more intensive practices designed to maximize productivity rather than to support lives worth living for the animals themselves. Efficiency and output remain the central imperatives, and digital optimization through AI does not challenge the industrial logic of livestock production – it reinforces it (Coghlan and Parker, 2023).

Digitalization has helped fuel a wider cultural erosion of shame. In technological environments shaped by anonymity, virality, and attention-driven incentives, traditional, community-enforced constraints of shame and social decency have been weakened (cf. Mayer et al., 2021). When these dynamics migrate into agricultural systems, the consequences are not merely cultural but institutional. Harmful practices risk becoming normalized precisely because they are mediated, quantified, and operationalized through technological infrastructures. In this respect, the danger is that digital management becomes little more than another instrument for intensifying human domination over nonhuman life (Sparrow and Howard, 2021; Santana et al., 2025). The ethical problem is not digitalization as such, but its embeddedness within industrial logics of scale, efficiency, and distance – logics that already treat animals primarily as units of production.

As Singer and Tse (2023, pp. 545–46) point out, by lowering the costs of factory farming, AI strengthen an industry that is already morally objectionable. Reduced costs may allow factory farming to persist longer or expand further, bringing even larger numbers of animals into existence only to endure even more miserable lives. Companies that help make this system more efficient and resilient – better able to resist replacement by less cruel and more sustainable alternatives – thereby help prolong what can only be described as a global moral catastrophe. From this perspective, the erosion of shame is not merely a psychological by-product of technological change but a structural feature of digitally mediated industrial agriculture itself. It is precisely this systemic shamelessness that renders animal suffering easier to ignore and far harder to confront.

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Citizenship and digital optimisation in agriculture and food: a reflexive analysis and transition

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Abstract

While digital optimisation in the agriculture and food sector promises to improve efficiency, it simultaneously carries the risk of simplifying and depoliticising fundamental problems, thereby undermining people's agency. Through a reflexive analysis of my previous research on the digital optimisation of food distribution in food banks, this paper connects efforts at digital optimisation within agrifood systems to ongoing research on food citizenship. In previous research, computational algorithms were utilised as the primary technical solution to address inefficiencies in the daily operations at a food bank. While such approaches and technologies offer the potential for some degree of advancement, they tend to obscure the ethical and political dimensions inherent in distribution processes, positioning people as passive recipients/providers of information rather than citizens with agency. Drawing inspiration from Julie Guthman's *The Problem with Solutions* and Kelly Bronson's *The Immaculate Conception of Data*, this paper critically analyses the trend towards digital optimisation in the agri-food sector, positioning my previous research in Japan as a case for close interrogation. This analysis highlights the need to recognise the multidimensional nature of problems and the agency with which people exercise their power to respond to these problems, leading to an exploration of the concept of food citizenship. Given the current state of what I term 'quiet' civic engagement observed within Japan's food networks, the paper argues that nurturing food citizenship is key to achieving just and sustainable digital optimisation within agri-food systems.

Keywords: techno-fix, solutionism, will to improve, immaculate conception of data, food citizens

Introduction

Currently, there are increasing efforts towards digital optimisation within the agriculture and food sectors. Digital agriculture is one such example, including the use of artificial intelligence to minimise fertiliser usage, predict crop growth, and utilise automated tractors, with the ultimate aim of feeding the world's increasing population while reducing environmental footprints. The food industry is pursuing the optimisation of production and distribution processes, seeking to reduce costs associated with waste and labour management. Furthermore, technology industries previously unaffiliated with agriculture and food have rapidly expanded their investment in the sector, particularly through digital technologies. Underpinning such optimisation in the agri-food sectors are the goals of improving efficiency and supporting human decision-making.

While digital optimisation offers the potential of increased productivity, it tends not to concern itself with the ethical and political dimensions of agri-food systems, positioning people as passive recipients/providers of information. What are the causes of the problem, and how should we address them? Yet, why has digital optimisation become such a dominant trend? This paper explores these questions by drawing on Julie Guthman's *The Problem with Solutions* and Kelly Bronson's *The Immaculate Conception of Data*, examining my previous research on digital optimisation as a case study. Finally, it argues that nurturing food citizenship is key to addressing the root causes of the crises.

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Theoretical lenses

Bronson and Guthman offer critical perspectives to analyse the current state of digital optimisation in the agriculture and food sectors. *The Immaculate Conception of Data* (Bronson, 2022) challenges narratives that posit big data and artificial intelligence as standing outside of humans, emphasising that human effort, values, and interests are always intrinsically embedded within processes of technological development and their use. Consequently, there is no such thing as truly immaculate data, nor data coming from a vacuum. While the notion of the 'immaculate conception of data (ICD)' is frequently invoked by actors seeking to garner support for their data science initiatives, including digital optimisation projects like digital agriculture, such a framing obscures the underlying political economies and moral orders that shape food systems and the everyday lives of the many. Digital optimisation in agriculture risks imposing a financial burden on small-scale farmers; while large corporations gain greater market dominance through data ownership, farmers' knowledge, skills and agency risk being replaced by code within a black box. Bronson calls for a more critical view of data, examining emerging technologies, intervening with data science through more intersectional approaches and counteracting the futuristic narratives that obscure current problems.

In her book *The Problem with Solutions*, Guthman (2024) points out that technological 'solutions' offered by tech industries – such as in Silicon Valley and universities, where people are encouraged to become 'solution-makers' – are driven by certain impulses: *techno-fix, solutionism, and the will to improve. Techno-fixes* employ technological advances to address societal problems, operating under the assumption that engineering solutions are a more practical way to address crises than altering societal structures or human behaviours. This approach often sidesteps political challenges that might hinder progress and maintains existing ways of life. Those inclined towards *solutionism* often develop solutions before defining the problems, resulting in problems being insufficiently understood, inadequately investigated, or left in a highly contentious state. *The will to improve* is the good intentions people have, coming from a place of deep goodwill, that often accompany acts in their own interests without being requested to do so by others. Situating these historical, political and economic contexts within neoliberalism, Guthman advocates the importance of 'response', which starts from a different point of departure than that of solutions; it carefully investigates what a given issue requires and opens up possibilities of new actions that solutions would otherwise foreclose.

Case

The Japanese context underlying digital optimisation in agriculture is characterised by a significant decline in the number of people engaged in farming, driven primarily by rapid population ageing. As a result of such demographic shifts, discussions surrounding digital optimisation in agriculture are becoming increasingly important. Across various sectors, including the food industry, the term 'digital transformation' is widely viewed positively (Ministry of Agriculture, Forestry and Fisheries, n.d.). Digital optimisation in the agri-food sector has attracted significant attention due to initiatives aimed at reducing food loss/waste and decreasing reliance on manual labour, and multiple funding programmes have been launched. Additionally, companies unconnected to agriculture and food have begun investing in the sector, with initiatives focused on production optimisation, as observed in Silicon Valley (Nippon Express Holdings, 2024).

This paper examines my previous work on digital optimisation of food distribution at a food bank as a case study. In order to address challenges in food systems, such as food waste and food insecurity, collaboration with a local food bank was established with the aim of supporting decision-making in food distribution from the perspective of agri-food systems engineering. The food distribution process was conceptualised as a combinatorial optimisation problem in discrete mathematics. Computational optimisation models

were developed to utilise all available food in the warehouse while meeting recipients' needs. This served as the primary technical solution to inefficiencies and low productivity in daily operations. The project included participatory observations, model development and implementation, and both qualitative and quantitative assessments (Matsuoka and Miyasaka, 2023). This case illustrates how digital optimisation is framed as a technological solution to systemic challenges in the agri-food sector.

Reflexive analysis

The project originated from my own strong *will to improve*. Motivated by a wish to contribute to addressing global food systems problems, I began by collaborating with the local food bank. Drawing on my background as an engineer, I implemented equity-oriented algorithms by prioritising requests from small-scale organisations supporting welfare recipients who have limited flexibility in their food choices. At the same time, this approach reflects a *techno-fix* mindset, positioning digital optimisation technology as the primary solution to the complex problems in food systems. As a student of agri-food systems engineering, I took it for granted that such technologies should be applied to the challenges of optimising food distribution. Indeed, this led to the identification of inefficiency in daily operations; however, this can be seen as a clear illustration of the *solutionism* mindset inherent in the project, as it reduced complex problems to those that can be addressed by applying digital optimisation.

The data used in the algorithm were limited, simplified, and carefully selected by the engineer (me) for the purpose of calculation. In hindsight, the process makes it clear that the data were not neutral, and therefore not *immaculate*. Nevertheless, once the optimisation system is operational and provides calculations to support the volunteers, it becomes a 'data-driven' actor, treating the limited aspects of data as the entire phenomenon and as an omnipotent source of information. Furthermore, framing the optimisation system as a black-box decision-maker risks undermining the agency of food bank volunteers in making independent decisions. The food bank volunteers ultimately chose not to implement the developed optimisation system, due to its initially low accuracy in meeting recipients' needs and the requirement for an adaptation period to transition to the new operational model. Meanwhile, as this project was led by an academic rather than a corporation, concerns regarding the reproduction of the corporate-led structure of the food system were minimal. Nonetheless, the two theoretical lenses proposed by Bronson and Guthman provide a critical perspective to examine the design of one digital optimisation project, suggesting that it is no exception to the global trend of digital optimisation underpinned by the ICD and 'Silicon Valley's ecosystem'. These lenses underscore that problems are multidimensional, cannot be reduced to mere issues of productivity, and require multifaceted responses from people with agency.

Food citizenship as a response

According to Guthman, what is required for the problems to be solved is a substantive response. Addressing the root social causes and considering how they might be transformed challenges the mindset of *techno-fixes*. Examining problems holistically and clarifying for whom they are problems fosters counter-*solutionism*. Furthermore, interrogating the positionality of those proposing the solution prompts critical reflection on who should lead efforts and under what conditions, thereby resisting the prevailing *will to improve*. The central question, then, becomes: what makes this transformation possible? When individuals take action while understanding the root causes and thoughtfully considering responsible solutions, they act not merely as engineers, farmers, or volunteers, but as citizens. From this standpoint, they are able to resist dominant narratives surrounding technology development, informed by *techno-fix*, *solutionism*, *the will to improve*, and *ICD* within the context of neoliberalism. This raises the subsequent question: how do individuals cultivate such citizenship? I argue that food citizenship

offers a response to the impulse towards optimisation and opens up possibilities that digital optimisation-driven approaches tend to foreclose.

Food citizenship lies at the heart of food democracy (Louvin, 2025), which is critical for sustainable food systems transformation (Hassanein, 2003). It refers to the capacity of individuals to actively shape and reshape food systems through collective and political means. This concept has been examined in various contexts, such as policy-making and everyday food practices, particularly in relation to the multidimensional nature of food at the local level. As digital optimisation and the adoption of technology become increasingly prevalent in the agri-food sector, decisions regarding which technologies to implement – for whom and how – represent a crucial exercise of agency accessible to citizens through the politicisation of processes that might otherwise appear neutral. Fostering food citizenship helps secure opportunities for such discussion and decision-making, leading to the realisation of more democratic digital optimisation and food systems. While food citizenship can empower individuals to *respond* to globalised and industrialised agri-food systems, its characteristic is highly context-dependent (Grasseni, 2025). In Japan, where civic engagement and political participation are limited (Tainaka, 2024), the food citizenship that does exist can be characterised as 'quiet' (Matsuoka and Hisano, 2026). The dynamics underlying this 'quietness' and the processes that nurture food citizenship warrant further investigation. Further findings from the ongoing research will likely clarify a pathway towards sustainable and just digital optimisation within agri-food systems, as well as the role of food citizenship in that process.

Conclusion

By drawing on Bronson and Guthman's critical and theoretical lenses and applying them to my previous research on digital optimisation, this paper has demonstrated how the case study of introducing digital optimisation technologies in a particular food bank in Japan embodied the mindset of *techno-fixes, solutionism, the will to improve,* and *ICD.* These perspectives may overlook individual agency and the multidimensional nature of problems, potentially prompting apolitical decision-making within agri-food systems. As a *response* to blindly accepting and promoting such impulses in digital optimisation, I argue that food citizenship is key and advocate that people should be encouraged to enact their food citizenship and participate in forming sustainable and just digital optimisation within agri-food systems.

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The ethics of sustainable transformations of the food system

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Abstract

The start of the journey is clear to most everyone with some insight in sustainability and shortcomings and negative effects of our current food system. For food systems: business-as-usual is no longer an option, as highlighted by recent UN warnings that only 16% of the SDGs are on track. We need change, and we need change in a more ethical and more sustainable direction, and more public endorsement and willingness to change. Change needs big numbers of supporters. But where is the journey heading and how to get there? There are fallacies on the way. The first one is to assume that all the signposts that point towards Sustainability or Ethics are pointing towards a unique destination. There are, in reality, multiple and sometimes competing visions of what "sustainable" or "ethical" food futures entail. The second fallacy is to assume that if we give a detailed description of the endpoint, then the road towards that goal becomes visible. In complex and "wicked" systems, pathways remain inherently uncertain, contested, and non-linear. The third fallacy is to assume that with some signposts in the fog we can avoid major uncertainty, ambiguity and controversy. The mistake is to measure the goodness and ethical quality of our effort towards change by the outcome. Our world is intrinsically complex, and fragility is the mark of most of our actions. Thus, ethical quality must be assessed through the process of change: how we engage with uncertainty, how we negotiate diverse values, and how inclusive and reflexive our decision-making becomes. What we need is not a shiny brochure of the "goal", but a guide how to encounter resistance, how to stake out a path together with others, and how to engage in action thru transformative knowledge. In this respect, our "Turtle model"[3] offers a heuristic for navigating complexity. It emphasises the role of diverse actors, such as government, academia, industry, and civil society, and highlights how push and pull factors, value landscapes, and knowledge pluralism shape ethical transformation pathways.

Keywords: value pluralism, transformative knowledge, democratic governance

Problem framing: why "business as usual" is not an option – ethically as well as ecologically

Global food systems are widely recognised as major drivers of environmental degradation, biodiversity loss, climate change, and public health crises, while simultaneously failing to eradicate hunger and malnutrition. On this background, the point of departure for our argument is largely uncontested among those familiar with sustainability debates: for food systems, business-as-usual is not an option. Yet, while the necessity of change is clear, its ethical orientation and practical pathways remain deeply contested (Willett et al., 2019).

We argue that this contestation is not an unfortunate sideeffect to be overcome, but a a structural feature of attempts to transform complex socio-ecological systems such as food systems. Any attempt to move towards "sustainability" or "ethics" must reckon with plural and sometimes conflicting values, identities,

[3] The main ideas and the concept of the 'Turtle model' are inspired by the paper (Kaiser et al 2026) where the present authors were co-authors. We thank the other co-authors Cordula Scherer and Mimi E. Lam for sharing these ideas with us.

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and knowledge systems. This plurality – often rooted in cultural, social, and territorial diversity – generates several recurring fallacies in how transformations are imagined, which our contribution seeks to expose and overcome.

First, it is a fallacy to assume that all signposts labelled "sustainable" or "ethical" converge on a single destination. Very different endstates – technocratic, marketdriven, communitarian, or justiceoriented – can legitimately claim the language of sustainability or ethics. In other words, the normative horizon of food system transformation is inherently plural rather than singular.

Second, even if a detailed and normatively attractive description of an endstate could be agreed upon, it is a fallacy to assume that the route towards it would thereby become visible. In complex, dynamic systems, the pathway is not a simple extrapolation from a chosen start- or endpoint; it remains hazy, contingent, and pathdependent. Transformations unfold through experimentation, conflict, and learning rather than through linear planning.

Third, it is a fallacy to believe that, by placing a few wellchosen signposts in this fog, we can avoid uncertainty, ambiguity, and controversy. Food systems are intrinsically "wicked" in the sense of Rittel and Webber (1973): problem framings are value-laden, solutions are better or worse rather than true or false, and there is no clear point at which a problem is definitively "solved." Attempts to depoliticise or technocratically "solve" such problems therefore risk obscuring the ethical and political dimensions that inevitably accompany transformation processes.

Recognising this, we suggest that the ethical quality of food system transformations cannot be judged primarily by their eventual outcomes, which will always be partly unforeseeable and vulnerable to external shocks. Instead, ethics must shift from an outcomecentric evaluation ("did we reach the right destination?") to a processcentric one ("how did we conduct ourselves in conditions of uncertainty?"). Fragility and uncertainty are intrinsic features of action in complex systems and they cannot be eliminated, only navigated collectively. The central ethical question therefore becomes not only what kind of food system we aim to achieve, but how societies deliberate, decide, and act together while moving through uncertainty.

From outcome ethics to process ethics: what counts as an "ethical transformation"?

This shift from outcomes to processes has several implications for how we conceptualise and guide food system change (Blok 2019). First, an ethically robust transformation cannot be reduced to maximising aggregate utility (as in standard utilitarianism) according to a predefined metric (e.g., calories, GDP, or even a narrow set of environmental indicators). Such approaches tend to treat people as objects of optimisation rather than as agents with dignity and rights, and they are illsuited to handling deep uncertainty and value pluralism. This technocratic tendency is also reflected in dominant policy approaches to environmental change. As Elizabeth Shove (Shove, 2010) observes in her critique of climate-change policy, policy frameworks often reduce environmental problems to questions of individual behaviour and consumer choice, drawing primarily on economics and psychology while neglecting broader social theories of practices and socio-technical change. By framing environmental change primarily as a matter of individual behavioural adjustment, such approaches risk marginalising structural and institutional dimensions of transformation. This critique is highly relevant to food system debates, where environmental sustainability is frequently framed in terms of "responsible consumption" (e.g., encouraging individuals to choose organic, local, or low-carbon diets) while the broader infrastructures, market structures, and governance arrangements that shape food production and distribution remain comparatively underexamined. As a result, responsibility for environmental

change is often shifted onto consumers rather than addressed through systemic transformations of the food system itself.

Second, the ethical benchmark for transformative efforts must instead be found in the way decisions are made, conflicts are handled, and knowledge is generated and shared over time. Scholars of sustainability governance have emphasised that complex societal transitions require approaches that "open up" debates about possible futures rather than prematurely "closing down" around a single optimal pathway (Stirling, 2010). From this perspective, the legitimacy of transformation efforts depends not only on the outcomes they produce but also on the inclusiveness, transparency, and reflexivity of the processes through which decisions are made. Processes are ethically qualified when they are inclusive, transparent, responsive to those affected, open about uncertainties and tradeoffs, and capable of learning (cf. on the relationship of sustainability and transdisciplinarity: Hadorn et al 2006). This does not guarantee "good" outcomes, but it makes them more likely and, crucially, more legitimate.

Third, this orientation requires what we call transformative knowledge: knowledge that is explicitly designed and used to enable collective sensemaking, deliberation, and action under conditions of complexity. Transformative knowledge is not purely descriptive, nor merely instrumental: it is reflexive about its own limits and about the values and assumptions embedded in analysis and modelling (cf. also: Kaljonen et al 2025 on food justice). It thus stands in contrast to a purely technocratic or expertdriven understanding of "what we need to know" to change the food system.

Taken together, these considerations imply that ethics in food system transformations is not an addon at the end of a largely technical process but rather constitutive of how problems are framed, how knowledge is produced, and how actors are involved from the outset. It can also include accounts of breakdown, decline and phase-out of old and excisting systems (cf also the X-curve framework: Hebinck et al 2022). What is needed, then, is not a glossy brochure of a final "ideal" food system, but a practical guide to encountering resistance, coping with disagreement, and cocreating pathways with others in ways that honour dignity, human rights, and justice.

Transformative knowledge and system analysis: why we need a "middlecomplexity" model

If the ethical focus is on process, the methodological challenge is to develop tools that can both acknowledge complexity and still guide action. Highly abstract or overly simplified models risk masking crucial dynamics and value conflicts: hyperdetailed, dataheavy models risk becoming opaque to nonexperts and unusable in democratic deliberation. We therefore argue for "middlecomplexity" frameworks: structured enough to capture key relations and leverage points, but simple enough to support inclusive discussion.

System analysis provides a natural foundation for such frameworks. For food systems, this means moving beyond linear "from farm to fork" chains to circular, networked representations that link production, processing, distribution, consumption, waste, governance, and the broader socialecological context. Rather than attempting to predict precise trajectories, the aim of such frameworks is to make visible key dynamics and points of interaction within the system. In particular, they can help illuminate:

- where powerful drivers ("push" and "pull" forces) arise,
- where constraints or barriers strongly limit change,
- and how different actor groups can interact constructively within these dynamics.

Within this perspective, system models should not be understood primarily as predictive tools, but as heuristic devices that support collective sense-making and deliberation. In previous work (Kaiser et al.,

2026), we have adapted a conceptual tool originally developed in German innovation studies and later applied to energy transitions – the "turtle model" – to the domain of food system transformations.

The turtle model: structuring drivers and actors in food system transformations

The turtle model visualises a socio-technical system – here, the food system – as a "turtle" whose body represents the core actors and whose movements are shaped by different enabling and constraining forces. Used as a heuristic framework, the model helps to organise discussions about actors, drivers of change, and systemic constraints within food system transformations.

The model provides a structured way of mapping interactions and tensions within complex transformation processes. At the centre of the model lies the "quadruple helix" of innovation (Carayannis, Campbell & Grigoroudis 2022), comprising four main actor groups: government (including municipalities and public agencies), industry (food producers, processors, retailers, and related businesses), academia (universities, research institutes, knowledge brokers), and civil society (citizens, NGOs, community groups, and social movements). These actors embody different mandates, knowledge types, interests, and value commitments. Rather than assuming a single privileged locus of authority or expertise, the model foregrounds their interactions and their potential for co-creation in transformation processes.

Surrounding this core are several categories of forces that influence the direction and pace of transformation. For analytical purposes, the model distinguishes between "push" drivers, which generate pressures for change, and "pull" drivers, which orient actors toward particular futures. Push drivers include regulatory frameworks, information flows, and technological developments that reshape the conditions under which actors operate. Pull drivers include incentive structures, market dynamics, and shared visions of desirable food futures. These forces interact in complex ways, shaping how actors interpret challenges, mobilise resources, and pursue change.

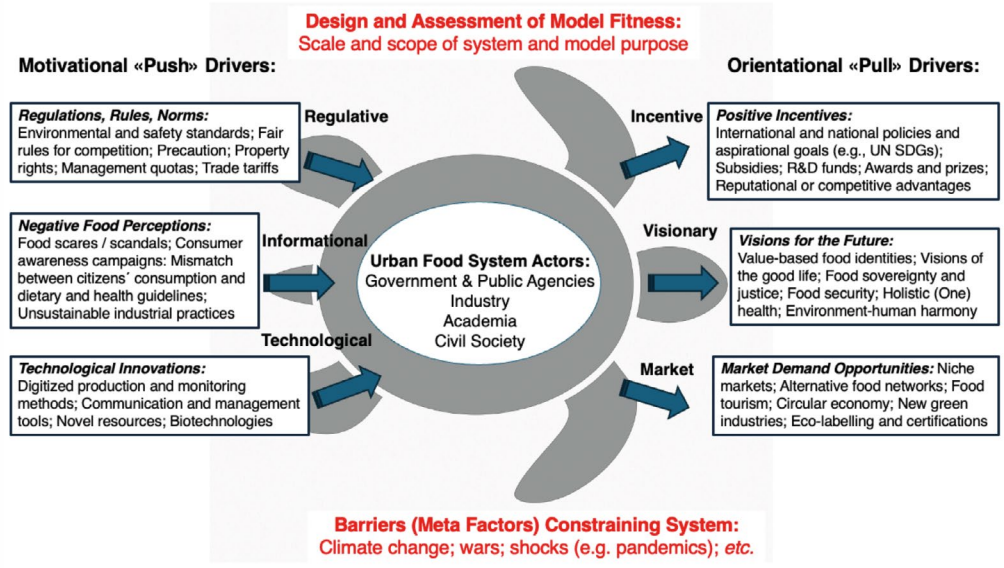


Figure 1. The Turtle Model for urban food system transformations (cf.: Kaiser et al 2026)

The outer "shell" of the turtle represents broader contextual conditions that strongly influence transformation processes. These include factors such as climate change, geopolitical dynamics, global trade regimes, pandemics, and structural inequalities. While actors within the system cannot easily modify these meta-conditions, they must navigate them and adapt resilient strategies. Recognising such constraints is therefore essential for situating food system transformations within wider socio-ecological dynamics. The model functions less as a predictive framework and more as a heuristic tool that supports process-oriented reflection on food system transformation.

Ethical principles and democratic food governance in food system transformations

The approach outlined above is not normatively neutral. Rather, it is grounded in a broader ethical framework that moves beyond purely utilitarian or technocratic understandings of transformation. In contrast to approaches that prioritise aggregate optimisation or efficiency metrics, we argue that ethically robust food system transformations should be guided by a constellation of normative principles that include dignity, human rights, justice, and trust.

First, the principle of dignity emphasises that individuals should not be treated merely as carriers of preferences or targets of behavioural change, but as agents entitled to respect and meaningful participation in decisions that affect their lives. In the context of food systems, this implies recognising citizens not only as consumers but as participants in shaping the norms, priorities, and institutions that govern food production, distribution, and consumption. They engage in deliberations about acceptable 'value-landscapes' (Kaiser 2024).

Second, human rights provide an important normative foundation for evaluating food system transformations. Rights such as the right to adequate food, health, and participation in public affairs establish minimum thresholds that transformation processes should not violate. They also provide a framework for assessing trade-offs between competing objectives, particularly where sustainability measures may have uneven social consequences.

Third, justice concerns the distribution of both the benefits and burdens associated with food system change (cf. also: Kaljonen et al 2025). This includes distributive dimensions (who gains and who loses from transformation processes), recognitional dimensions (whose identities, values, and knowledge systems are acknowledged), and procedural dimensions (who is able to participate in shaping decisions). Attending to these different dimensions of justice is particularly important in food systems, where structural inequalities often shape both vulnerability and access to resources.

Finally, ethically robust transformation processes depend on trust among actors. Trust allows actors to engage in collective experimentation and deliberation despite uncertainty and disagreement. Such trust is sustained not only by institutional arrangements but also by virtues such as honesty, humility, and practical judgement among individuals and organisations.

Within this normative framework, a central shift concerns how we conceptualise the role of the public in food system governance. Conventional policy language often refers to actors primarily as "stakeholders," emphasising their interests and positions. By contrast, framing actors as citizens foregrounds their role as members of a political community who participate in shaping collective visions of food futures.

From this perspective, citizens are not merely consumers whose individual choices drive market demand, nor passive recipients of policy interventions. They are co-authors of the visions, norms, and institutional arrangements that shape food systems. Their diverse food identities – rooted in cultural traditions, social

experiences, and aspirations for the future – can therefore play an important role in shaping collective imaginaries of desirable food futures.

Practically, this implies the need for governance arrangements that enable meaningful participation and deliberation. These may include inclusive forums in which different forms of knowledge – scientific, experiential, local, and indigenous – can interact, as well as participatory approaches to policy design and experimentation. Within such settings, tools such as the turtle model can support dialogue by helping actors reflect on the drivers, constraints, and trade-offs involved in transformation processes.

Seen in this light, the ethical challenge of food system transformation is not only to identify desirable outcomes but to cultivate governance processes capable of navigating uncertainty, disagreement, and plural values in legitimate and reflexive ways.

Conclusion

While the need for transformation of food systems is broadly acknowledged, the ethical orientation of such transformations and the pathways through which they should unfold remain deeply contested. In this context, we argue that the ethical quality of food system transformation should not be judged primarily by its outcomes – whose precise form remains inherently uncertain – but by the processes through which change is pursued. Ethically robust transformations therefore depend on governance processes that respect dignity, uphold human rights, attend to multiple dimensions of justice, and foster trust among diverse actors.

To support such processes, we propose the turtle model as a heuristic tool that helps make visible the actors, drivers, and structural constraints shaping food system transformations. Rather than prescribing a single pathway, the model provides a structured way of reflecting on possible trajectories and engaging different actor groups in dialogue.

Ultimately, the contribution of this approach lies less in defining an ideal food system than in supporting processes through which societies can navigate uncertainty, disagreement, and plural values while collectively shaping more sustainable food futures.

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Trust in the food chain – the case of 'fake meat'

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Abstract

This paper examines trust in contemporary food systems through the case of 'fake meat' or alternative proteins, a category that includes plant-based meat analogues, microbial and fermented proteins, and emerging cultivated meat, each associated with distinct regulatory, health, and environmental debates. We highlight how modern food production remains characterized by asymmetrical trust relations. Consumers depend on producers, regulators, and experts for safety and transparency, yet face increasing uncertainty in a complex information environment. While all food involves some degree of risk, alternative proteins represent a particularly contested category, where scientific disagreement, ethical considerations, and technological novelty intersect. We situate trust within the broader dynamics of the modern 'risk society', where individuals are expected to engage in reflexive trust rather than relying on blind confidence. Food labelling, branding, and regulatory frameworks function as communicative tools that address these dimensions, but transparency alone is insufficient to secure trust. Drawing on classical rhetorical theory, we conceptualize trust as grounded in three dimensions: rational argument (Logos), credibility (Ethos), and emotional appeal (Pathos). Trust in food is shaped not only by factual knowledge but also by cultural values, emotional responses, and perceptions of institutional credibility. Alternative proteins face particular challenges: their health and environmental benefits are contested (a Logos challenge), trust in producers and authorities may be weakened (an Ethos challenge), and their perceived artificiality can trigger negative emotional reactions (a Pathos challenge). Finally, we emphasize shared responsibility in fostering well-founded trust. Producers, regulators, scientists, and retailers must provide balanced, accessible information that acknowledges uncertainties and competing values. At the same time, consumers should engage critically with the available information. Building trust in alternative proteins requires not only technical transparency but also an inclusive public dialogue that integrates diverse societal perspectives.

Keywords: alternative proteins, consumer trust, logos, ethos, pathos

Introduction

Despite increased focus on labelling, traceability, and consumer rights regimes, current food production systems are still arenas with uneven distributions of power, knowledge, and responsibility between consumers and those who produce and regulate food. In other words, in these relations, the trustors are dependent on the trustees for safety and transparency. At the outset, all kinds of food are sources of health risk, and for most people an arena of trust. However, there are some food products that raise the risk and trust issues beyond the trust challenges pertaining to all kinds of food. In some cases, there is scientific and public consensus that they may pose risk, such as food that has exceeded the expiration date or food that is exempted from accepted safety measures, such as non-pasteurized milk. In other cases, the risk issue is a matter of disagreement, meaning that the risk is contested. Examples include GM food, different diets and so-called ultra-processed food. This paper takes the concept of 'fake meat' or (more neutrally) 'alternative proteins' as a case, exemplifying products that are contested, and that typically involve complex industrial techniques and processes. In this context, 'fake meat' or 'alternative proteins' cover proteins produced from plants, fungi, fermented microbial processes, milk and egg alternatives,

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cultivated meat, and other products that are produced in order to (at least to a certain extent) resemble characteristics of conventional meat. Under what conditions should consumers trust 'fake meat', and who are responsible for ensuring well-founded trust in such products? We argue that the responsibility is shared between consumers and food system actors. However, given the asymmetrical trust in food system relations, a significant responsibility is placed on those who shape the conditions for trust, as for example industry bodies and regulatory agencies. The conditions for trust are further shaped by the modern information society where increased access to information provides a more detailed, but also a more complicated picture, distorted by information overflow, misinformation and irrelevant 'noise'. There is a decline in trust in the food systems in Europe (EIT, 2024; EFSA, 2022). Mass media plays a significant role in setting premises for the public discourse on novel food, guiding it towards issues of health and safety, with focus on risks, arguably fostering or increasing 'food scares' (Veflen et al. 2017). Although increased information regarded in isolation is positive, this food information landscape may subject individuals to misinformation and confusing, polarized debates. However, there are several other factors besides the media information flow influencing what food products people choose to consume, including cultural preferences, ethical considerations, advertising, labelling, economic incentives and other forms of legal and voluntary regulation.

To be a responsible consumer means to make informed choices based on reflexive rather than blind trust; in other words, it is necessary to make choices based on active engagement with the available facts concerning benefits, risks and uncertainties. At the same time, trust in food products is not solely based on assessment of facts, but is also guided by value assessments, with emotional components, and dependent on the credibility of the actors involved.

The case of 'fake meat'

'Fake meat' – in the sense of products functioning as alternatives to meat and meat products – is not a new invention. Products such as tofu and seitan have existed for hundreds of years. Over the past couple of decades, a number of meat analogues as plant-based products derived from soy, wheat, or peas – have entered the market, some of which efficiently imitate conventional meat both in look, texture, and taste. In addition, meat replacement products based on non-plant raw-materials – such as milk proteins, egg proteins, or fungi/mycoprotein, have also entered the market. More recently, proteins produced through microbial fermentation as microbial biomass and precision fermented ingredients as caseins, whey, egg-white proteins, heme-like precursors have emerged as a new category of proteins (Surendran et al., 2025). And lastly, cultivated meat – that is, meat produced in vitro, from cellular cultures of animal cells rather than from slaughtered animals – are slowly moving from scientific concepts to the store shelves. In Europe, cultivated meat products (e.g., cultivated foie gras and beef) are under review but have not yet been approved for commercialisation. National policies also come into play, for example in Italy, where a law that bans cultivated meat for human consumption was adopted already in 2023. In contrast, several countries outside of Europe, including Singapore, USA and Israel has approved the commercial sale of specific cultivated meat products as chicken and beef.

Clearly, these diverging regulatory pathways contribute to a heterogenous product landscape, in which the different forms of alternative proteins carry their own set of health, environmental, and economic risks and benefits. At the same time, they feed into an increasingly polarized public discourse, where complex questions of facts, values and societal priorities intersect.

These factual complexities are supplemented with an equally challenging value landscape. Cultivated meat products, like other alternative proteins, are presented as a moral alternative to meat-based food. Keywords here are animal welfare issues in industrialized farming and environmental impact from meat production. Furthermore, most alternative protein products fall under the loose definition of

ultra-processed food, in other words products not made from pure raw materials, but from industrially processed ingredients such as protein isolates (e.g. whey), starch, hydrogenated oil/fat, or flavour enhancers. The potential health implications of a high degree of processing remain unclear. As a result, discussions about alternative proteins often become polarised, with concerns about health and technology that hinge on a deeper question: Who and what the consumers can trust.

Trust as complexity-reduction

Many consumers feel overwhelmed when confronted with the complexities of the modern food system (Øygarden and Kilsti, 2024). Giddens (1991) and Beck (1992) argue that the shift towards a modern 'risk society' changes the basis and nature of trust, from unconditional confidence to reflexive trust. Reflexive trust requires that consumers take an active stand to the available facts and evaluate recommendations and directives from authorities, including experts and institutions. It is common to hold that trust is primarily a matter of trustworthiness, and in line with this, that transparency is a key term when it comes to securing consumers' trust. Increasingly explicit reporting on the social and environmental impact of food production points towards this development. However, transparency does not fully cover how trust in food products and food producers is gained or lost, since we base our trust or lack of trust on a lot more than just the available information. Trust also depends on how consumers interpret the information, and the credibility of the actors involved. It is influenced by how information about the product is presented, labelling, traceability, regulations, and the integrity of the food producers (Wu et al., 2021). In addition, there are also social and cultural factors that shape perceptions of risk. Hence, in some cases, openness and transparent regulation may diminish rather than increase trust (O'Neill, 2002).

Luhmann (2000) argues that trust is a way to manage uncertainty by reducing the complexity of decision-making situations. This concerns rational argumentation, but also the appeal to ethical values and emotions. According to Giddens (1991) trust involves an emotional commitment, a 'leap of faith' which cannot be fully founded in rationality. To display these different aspects of communication, we can deploy the well-known division from the Aristotelian Rhetoric, between three modes of persuasion: Logos, Ethos, and Pathos (Carson, 2019). These modes are sometimes referred to as 'ethical strategies' and may be explicated as three ways in which a speaker can earn the trust of her listeners. In this context, the modes refer to three different aspects of the basis for public trust in food products.

Labels, brands, and other explicit policies to address health and sustainability issues can from this perspective be viewed as rhetorical devices by which food producers, retailers, or regulators seek to appear as trustworthy institutions (Wæraas & Ihlen, 2009). Labelling schemes, environmental branding etc. provide rational arguments (Logos) as well as elements supporting the credibility of the product or producer (Ethos) and the appeal to emotional aspects such as belonging (Pathos). The appeal to Logos in this context means to provide transparent, rational arguments regarding the environmental footprint and health properties of the product, e.g. compared to alternative or competing products. The appeal to Ethos means to establish the credibility of the food producer and/or the external authority or system backing the claim, for example through a third-party certifications, risk assessment or governmental agency. The appeal to Pathos may be used in order to establish trustworthiness, since conveying rational arguments in a reliable way is not sufficient if the emotional acceptance of a food product or producer is not in place (Solomon and Flores 2003). Not least when it comes to food, where concerns about safety and identity is important, the emotional element of trust is essential. In general, commercials typically invoke trust by the appeal to Pathos. For example, the label "Nyt Norge" ("Enjoy Norway"), which guarantees that the product is produced in Norway from Norwegian raw materials, uses images and a voiceover with a dialect from Norwegian fjords (Refle and Tangen, 2012), all strengthening perceptions of authenticity and trustworthiness.

Considering the three rhetorical elements, various communicative strategies are necessary in order to establish trust in an alternative protein product:

1. A *Logos* strategy: The information about the products must be accessible and provide sufficient rational argumentation for its health benefits, environmental sustainability, and other relevant aspects;
2. An *Ethos* strategy: The providers of the product must gain credibility in the eyes of the consumers, preferably through a third-party certification, for example through risk assessment procedures, and regulatory oversight;
3. A *Pathos* strategy: The products must appeal emotionally to their stakeholders. This means overcoming customers' potential feeling that there is something wrong – say, something 'artificial' – with the way the products are manufactured and/or the end product.

'Fake meat' or alternative protein products face Logos challenges in the sense that the rational arguments concerning health and environmental benefits are contested, and Ethos challenges in the sense that the credibility of the spokespersons of the industry or expert authorities is undermined. In addition, media coverage often reinforces the polarized debate.

When it comes to Pathos, attitudes towards food clearly involves strong feelings – of safety and health as well as identity and culture – which could explain why food producers might need to work harder to gain the trust of the consumers. The high-tech profile of the alternative protein industry may give them a particular challenge regarding these emotional aspects, given that "freshness" and "naturalness" are key values by food consumers, according to a report by Consumption Research Norway (SIFO) (Bugge et al., 2025). This report also shows that 34 percent of consumers claim to actively avoid ultra-processed food.

At the same time, a recent survey by the Norwegian Consumer Council shows that consumers are more concerned about the environmental impact of "pure" foods such as farmed fish, chicken, and imported fruit and vegetables, than they are about processed foods such as ready-made meals and snacks (Forbrukerrådet, 2023). This contrast underlines the complexity of trust in food: Perceptions of risk do not need to align with the product's properties but may be shaped by broader cultural and emotional frameworks.

The responsible consumer

In Norway, the regulatory system and political governance of the food market seem to provide a complexity-reducing effect, as consumers so far in general have placed a high trust in these bodies (Dulsrud et al. 2006; Halkier et al., 2007; Forbrukerrådet, 2023). However, providing balanced information regarding alternative proteins may lead to new challenges for consumer trust. These products have other origins than the trusted farm products and raise questions based on contested facts and diverse values regarding nutritional composition, environmental concerns, new technologies and cultural expectations.

Given the complexity of the food chain and the polarized debate concerning healthy foods, food producers and retailers, scientists, and regulators have a joint responsibility to provide balanced and accessible information on the scientific, socio-economic, environmental, cultural, and ethical complexities and uncertainties associated with alternative protein products. To be trustworthy and provide the needed consumer support, these actors should pay attention to both the Logos, Ethos, and Pathos aspects of trust. This entails making room for inclusive public engagement processes, ensuring that political decisions are informed by positions and arguments representing a diversity of societal groups. Without such reflexive and participatory approaches, trust will be fragile, and the promise of

alternative proteins as a sustainable solution may be undermined by unresolved ethical, cultural and political tensions.

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Cultural rights and climate duties in the context of meat consumption

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Abstract

Meat consumption is a significant contributor to global greenhouse gas emissions, it is also an important element of cultural events and traditions in many societies. Climate mitigation efforts require individuals to reduce their high-emission activities; however, certain food traditions fall into this category while remaining deeply tied to identity, belonging, and cultural continuity. To address this tension, this paper integrates perspectives from cultural rights and climate ethics to evaluate how cultural practices relate to individual climate duties to reduce emissions. In a first step, we argue that cultural rights, including the right to partake in dietary traditions, must be recognised as essential to human dignity and inclusion. Building on this foundation, in a second step, we develop an ethical framework to define how individual moral responsibilities relate to fairness-based approaches concerning the distribution of the remaining emissions budget. Within this framework, we categorise emissions as subsistence, participation, or luxury emissions, allowing for context-sensitive ethical evaluation of meat consumption. The analysis concludes that meat consumption may be justified when it fulfils subsistence purposes, meeting essential nutritional needs or reflecting limited access to alternatives, or when it functions as a participatory practice.

Keywords: cultural rights, climate ethics, meat consumption, climate justice, fair share

Introduction

Meat consumption has become a concern in discussions of climate change and sustainability as the livestock sector is responsible for approximately 14.5% of global greenhouse gas emissions (FAO, 2017). Therefore, its contribution to climate change alongside other environmental impacts such as land degradation and biodiversity loss should not be overlooked (Gerber et al., 2013). Due to this, reducing meat consumption should be considered a necessary step toward mitigating climate change.

However, meat is not merely a source of nutrition; it is also deeply embedded in cultural traditions, religious practices, and everyday social life. Meals involving meat often structure celebrations, rituals, and shared identities, making dietary practices an important component of cultural belonging (Font-i-Furnols, 2023). This creates a normative tension: while individuals are expected to reduce emissions, they also hold cultural rights to participate in meaningful cultural life.

This paper addresses the question: under what conditions can meat consumption be morally justified in the context of climate change? We argue that answering this question requires integrating insights from cultural rights and climate ethics debates. Rather than treating all meat consumption as equally problematic, we propose a framework that distinguishes between different types of emissions: subsistence, participation and luxury emissions. This allows for a more precise evaluation of when meat consumption should be justified and when it should be reduced.

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Cultural practices and human rights in the context of diet

Cultural rights form part of international human rights frameworks as they protect individuals' ability not only to access cultural goods, but to actively participate in cultural life through practices, expressions, and ways of living that are central to identity and belonging. The United Nations Committee on Economic, Social and Cultural Rights (CESCR) clarified in General Comment No. 21 that culture should be understood as a dynamic and evolving process, including therefore practices and forms of life through which individuals express and maintain their identity (CESCR, 2009). In this sense, cultural rights are closely linked to human dignity and social inclusion, as they allow individuals to define themselves in relation to their communities and to maintain meaningful social ties.

Food practices are an expression of this participatory part of culture, as certain meals let individuals celebrate their cultural background and identity (Alonso et al., 2018). Therefore, eating habits are not simply individual preferences but are culturally transmitted practices that teach individuals what foods are acceptable, how meals should be structured, and who participates in food preparation and consumption (Alonso et al., 2018; Cantarero et al., 2012). Family meals, observing fasting periods like Ramadan, and associating meat consumption with masculinity demonstrate how eating behaviours reflect broader cultural values (De Backer et al., 2020; Ruby and Heine, 2011). However, these culturally embedded practices, particularly those involving meat, also have significant environmental consequences. Meat production is associated with high greenhouse gas emissions, as well as broader impacts such as land use change, biodiversity loss, and resource depletion, making it a major contributor to climate change (Gerber et al., 2013).

This creates a central tension: while meat consumption can be a meaningful cultural practice, it is also a significant driver of environmental degradation. Traditions that once served to strengthen social bonds now contribute to ecological harm (Biermann and Rau, 2020). At the same time, not all meat consumption carries cultural significance. While some instances are tied to rituals or collective identity, much of contemporary consumption occurs in everyday life. As a result, practices that may be culturally meaningful in some cases risk being used to justify forms of consumption that are environmentally costly without serving a clear cultural function. What was once primarily reserved for special occasions or cultural celebrations has become a regular feature of everyday consumption. This transformation is not solely cultural, but also the result of structural and economic changes, including increased availability, industrialisation of food systems, and rising incomes (Grigg, 1995; Williams, 2000). This tension between culturally meaningful and everyday meat consumption calls for an ethical framework to evaluate when meat consumption can be justified and when it should be reduced.

From duties to justifiable practices

In what follows, this paper focuses on individual-level practices and how they are expressed through individual actions, such as dietary choices. While climate change is often framed as a structural problem, embedded in economic systems and institutional arrangements, these structures are sustained through repeated patterns of individual behaviour (Young, 2013). Food choices are a daily and recurring practice through which individuals contribute to broader environmental outcomes. Even if a single instance of meat consumption appears negligible, it is precisely the accumulation of such choices that generates significant environmental harm. In this sense, individual actions are not morally irrelevant, but form part of a larger pattern of practices that sustain high-emission systems (Fragnière, 2016; Schübel, 2023).

At the same time, individual responsibility must be understood within a framework of fairness. Climate change is fundamentally a problem of limited resources, as the global carbon budget available to avoid dangerous warming is finite. This raises the question not only of reducing emissions, but of how the

remaining emissions should be distributed. Fairness-based approaches, such as Equal per Capita and Fair Share principles, suggest that individuals should not exceed their share of permissible emissions, particularly when doing so limits others' ability to meet basic needs (Baatz and Voget-Kleschin, 2019; Caney, 2010). However, these approaches also highlight that not all emissions are equally necessary or equally justifiable. Some emissions are required to secure basic well-being, while others enable individuals to participate meaningfully in social and cultural life, and others still are avoidable without significant loss.

To capture these distinctions, this paper adopts a typology of emissions that differentiates between subsistence, participation, and luxury emissions (Schübel and Wallimann-Helmer, 2024; Wallimann-Helmer and Schübel, 2024). Subsistence emissions are emissions required to meet basic human needs, such as nutrition, health, and safety, and therefore cannot be avoided. Participation emissions are those required for individuals to function as full members of society and to maintain meaningful social and cultural relationships, important to belonging and inclusion. Luxury emissions, on the other hand, are avoidable emissions that exceed what is necessary for subsistence or participation and can be avoided without sacrificing morally significant goods.

This typology provides a normative framework for evaluating practices such as meat consumption. It enables a context-sensitive analysis that recognises both the moral importance of cultural participation and the need to remain within fair limits of emissions. Rather than treating all emissions as equally problematic, it distinguishes between those that are necessary, those that are meaningful, and those that are excessive. In doing so, it offers a way to move beyond general calls for emission reduction and towards a more precise evaluation of when specific practices and their emissions can be considered ethically justified.

When is meat consumption justifiable?

Building on this framework, we argue that meat consumption is morally justifiable only under two conditions: when it constitutes either a subsistence or a participation emission. In all other cases, it should be considered a luxury emission and, therefore, should be avoided.

First, meat consumption is permissible when it constitutes a subsistence emission. Following Shue (1993), subsistence emissions are those necessary to meet basic human needs, such as nutrition, health, and survival. This includes situations in which individuals lack access to adequate or affordable alternatives to meat or where avoiding meat would compromise their nutritional needs. In such contexts, emissions associated with meat consumption are tied to the satisfaction of basic well-being and cannot be reasonably reduced without imposing burdens on the individual. Importantly, subsistence must be assessed in relation to real-world constraints, such as access, affordability, time, and knowledge.

Second, meat consumption may be justified as a participation emission. Building on recent extensions of Shue's framework, participation emissions refer to those emissions required for individuals to take part in meaningful social and cultural practices as full members (Wallimann-Helmer and Schübel, 2024). This occurs when consuming meat enables individuals to participate in culturally or religiously significant practices, and where opting out would undermine belonging or signal exclusion. In these cases, meat consumption functions not merely as nourishment but as a marker of identity and social recognition. However, these justifications are limited. Participation emissions must remain occasional and proportionate, as their ethical relevance depends on their role as meaningful, non-routine practices. If the individual has a choice to an alternative that causes a lower number of emissions and does not undermine their cultural belonging, they should choose the lower emission.

For instance, in the case of a culturally codified celebration where a specific dish is central to the event, such as a traditional Christmas meal or a religious feast, opting out of the dish may risk exclusion or signal non-participation, making the emission plausibly participatory. In other social settings, such as a casual gathering or a shared meal where alternatives are available and socially accepted, choosing a lower-emission option would not undermine participation. In such cases, continuing to consume meat reflects preference rather than necessity, and the justification as a participation emission becomes weaker.

Lastly, much of everyday meat consumption, particularly in contexts where alternatives are readily available, constitutes luxury emissions. These are emissions that exceed what is necessary for subsistence or participation and can be reduced without sacrificing morally significant goods (Shue, 1993). When meat consumption is driven by habit, convenience, or preference rather than necessity or cultural meaning, it surpasses what can be justified under a fair-share framework (Baatz and Voget-Kleschin, 2019). In such cases, reducing meat consumption becomes a moral requirement.

By shifting the unit of analysis from individuals to specific consumption instances, this framework captures the variability of everyday practices. The same individual may engage in subsistence, participation, or luxury emissions depending on the context in which a meal takes place. This allows for a more precise and context-sensitive evaluation of meat consumption, avoiding both the overgeneralisation that all meat consumption is unjustified and the assumption that cultural significance alone is sufficient to justify it.

Conclusion

This paper has argued that meat consumption can be morally justified only under specific conditions. By integrating cultural rights with fairness-based climate ethics, it develops a framework that distinguishes between subsistence, participation, and luxury emissions. Within this framework, meat consumption is permissible when it is necessary to secure basic well-being or when it enables meaningful cultural participation, but not when it constitutes avoidable luxury consumption.

Rather than framing cultural practices and climate responsibilities as conflicting, the analysis shows that they can be reconciled through a context-sensitive approach. Individuals can participate in cultural life while respecting planetary limits, provided that high-emission practices are limited to cases of subsistence and meaningful participation. By shifting the unit of analysis to specific consumption instances, the framework offers a more precise way of evaluating everyday practices without overgeneralising individual behaviour.

At the same time, this framework has several limitations. First, it does not engage with questions of animal ethics or animal rights, which may provide independent reasons to restrict meat consumption beyond climate considerations. Second, it does not differentiate between types of meat, despite significant variations in their environmental impact, as doing so would require a more detailed, quantitative analysis. Third, the framework is context-dependent and may not fully capture the diversity of cultural and socio-economic conditions across different regions. Finally, while the focus on individual practices provides a useful entry point for ethical evaluation, broader structural and institutional factors remain crucial in shaping food systems and available choices.

Despite these limitations, the framework offers a practical tool for navigating the tension between cultural belonging and climate responsibility. It suggests that the challenge is not to abandon cultural practices altogether, but to critically assess when and how they are to celebrate them in these times of climatic concerns.

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Feeding exclusion: why charitable food fails food justice

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Abstract

In high-income countries, charitable food has become the dominant response to food insecurity. Food banks and related initiatives, once designed for emergencies, are now permanent fixtures of welfare systems. They are widely celebrated as win-win practices that simultaneously prevent waste and relieve hunger. Yet this apparent success conceals significant shortcomings for food justice.

Using the concepts of convenience frames and Carol Bacchi's "What's the Problem Represented to be?" (WPR) approach, this paper critically examines how charitable food depoliticises hunger and shifts responsibility. We identify three dynamics: (i) food insecurity is framed as a technical matter of hunger relief, disconnected from structural poverty; (ii) the retreat of state responsibility fosters a "shadow welfare system" sustained by NGOs and volunteers; and (iii) the moral aura of solidarity shields these practices from critique. Within this framework, surplus food is re-commodified into a "charity economy" that benefits corporations while leaving users dependent on leftovers, with hidden costs of stigma, shame and exclusion.

In the dominant narrative, in High-Income Countries, channelling surplus food to vulnerable people is often presented as a win-win solution. This text uses Bacchi's model to offer an explanation of this established fact. The aim is to step back from taken-for-granted objects and concepts to determine how they came to be; thus, this contribution aims to make a critical contribution to the described phenomenon.

We argue, through a logical-critical reflection based on a comprehensive review of specialized bibliography that charitable food acts as a "successful failure": it persists and reassures societies but does not structurally reduce food insecurity. A constructive way forward is to re-politicise the issue: recognising food insecurity as rooted in inequality, reaffirming public accountability for the right to food, and designing policies that secure dignified, equitable and socially acceptable access to food for all.

Keywords: charity, rights, food insecurity, successful failure, politicization

Introduction

It is necessary to ask a series of questions to try to clarify the established relationship between the need for food and charitable aid resources. In high-income countries, these types of resources are rapidly expanding (Riches, 2018) and seem to persist indefinitely (Ronson and Caraher, 2016: 79); we must ask ourselves why. Some related aspects have to do with its contribution to the efficiency of the food system, by its capacity to get rid of food surplus (Booth and Whelan, 2014: 1399), or by its ability to re-value waste as hunger relief in an industrial food system that accumulates wealth (Lohnes, 2021: 360).

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This work highlights, through a logical-critical reflection, the necessary questions we must ask ourselves to understand this phenomenon. The questions posed by Carol Bacchi in her essay "What's the problem represented to be?" serve as an argumentative guide to reveal what lies hidden behind the response to food insecurity through charity. Ultimately, it is essential to examine this issue in a way that ensures the response to food insecurity is built upon the right to food.

The necessary questions regarding the problematization of food insecurity

In high-income countries, charitable food aid has become the primary response to food insecurity. Food banks, initially created for emergencies, have become permanent fixtures and are seen as effective solutions that reduce waste and hunger. However, this apparent success masks significant problems in terms of food justice. On the one hand, food insecurity is presented as a technical issue, disconnected from structural poverty. On the other, the retreat of the state gives rise to a parallel welfare system sustained by NGOs and volunteers. In short, food aid functions as a "successful failure": it sustains and reassures society, but it does not structurally reduce food insecurity.

The policy problematization perspective using Carol Bacchi's methodological approach known as *What's the Problem Represented to be*? (WPR), aims of characterizing a widely adopted approach to addressing food insecurity in High-Income Countries (HICs). As Bacchi points out, the purpose is to move beyond commonly taken-for-granted concepts and objects in order to understand how they have been constructed, analyzing the heterogeneous strategic relationships that shape social life. Problematizing policy analysis fosters critical thinking that questions what is considered natural or unquestionable, reviewing and examining unexplored ways of thinking to show that they have a history and to underscore the need to question their implications (Bacchi, 2012; Bacchi and Goodwin, 2016: 16). The application of the WPR approach to the study of food insecurity in HICs has been based on a review of specialized literature. This work constitutes step toward a critical analysis of the impact of this perspective on the most vulnerable populations.

The first question of the WPR methodology, 'What is the problem represented in a particular policy or policies?' aims to examine the problem representation to see what is being problematised (Bacchi and Goodwin, 2016: 20). The initial way of framing the problem is to focus on food insecurity as a consequence of economic hardship, assumed to be only partially addressed through measures implemented under European guidelines and through the actions of third-sector organizations. Eurostat defines food insecurity as the inability to afford a meal with meat, fish, or a vegetarian equivalent every second day, which captures the inability to afford essential goods, services, or social activities (Eurostat, 2023). Since 2014, the European Union has addressed food deprivation through the Fund for European Aid to the Most Deprived (FEAD) (European Commission, 2015). FEAD can be described as "a redistributive and highly targeted European anti-poverty programme" (Greiss et al., 2021: 622). In 2020, FEAD assisted around 15 million people with food, alongside material and social inclusion support (European Commission, 2022a, 2022b). However, despite its broader objectives, it remains predominantly a food assistance programme (European Court of Auditors, 2019).

In 2024, the members of the FEBA in 30 European countries distributed 834.000 tonnes of food to 43,345 charitable organizations serving 12.2 million most deprived people (FEBA, 2025). More than 58% of the food sourced consists of surplus recovered from food businesses and the EU fruit and vegetable withdrawal scheme. In Europe, European Food Banks Federation (FEBA) members redistribute food financed through EU and national programmes, as well as through individual and corporate donations (FEBA, 2023).

Carol Bacchi's second question – "What deep-seated assumptions underlie this representation of the 'problem'?" – can be explored by examining how this framing is made meaningful and intelligible, and how it is socially constructed (Bacchi and Goodwin, 2016: 21). A linear and unidirectional pathway is built, linking food surplus to food insecurity through charitable food provision. Within this framing, people's food needs are treated as measurable and manageable, while surplus food is positioned as a solution to hunger. Furthermore, they are presented as a sensitive, natural, effective, and common solution to poverty (Möller, 2022: 36). They have become "successful failures" (Seibel, 1996), requiring infinite resources to meet endless demand. Their voluntary or faith-based nature fails to meet the needs of the people they are supposed to be helping but protects them from criticism.

In addressing the third question – "How has this representation of the problem come about?" – Carol Bacchi argues that such framings emerge from specific decisions and developments within particular institutional contexts, and that alternative representations could have prevailed had different pathways been taken (Bacchi, 2009: 10). The dominance of this perspective is reinforced by established power structures, notably through the role of the third sector in responding urgently to food needs and that of governments in relation to the right to food, thereby consolidating a charity-based model. As Douglas et al. (2015: 311) note, charitable responses to food poverty tend to assume that hunger can be addressed without recognising the agency of recipients. At the same time, reliance on third-sector resources shifts responsibility away from public authorities, effectively compensating for gaps in welfare systems and sustaining policy shortcomings in addressing poverty (Ghys, 2018: 177). In this context, food banks play an increasingly central role in mitigating the effects of austerity at the grassroots level (Strong, 2020: 211). While assistance is provided as an act of charity rather than as a guaranteed right (Salamon, 1987: 41), consequences have to be taken into account.

At the same time, the re-commodification of donated and/or otherwise wasted food within a secondary cycle has given rise to a "new charity economy" (Kessl et al., 2020): a system in which surplus essential goods are either distributed free of charge or sold at reduced prices to individuals who are unable to fully participate in the market economy, or can do so only partially through volunteer work. Kessl et al. (2020: 361, 369) explain that this secondary circulation of surplus goods from the dominant capitalist market, although formally situated within civil society, is also connected to and integrated into welfare state social services, and increasingly into the economic sphere. Moreover, by avoiding the costs associated with food waste, businesses can also benefit from a "halo effect" by highlighting these charitable actions (Caraher and Furey, 2022).

So, how can we problematize food insecurity?

Therefore, the fourth question – "What is left unproblematic in this problem representation? Where are the silences? Can the 'problem' be conceptualized differently?" – enables critical practices to rethink assumptions, imagine what remains unproblematised, and approach the issue from alternative perspectives (Bacchi and Goodwin, 2016: 22). In this case, charitable food aid addresses hunger while overlooking rights, thereby avoiding reflection on its implications for the welfare state and the structural causes of poverty. At the same time, charitable food provision is framed as a matter of gift rather than entitlement, and thus fails to ensure equal and legitimate access to food for all citizens, ultimately undermining social rights (Lambie-Mumford and Silvasti, 2020: 7). According to Riches (2018: 9), the rise of market-driven global food philanthropy has enabled governments to evade accountability for fulfilling their human rights obligations to combat domestic hunger. Dowler and O'Connor (2012: 45) further argue that food security entails the ability to access food with dignity, in line with social norms – that is, access to nutritionally adequate, safe, appropriate, and socially acceptable food. The silencing of this dimension invites us to reconceptualize and problematise food insecurity in different ways.

The fifth question of the WPR on the effects of problem representation invites analysts to consider three types of interrelated effects: discursive effects, which establish the limits of what can be said and thought; subjectification effects, which are the forms in which subjects are constituted in discourse; and lived effects, which directly affect people's material lives (Bacchi and Goodwin, 2016: 23). The isolation of food insecurity from other structural problems is a closely related phenomenon. Fisher (2017: 37) describes hunger as an issue detached from broader societal dynamics and systemic solutions, deliberately or inadvertently separated over time by various organizations and individuals, thereby becoming inherently political. A form of "invisibility" has emerged, whereby the presence of food banks creates the impression that poverty is being adequately managed and thus no longer visible (McIntyre et al., 2015). However, such measures fall short of the social standards of affluent societies, where inclusion entails participation in both the labour market and consumer society, as well as meaningful access to markets. Recipients are often portrayed as passive beneficiaries, having little choice when faced with hunger (Lorenz, 2012: 393). Their needs and aspirations tend to be overlooked (Salonen et al., 2018), and they are frequently constrained to consuming cheap, convenient, and filling foods (Gartwaite et al., 2015). In this way, recipients of food aid become disenfranchised, while dominant discourses of the "needy" and the "hungry" contribute to their alienation and social exclusion (Lambie-Mumford, 2019: 14–15).

The sixth question of the WPR framework examines how and where problematizations are produced, disseminated, and defended, as well as how they might be disrupted or replaced. It draws attention to the practices that authorise particular representations of problems and explain why some come to dominate over others (Bacchi and Goodwin, 2016: 24). In other words, it concerns the processes through which these representations reach the public and acquire legitimacy (Bacchi, 2009: 19). In this context, policy instruments addressing food insecurity – such as the FEAD – appear to legitimise charitable food aid across Europe, as FEAD-funded initiatives have become increasingly formalised and standardised through regulatory frameworks (Greiss et al., 2021: 632). At the same time, the very existence of food banks and charitable food aid organisations contributes to their own reproduction. As Poppendieck (1999: 5–6) argues, these mechanisms foster "a culture of charity that normalises destitution and legitimises personal generosity as a response to major social and economic dislocations, creating the illusion of effective action and offering numerous ways to participate in it." Moreover, the commodification of poverty relief provides donors with the added benefit of immediate emotional gratification, reinforcing their sense of being valuable and engaged members of the community (Möller, 2022: 168).

Conclusions

Addressing food insecurity through technical resources, often with a charitable bent, has led to the neglect of the structural processes that cause social inequalities and, ultimately, hunger. The legitimizing narrative of responding to food insecurity through third-sector resources has created a secondary safety net for these vulnerable individuals, whose right to food is not, however, guaranteed under the same conditions as that enjoyed by the segment of the population who do not face such problems in a consumer society.

This concealment of the true extent of the problem also obscures the advantages the food production system has in disposing of surplus food through these channels, as well as the profits of powerful food corporations, or Big Food. A first step towards repoliticization as an alternative must be to repoliticize the problem, recognizing its roots in inequality, strengthening public responsibility, and guaranteeing dignified and equitable access to food.

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Mapping ethical tensions in cell-based animal-origin food: from animal welfare to systemic justice

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Abstract

Cell-based animal-origin food (cell-based AO food) is promoted as an ethical innovation that could reduce animal suffering while improving sustainability and public health. Yet controversies surrounding these products extend far beyond narratives of "slaughter-free meat". This paper introduces the Concentric Ethical Matrix (Concentric EM), a framework to analyse ethical tensions at three interrelated levels: (i) ontological, where disputes concern meaning, legitimacy, and cultural categories; (ii) intrinsic, addressing product-specific features such as safety, nutrition, labelling, and evolving welfare profiles; and (iii) systemic-transitional, highlighting broader challenges of sustainability, distributive justice, sovereignty, and global power asymmetries.

The framework shows that ethical reflection is not a brake on innovation but a condition of legitimacy. As the European GMO debate revealed, safety assessments alone cannot secure trust when cultural and systemic concerns remain unaddressed. Similar tensions now shape the fragmented governance of cell-based AO food, with divergent national strategies and unresolved questions about public accountability.

By mapping rather than dissolving value conflicts, the Concentric EM clarifies why governance must articulate plural ethical concerns instead of suppressing them through technocratic closure. For European food law and policy, this requires embedding transparency, participation, and cultural pluralism alongside scientific evaluation and innovation incentives. Linking the initial promise of animal welfare with systemic demands of justice and sustainability, the paper argues that only plural and participatory governance can enable cell-based AO food to contribute to a democratic and sustainable protein transition.

Keywords: cell based meat, concentric ethical matrix, just protein transition, food governance

Introduction

Food is never just a biological necessity. It is memory, ritual, power, and belonging. Across cultures, what we eat is bound up with who we are and how we live together. This is why innovations in food rarely pass unnoticed: they touch sensitive fibres of meaning and legitimacy.

Few examples make this clearer than cell-based animal-origin food (cell-based AO food) – edible tissues derived from animal cells cultivated in vitro. Proponents describe it as a radical promise: meat without slaughter, protein without ecological guilt, food without the looming shadow of zoonotic risks. In times of climate change, pandemics, and growing sensitivity to animal welfare, such promises sound almost irresistible. But enthusiasm is met with scepticism. Critics point to energy-intensive processes, high costs, and products that, for now, resemble nuggets or pâtés more than the "steaks of the future". Others warn of cultural alienation-meat that no longer comes from farms or animals, but from bioreactors-and of the risk of reinforcing industrial logics rather than transforming them. In Italy, Parliament went

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as far as banning production and marketing in 2023. In Singapore and the United States, regulators authorised commercialisation, while in Europe the debate remains open, with EFSA preparing but not yet approving dossiers.

These tensions make cell-based AO food a test case for the relationship between science and society. They show that innovation in food cannot be treated as a purely technical matter of safety, nor as a simple question of consumer choice. It is, at heart, a matter of ethics and governance. The argument advanced in this paper is that ethical reflection is not a brake on innovation, but the very condition for its legitimacy. To explore this claim, I draw on the Concentric Ethical Matrix (Concentric EM), a framework designed to make visible the different layers of value conflict that shape how such technologies are perceived, regulated, and contested.

Narratives of promise and contestation

Every new technology comes wrapped in stories. Cell-based AO food is no exception. Advocates tell a story of moral and ecological redemption: (1)Animal welfare: meat without slaughter, a way to free consumption from the suffering of billions of animals. (2) Sustainability: fewer greenhouse gas emissions, less land, more efficient use of resources. (3) Public health: safer protein production, with lower risks of pathogens, antibiotic resistance, or future pandemics. These narratives resonate with broader political projects: the EU Green Deal, the Farm to Fork Strategy, the search for resilient and sustainable food systems. They position cell-based AO food as a technological fix to some of the most urgent ethical challenges of our time.

Yet, alongside the promise, counter-narratives grow. Early life-cycle analyses suggest that large-scale cultivation may be far more energy-intensive than anticipated, questioning environmental gains (Mattick et al., 2015; Sinke et al., 2023). Research still relies on fetal bovine serum, making the "slaughter-free" label premature (Allah Bakhsh et al., 2025). Cultural critics ask whether something cultivated in a bioreactor can ever be called "natural" or "authentic", values deeply embedded in European food cultures (Verhoog et al., 2003; Rijssenbeek et al., 2025). These narratives are more than marketing slogans. They are moral imaginations of what the future of food should look like, and they shape regulation and consumer acceptance as much as empirical data do. The European experience with GMOs is telling: despite rigorous safety assessments, legitimacy collapsed because deeper questions of meaning and power were left unaddressed (Davison & Ammann, 2017; Purnhagen, 2019). Cell-based AO food risks repeating this story if ethical tensions are not recognised and debated openly.

The Concentric Ethical Matrix: a framework for food futures

How, then, can we make sense of these layered disputes? One way forward is to move beyond a merely additive or checklist-like use of ethics, in which principles or values are treated as isolated items rather than as mutually conditioning dimensions of a concrete socio-technical transition. The point is not that principle-based ethical approaches are intrinsically inadequate. Principles such as well-being, autonomy, fairness, safety, sustainability, or animal welfare remain indispensable. The difficulty arises when applied ethical assessment treats them as separable criteria to be listed, scored, or balanced without examining how they interact across different levels of meaning, product design, institutional power, and social transition. The Concentric Ethical Matrix (Concentric EM), building on but also departing from Ben Mepham's original Ethical Matrix (Mepham, 2000), offers such a perspective. Whereas Mepham's tool cross-tabulated stakeholders (producers, consumers, animals, environment) against principles (well-being, autonomy, fairness), the Concentric EM reframes analysis through three nested levels that illuminate different depths of value conflict.

These three levels are not proposed as an exhaustive taxonomy of all possible ethical dimensions. They are used as analytic categories because they correspond to three recurrent sources of ethical conflict in cell-based AO food: first, disputes about the nature and meaning of the object itself; second, concerns attached to the product and its production process; and third, the broader consequences of sociotechnical transition if such products are scaled, normalised, and integrated into food systems. The ontological, intrinsic, and systemic-transitional levels therefore distinguish between conflicts concerning classification and meaning, conflicts concerning product- and process-related characteristics, and conflicts concerning wider institutional, ecological, and distributive effects.

At the ontological level, disputes arise around meaning, legitimacy, and categorisation. Is a steak grown in a bioreactor "meat" in the cultural sense? Does cultivating tissues outside an animal sever the symbolic bond that meat has long carried with life and death? And what does it mean to call such food "natural" in a society where naturalness carries strong normative connotations (Verhoog et al., 2003)? These questions are not technical, yet they frame the legitimacy of regulation and the plausibility of consumer acceptance.

At the intrinsic level, attention shifts to product-specific features. Here, the concerns are safety, nutrition, residues from growth media and scaffolds, microbiological stability, and the evolving profile of animal welfare. Labelling and traceability also belong to this level, because they determine whether consumers can make informed choices. The ethical challenge is methodological honesty: comparisons with conventional meat or plant proteins must be transparent about assumptions, system boundaries, and uncertainties (Tuomisto & de Mattos, 2011; EFSA, 2024). In this sense, intrinsic analysis is inseparable from the legitimacy of risk assessment.

Finally, at the systemic-transitional level, the focus broadens to socio-technical reconfigurations. Cell-based AO food interacts with existing food regimes and infrastructures, raising questions about distributional justice, ownership, power asymmetries, and cultural diversity (Sodano & Gorgitano, 2022; Horton et al., 2017). Will such foods democratise protein supply, or will they deepen the hold of industrial logics on agriculture? Will public funds support only high-tech pathways, or also agroecological alternatives? At this level, the question is less whether the products are "safe" and more whether they contribute to a just and sustainable food transition.

The concentric form is more than a diagrammatic choice. It signals that the levels are interdependent. Ontological framings condition how product- and process-related evidence is interpreted; intrinsic findings constrain what systemic transitions are credible; systemic governance, in turn, shapes which ontological narratives gain traction. By mapping tensions across these levels, the Concentric EM prevents conflation between heterogeneous debates and provides regulators, companies, and civil society with a clearer picture of where conflicts truly lie.

The matrix is therefore not intended to predetermine ethical conclusions. Its function is diagnostic: it helps identify where a disagreement is located, whether it concerns the meaning of the object, the characteristics of the product or process, or the broader direction of food-system transformation.

Ethical conflicts across levels

Applying the Concentric EM to cell-based animal-origin food makes visible how ethical conflicts do not occur on a single plane but cut across different layers. At the ontological level (i), the disputes centre on meaning, legitimacy, and naturalness. The question of whether cultivated tissues can be called "meat" is not resolved by nutritional analysis alone. It involves symbolic dimensions tied to authenticity, identity, and tradition. This is why disagreement persists even when empirical risks appear minimal or uncertain.

Table 1. Illustrative structure of the Concentric Ethical Matrix for cell-based AO food

Analytic level	Core ethical question	Typical value conflict	Illustrative issues
Ontological	What kind of object or practice is being evaluated?	Meat/non-meat; natural/artificial; continuity/disruption	Meaning of "meat"; authenticity; cultural legitimacy; symbolic relation to animal life and death
Intrinsic	What ethical concerns arise from the product and production process themselves?	Safety/uncertainty; innovation/ precaution; welfare promise/residual animal use	Cell sourcing; serum and media; scaffolds; nutrition; traceability; labelling; methodological transparency
Systemic-transitional	What follows from scaling and normalising this innovation within food systems?	Sustainability/justice; efficiency/ pluralism; disruption/resilience	Farmers and rural livelihoods; ownership; patents; market concentration; public funding priorities; food sovereignty; biodiversity

As the European debate over GMOs demonstrated, ontological objections, if left unaddressed, can erode legitimacy irrespective of scientific reassurance (Davison & Ammann, 2017).

At the intrinsic level (ii), ethical conflict emerges in relation to product-specific features. Here, safety assessments must consider genetic stability of cell lines, potential residues from scaffolds or growth factors, and the comparability of nutritional profiles to conventional meat. Animal welfare enters in a transitional mode: although the promise is to avoid slaughter, biopsies and animal-derived serum remain part of current practices, creating a gap between ethical aspiration and technological reality (Allah Bakhsh et al., 2025). Environmental claims also belong here, but require methodological honesty: life-cycle assessments vary widely depending on assumptions, and presenting optimistic scenarios as established facts risks undermining credibility (Tuomisto & de Mattos, 2011; Mattick et al., 2015). Labelling and traceability are equally crucial, since consumer autonomy depends on clear and non-misleading information (Bryant & Barnett, 2018). The expression "intrinsic" is therefore used here in a limited analytic sense: it does not refer to self-evident moral properties, but to ethical concerns arising from the characteristics of the product and production process themselves.

At the systemic-transitional level (iii), the conflicts are no longer about individual products but about the direction of food systems. Will cell-based AO food contribute to sustainability at scale, or simply shift impacts elsewhere? Will they enhance food security, or remain niche products accessible only to affluent consumers? Will they democratise protein transitions, or reinforce concentration of power through patents and venture capital (Howard, 2022)? These questions link innovation to justice, sovereignty, and cultural pluralism, and they cannot be resolved within the narrow frame of risk assessment alone.

Seen together, these conflicts reveal why governance cannot collapse all issues into the technical domain. Ethical disputes are layered, persistent, and mutually reinforcing. Recognising this structure is the first step towards designing governance frameworks that do not suppress pluralism, but channel it into democratic deliberation.

From animal welfare to systemic justice

The promise of animal welfare has been the most powerful narrative driving the appeal of cell-based animal-origin food. To many, the prospect of eating meat without slaughter represents a moral breakthrough, aligning food practices with growing societal concern about the suffering of billions of farmed animals (Post, 2012; Singer, 2017). Yet, once examined through the Concentric EM, it becomes clear that animal welfare is only the entry point of a much broader ethical field.

At the ontological level (i), the very claim of "slaughter-free meat" is fraught with ambiguity. If cell cultures continue to depend on animal biopsies or on serum derived from fetuses, then the absence of animal suffering is partial at best. The rhetoric of welfare improvement risks moving faster than technological progress, generating what one might call an "ethical debt" between aspiration and reality (Hopkins & Dacey, 2008).

At the intrinsic level (ii), animal welfare interacts with questions of safety and nutrition. For example, removing animal-derived serum is not only an ethical demand but also a technical requirement for consistency and safety in production. Similarly, transparent labelling is ethically necessary to protect consumer autonomy, but also technically indispensable to trace potential risks. These interdependencies illustrate how welfare cannot be isolated from other product-level attributes.

At the systemic-transitional level (iii), the debate shifts to justice in distribution. Even if slaughter is avoided, who benefits from this innovation? Will ecological gains come at the cost of rural livelihoods? Will public funds be directed primarily to high-tech cellular agriculture while agroecological alternatives remain under-supported? Here the principle of a "just transition", already applied in climate and energy policy, becomes relevant: sustainability gains must not be pursued at the expense of farmers, workers, or vulnerable communities (Moritz et al., 2025). In short, animal welfare is necessary but not sufficient. If cell-based AO food are to contribute to a democratic and sustainable protein transition, their legitimacy will depend on whether they also advance systemic justice. This means moving from an ethical discourse centred on cruelty reduction to one that incorporates fairness, sustainability, and respect for cultural diversity. Only then can these products avoid becoming a narrow techno-fix and instead become part of a broader social contract about the future of food.

Governance, participation, and democratic legitimacy

The governance of cell-based animal-origin food in Europe illustrates how ethical and political concerns resurface even within highly technical regulatory frameworks. Under the Novel Food Regulation (Regulation (EU) 2015/2283), the European Food Safety Authority (EFSA) is tasked with producing a strictly scientific risk assessment. Yet the final authorisation does not rest with EFSA but with the Standing Committee on Plants, Animals, Food and Feed (PAFF), where representatives of Member States deliberate and vote. This two-step model reflects the structural distinction in EU food law between risk assessment and risk management (Regulation (EC) 178/2002). But it also creates an institutional space where ethical and cultural objections inevitably re-emerge.

The Italian prohibition of cultivated meat in 2023 (Law 172/2023), now under scrutiny for compatibility with the internal market, is a case in point. Even as EU law provides harmonised procedures for ensuring safety, national governments can mobilise systemic or cultural arguments-protecting gastronomic heritage, defending farmers-as legitimate grounds for resistance. What appears, on the surface, as a clash over trade law is, at a deeper level, a contest over values and identities.

Recent regulatory instruments in the EU have begun to recognise this. The Transparency Regulation (Regulation (EU) 2019/1381) enhances legitimacy not by accelerating innovation but by requiring that evidence, uncertainties, and stakeholder inputs be made visible. This reflects a shift from a technocratic model of governance, where science is expected to deliver definitive answers, to a participatory model, where plural values are acknowledged and openly debated. The EU Green Deal and the Farm to Fork Strategy embody a similar ethos, stressing participation, equity, and cultural diversity alongside efficiency and competitiveness.

From the perspective of the Concentric EM, this is crucial. At the ontological level, naming practices and cultural categories need explicit recognition. At the intrinsic level, transparency about assumptions, boundaries, and limitations of evidence is ethically indispensable. At the systemic-transitional level, governance must address distributive justice, power asymmetries, and sovereignty. The challenge is not to eliminate disagreement but to articulate it within democratic structures.

If governance seeks to suppress conflict through technocratic closure, it risks reproducing the legitimacy failures already witnessed in the GMO debate. If, instead, it accepts ethical pluralism as a permanent feature of food innovation, then governance becomes an arena for negotiation, accountability, and shared responsibility. In this sense, ethics is not external to regulation but its enabling architecture. For this reason, participatory governance should not be understood as an optional supplement to scientific assessment, but as the institutional mechanism through which ontological, intrinsic, and systemic-transitional concerns can be made visible, weighed, and contested without being reduced to questions of technical risk alone.

Conclusions: ethical architectures for food futures

Cell-based animal-origin food are more than another step in the long history of food technologies. They are a test case for the relationship between science, society, and governance. Their promises-animal welfare, sustainability, food security-are powerful, but so are the doubts they provoke about cultural legitimacy, ecological trade-offs, and distributive justice. What the Concentric Ethical Matrix reveals is that these tensions do not unfold on a single level. At the ontological level, they touch on the meaning of meat, naturalness, and authenticity. At the intrinsic level, they concern safety, nutrition, welfare, and transparency. At the systemic-transitional level, they raise questions of justice, sovereignty, and power. No amount of technical refinement will erase these conflicts, because they are embedded in values, traditions, and visions of the future.

The lesson is that ethical reflection is not a brake on innovation but the condition of its legitimacy. Ignoring ethical tensions, as happened with GMOs, leads to mistrust and polarisation. Integrating them early, openly, and systematically allows governance to move from defensive regulation to democratic stewardship. This means: (i) naming and debating contested categories, (ii) ensuring methodological honesty and transparency in product-level assessments, and (iii) designing systemic frameworks that embed participation, justice, and cultural pluralism. Cell-based AO food will not determine the future of protein transitions alone. But they show, with unusual clarity, that the legitimacy of innovation depends less on technological capacity than on how societies manage value conflicts. If these products are governed transparently and inclusively, they can contribute to a just and sustainable food transition. If they are reduced to a techno-fix, insulated from ethical debate, they risk becoming another chapter in the story of failed promises.

For scholars, policymakers, and citizens alike, the task is therefore not to ask whether cell-based AO food are "good" or "bad" in the abstract, but to decide under what conditions they might become part of a democratic food future. That is the work of ethical architecture: building institutions, practices, and norms that allow innovation to serve justice, sustainability, and human dignity.

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Section 6.
One health and veterinary ethics

Defining health in One Health

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Abstract

The One Health approach, as defined by the One Health High-Level Expert Panel (OHHLEP), emphasizes the interdependencies between the health of humans, animals, plants, and the wider environment. It calls for an integrated strategy to "sustainably balance and optimise" these diverse health interests. However, without a unified definition of "health" that applies across humans, animals, plants and ecosystems, it is nearly impossible to compare, balance, or optimise these often-competing health interests. This paper proposes a common framework for health based on 'normal species functioning'. We argue that while existing definitions offer certain benefits, they often remain too vague or species-specific to serve as a common health metric. First, we outline the incommensurability challenge of comparing health of humans, animals, plants and ecosystems. Second, we propose that normal species functioning provides a consistent reference point for individual living beings. Third, we extend this definition to ecosystems. We argue that ecosystem health should be understood as ecosystem integrity, flourishing or resilience. Last, we illustrate how health, understood as normal (species) functioning, can be balanced and optimised within the One Health context, as required by OHHLEP.

Keywords: One Health ethics, OHHLEP, definition of health, environment, animals

Introduction

The One Health approach fosters balanced management of human, animal and environmental health. Rather than focusing on the interests of one group, it takes an integrated approach to health and environmental challenges by incorporating multispecies health interests. In an era of growing interconnectedness in environmental issues such as zoonotic diseases, antimicrobial resistance, biodiversity loss, and climate change, One Health has gained significant traction. According to the One Health High-Level Expert Panel (OHHLEP), established by the Agriculture Organization of the United Nations (FAO), United Nations Environment Programme (UNEP), World Health Organization (WHO) and World Organisation for Animal Health (WOAH), One Health recognises the interdependencies of "the health of humans, domesticated and wild animals, plants, and the wider environment (including ecosystems)" (OHHLEP, 2022). Promoting One Health means "to sustainably balance and optimize the health of people, animals, and ecosystems" (OHHLEP et al., 2022). In this paper, we argue that balancing these various health interests requires a common reference point to compare health in humans, animals, and ecosystems. We propose a definition of health in terms of 'normal species functioning', demonstrating how it can facilitate the integration, balancing and optimising of these interests.

The paper proceeds in four steps. First, we explain why it is more difficult to compare, balance and optimise the health of humans, animals, plants and the environment than the One Health approach seems to suggest. Second, we argue that the health of each individual living being can be ascribed what is termed 'normal species functioning', i.e. the typical functioning of an individual member of an evolutionary cohort if they are not impaired by illness, injury, or any other form of harm caused by humans or other animals. Third, we argue that ecosystem health should be understood as ecosystem

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integrity, flourishing or resilience. While ecosystems lack a single 'species' profile, a healthy ecosystem achieves a stable level of functioning that supports, and is supported by, the normal functioning of its constituent species. Finally, we conclude that according to our proposed definition of health, it becomes possible to compare and consequently balance and optimise the health of humans, animals and the environment.

The health incommensurability challenge

Should we have the very same understanding and definition of human, animal *and* environmental health within One Health (Huth et al., 2019; Lerner and Zinsstag, 2021)? Or do we need different understandings of health, depending on the context of the entity? That is, should we, for example, define the health of wild boars differently than the health of domesticated pigs destined for the meat industry? And should human health be interpreted differently to plant health? And what about the health of ecosystems in comparison to its constituent individuals? Answering these questions is of crucial importance for One Health: if there is no clear understanding of 'health', how can the health of humans, animals, plants, and the environment be sustainably balanced and optimised, as required by OHHLEP?

Various interpretations of 'health' are proposed in the One Health literature. They include resilience, well-being, balance, natural functioning, and the capacity to achieve vital goals, amongst others (Lerner, 2019; van Herten et al., 2019; Selter and Salloch, 2023). However, no consensus exists on how 'health' should be defined within One Health generally and particularly within OHHLEP's definition. While the different definitions have their advantages, they also tend to focus on specific aspects of health or remain vague. For example, resilience describes the capacity to overcome adverse events, but not health. Well-being focuses on preference satisfaction, which is likely not applicable to plants and ecosystems. Achieving vital goals is telos-oriented and does not necessarily describe health. Finally, balance and natural functioning remain vague: they do not provide a reference point according to which they become relevant for health, and the term 'natural' is notoriously unclear.

Furthermore, a closer look reveals that the health of different species is difficult to compare, balance and optimise. For example, while it is commonly assumed that sentient humans and animals share well-being as a common characteristic, the same is not the case of plants. In our view, this inability to compare the health of different species is a core challenge to One Health, as it makes it difficult to achieve the goal of balancing and optimising their health in the first place. We call this the 'commensurability thesis: One Health needs a common definition of health for all relevant stakeholders, otherwise their health cannot be compared, balanced and optimised.

Moreover, OHHLEP demands the balancing and optimising of the health of humans, animals, plants *and* the environment or ecosystems. In other words, the focus lies both on individuals (humans, animals and plants) *and* wholes (environment or ecosystems). This renders the task of defining 'health' even more complicated. Ecosystems consist of a multitude of species that co-exist in a specific place. In such a network of interdependencies, the health of one individual is less relevant than the ability of the ecosystem to thrive, flourish or be resilient to disturbances (although, admittedly, OHHLEP still requires the intrinsic value of all living things to be acknowledged, as set out in their third principle). Therefore, the conditions for defining the health of the environment may differ from those for defining the health of individual plants, animals, and humans. The same applies when discussing the health of entire populations of a species in a particular place.

These examples demonstrate the challenge of incommensurability that needs to be overcome in order to balance and optimise the health of humans, animals, plants and the environment within One Health. If

the definition of health for the various stakeholders considered in the One Health approach differs too much, it becomes difficult to compare their health conditions in order to balance and optimise them.

Health as normal species functioning

To overcome the incommensurability challenge, it is crucial to define health in a way that applies to all relevant stakeholders in the One Health approach, including humans, animals, plants, and the environment or ecosystems. We believe that the definition of health as *normal species functioning* can provide this common ground for all stakeholders in the One Health context. It functions as an 'umbrella' concept that covers crucial aspects of other definitions, such as the importance of well-being (where it applies), capacity to achieve vital goals, and the like. Furthermore, it is more precise than defining health as natural functioning or balance.

In the context of *human* health, two relevant suggestions have been proposed. According to Christopher Boorse, a healthy human being is an individual that can perform normal species functioning (Boorse, 1977). He argues that this is defined by the statistical average functioning of human beings at a certain evolutionary level of development. Therefore, normal species functioning provides a biological definition of what it means for a human being to be healthy. It is a definition independent of the environment a human being lives in. The only reference point for health is the evolutionary cohort of humans.

Based on this normal species functioning definition of health, Norman Daniels develops a theory of public health justice (Daniels, 2007). According to his theory, normal species functioning provides the basis to define the opportunity ranges that a healthy human being normally should be able to realize in a given society (the normal opportunity range). Unhealthy individuals face impairments in their opportunities if they do not get support or health treatment. To illustrate, consider eyesight, which is considered normal for a species. Nowadays, people with impaired vision receive medical treatment or wear glasses to improve their vision. Hence, while the first, normal species functioning definition of health relies on the biological conditions of humans only, the latter definition of health is relative to the societal conditions a human being lives in.

The normal functioning of species can also be attributed to individual animals and plants. Every living being can be described in terms of its normal functioning as part of an evolutionary cohort. Therefore, defining health in terms of normal species functioning also allows to define and compare the health of individuals of different species. This is a crucial first step towards balancing and optimising the health of humans, animals and plants.

In addition, dependence of humans, animals and plants on external conditions can be described in terms of the opportunities they can normally realise within their environment or an ecosystem. Therefore, it is possible to define the health of individuals of various species either independently of their environment, or in relation to their specific environment (broadly conceived, including ecological, social and legal aspects).

For example, consider a wild boar and a pig that has been genetically selected for the meat industry. Both depend on their external environment for their health. However, the opportunities available to the bred pig in a small enclosure are more restricted than those available to the wild boar due to the latter's more natural environment. Furthermore, it could be argued that the bred pig is no longer functioning normally as part of an evolutionary cohort; rather, it is the normal functioning of domestic pigs as a species that should be considered as relevant reference point, and we may question whether current selective breeding practices aimed at meat maximisation can be described as healthy, given that they are not a natural evolutionary process.

Different views exist on whether health as normal species functioning or a normal opportunity range establish *entitlements*. As descriptive definitions, they describe a specific state of a living being, but does not imply any entitlement. By contrast, in a normative theory such as that of Norman Daniels, health can be seen as a normative concept: the ability to realise the normal opportunity range of a given society establishes an entitlement: every member of a society should be healthy enough to realise their range of species opportunities. For the purposes of this discussion, we will not delve further into this issue and will leave it aside.

Ecosystem functioning

Thus far, we have presented a common definition of health that can be applied to individual living beings of different species, whether they are humans, animals or plants. However, the One Health approach also aims to balance and optimise the health of these individuals with that of the environment or ecosystems. Our considerations thus far cannot explain how to define the health of the natural environments or ecosystems individuals live in.

Ecosystems as natural environments do not have a typical species functioning, as they consist of various species. Furthermore, ecosystems tend to change or even be temporally destroyed due to changing environmental or climatic conditions (such as wildfires or drought) but can still be considered healthy. Therefore, it might seem odd to define the health of ecosystems in terms of normal species functioning or a normal opportunity range.

However, although ecosystems cannot be described in terms of normal species functioning, they can certainly be described in terms of their *own functioning*. Some have suggested calling the stable functioning of an ecosystem its 'integrity', while others call it its 'flourishing' (Melin, 2021). Others have suggested describing the stable functioning of an ecosystem as its resilience to various threats, i.e. its adaptive capacity to return to a stable state despite disturbance (Kortetmäki, 2018). Regardless of how we define the stable functioning of ecosystems, we believe that these definitions can be used to determine the basic threshold below which an ecosystem can be considered unhealthy, i.e. an ecosystem's health in terms of its normal level of functioning.

If the health of an ecosystem can be described in terms of its normal level of functioning, then it can be conceptualised in the same way as the health of individuals. An ecosystem is healthy if it has reached a normal level of functioning, as defined by its integrity, flourishing or resilience. Thus, the relevant comparison is not species functioning but a normal level of ecosystem functioning (in terms of, e.g., its integrity, flourishing or resilience).

If this argument is correct, then we can also see how the health of natural environments and of individual living beings depend on each other. Since an ecosystem is composed of various species and their stable interrelationship, a healthy ecosystem depends on a majority of healthy individuals or populations that define its integrity, flourishing and resilience. Conversely, a healthy ecosystem is a prerequisite for individual living beings to realise their normal opportunity range within this environment, provided they possess normal species functioning.

Therefore, it appears that there is a reciprocal dependence between the health of ecosystems or the environment and the individuals that inhabit them. This gives us a first indication of how to balance and optimise the health interests of the environment and individual living beings. Ecosystem health must be optimised for the health of its constituent individuals, whilst their health should be balanced with their ecosystem's health. The next section illustrates and further clarifies how our proposed definition of health as normal functioning can help balance and optimise the health interests of humans, animals, plants and ecosystems.

Balancing and optimising commensurable health

According to OHHLEP's definition, One Health aims to sustainably balance and optimise the health of humans, animals, plants and the environment or ecosystems. Since we propose defining health in terms of normal species functioning or ecosystem functioning, it may be difficult to understand what optimising and balancing might mean in this context.

Consider balancing first. Our proposal allows for comparing human, animal and ecosystem health, which allows for their balancing. Sustainably balancing the health of humans, animals, plants and ecosystems implies that the health of no individual or other entity has absolute priority but must be weighted with the health of all other stakeholders. Accordingly, our definition of health implies that the health of no stakeholder (humans, animals, plants or ecosystems) has priority over that of any other stakeholder because our definition assumes the equal status of all relevant entities, which means taking their health interests seriously.

Second, let us consider optimisation. We have demonstrated that health, in terms of functioning, should be understood as the normal functioning for a given species or ecosystem. Often, entities such as humans, animals and plants fall below this normal level of functioning. For instance, wild animals often suffer from parasites and diseases, which can hinder their normal functioning. Improving their health, for example through adequate treatment and vaccinations, would consequently raise their level of functioning within their species range. In turn, this may have positive impacts on the health of humans and the environment, due to their health interrelatedness. This approach avoids the suggestion that optimising health entails radical enhancement, such as the genetic modification of humans, animals, plants and the environment to make them as healthy as possible. Instead, normal species functioning should be understood as a range that can be fulfilled to a greater or lesser extent. Optimisation ensures that the level of normal species functioning is achieved for as many stakeholders as possible.

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Inclusive and fair One Health through the integration of nonhuman interests

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Abstract:

One Health – the view that human, animal, and environmental health are interdependent – has gained significant traction over recent decades. The most widely endorsed definition of One Health, developed by the One Health High-Level Expert Panel (OHHLEP), is characterised by several key features, including: i) the aim to sustainably balance and optimise human, animal, and environmental health; ii) the inclusion of diverse disciplines, sectors, and perspectives; and iii) a commitment to respecting the intrinsic value of all living beings in the ecosystem to achieve a socio-ecological equilibrium. By acknowledging the intrinsic value of all living entities, OHHLEP's definition explicitly endorses biocentrism – the view that all living beings matter for their own sake. Furthermore, inclusion is a central principle of One Health, understood as the integration of actors from different disciplines, sectors, and communities. Yet despite this emphasis, the active inclusion and involvement of two highly relevant groups – animals and nature – currently remain largely ignored in One Health decision-making and practice. There is a significant gap in the literature concerning how animals' and nature's interests and needs could be meaningfully incorporated into One Health decision-making to both optimise health outcomes and respect their intrinsic value. In this paper, I argue that moving beyond an anthropocentric interpretation of One Health requires the inclusion of animals and nature in One Health approaches. I present three justifications for this claim: the affectedness of animals and nature by One Health measures, considerations of procedural justice, and biocentrism. Subsequently, I discuss three relevant models developed in fields beyond the One Health domain and demonstrate how they can be fruitfully applied to this context. These include: i) animal agency; ii) inclusion through human diversity; and iii) assigning a human to speak on behalf of animals and nature in One Health decision-making. I outline the advantages and limits of each proposal and suggest that the third option – representation of animals and nature by a human person – is likely the fairest and most promising approach.

Keywords: One Health ethics, inclusion, interdisciplinarity, biocentrism

Introduction

One Health – the view that human, animal, and environmental health are interdependent and closely linked – has gained significant traction and importance over the last decades. The most prominent and widely endorsed definition of One Health was developed in 2021 by the One Health High-Level Expert Panel (OHHLEP), which was established by the Food and Agriculture Organization (FAO), the World Organisation for Animal Health (WOAH, formerly OIE), the United Nations Environment Programme (UNEP), and the World Health Organization (WHO). This definition is characterised by several features: first, the core idea that One Health approaches aim to sustainably balance and even optimise human, animal, and environmental health; second, the inclusion of different academic disciplines, as well as diverse sectors and perspectives (including traditional and non-traditional forms of knowledge), to attain this goal; and third, a commitment to respecting and acknowledging the intrinsic value of all living things in the ecosystem, to achieve a socio-ecological equilibrium that allows for a

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harmonious balance between human–animal–environmental interactions (OHHLEP, 2022). As most governments, international organisations, and One Health researchers and practitioners endorse this definition, I will use it as the basis for the development of my arguments.

A major adage of OHHLEP's One Health definition, as seen above, is *inclusion*: One Health approaches are supposed to bring together actors from different sectors, disciplines, and communities, thereby making clear an aspiration for justice and pluralism. Yet, the inclusion of two further highly relevant groups – animals and nature – remains neglected in One Health literature; there is a research lacuna regarding whether, why, and how their interests and needs could be included in One Health approaches to optimise human, animal, and environmental health, and to respect the intrinsic value of all living entities in the ecosystem.

This gap is significant. First, two of the three groups most affected by One Health remain neglected in decision-making processes, despite being directly impacted by One Health interventions. Second, OHHLEP's definition explicitly endorses a biocentric stance: the intrinsic value of all living beings in the ecosystem should be acknowledged. Neglecting the inclusion of animals and nature within One Health decision-making, I will argue, may be at odds with the biocentric commitment to acknowledge the intrinsic value of all living entities.

The aim of this paper is twofold: first, to outline three reasons to move beyond the common anthropocentric interpretation of One Health and implement a biocentric approach, which implies meaningfully incorporating not only humans, but also animals and nature into One Health decision-making and practice; and second, to explore models for incorporating animal and environmental interests practically into One Health approaches. In a nutshell, I argue that by directly including the interests of animals and nature in One Health approaches and decision-making, One Health becomes a fairer and more inclusive endeavour that may guarantee respect for the intrinsic value of all living beings, as required by OHHLEP's definition.

I proceed as follows. In the first step, I present three reasons for including animals and the environment more thoroughly in One Health decision-making and practice: the impact of One Health approaches on animals and nature; considerations regarding procedural justice; and the commitment to biocentrism. Second, I explore three models to facilitate this involvement that are, in my view, promising: animal agency; the consultation of local populations who may be sensitised to environmental issues and animal welfare; and the representation of animals and the environment in One Health decision-making. I outline the advantages and limitations of each proposal, concluding that the most promising option is to appoint a human representative for animals and the environment in One Health approaches.

Justifying the inclusion of animals and the environment in One Health decision-making

The idea of including animals and the environment in One Health decision-making may seem odd, at least at first glance. After all, animals and the environment cannot communicate their interests to humans directly – or so one may think. However, in recent years, scholarship beyond the One Health field has explored how to involve animals and the environment more thoroughly in decision-making processes (see, for example, Goodin, 1996; Jones and Cloke, 2008; Dobson, 2010; van Dooren et al., 2016; Donoso, 2017; Simons, 2017; Ressiore et al., 2024; Roudavski and Brock, 2025). Before turning to these models, though, it is crucial to inquire *why* it may be ethically relevant, or even required, to include animals and nature more comprehensively in One Health decision-making. In this section, I outline three reasons for this inclusion: i) their affectedness by One Health measures; ii) considerations

of procedural justice; and iii) an argument based on the biocentric stance taken in OHHLEP's One Health definition.

Let us consider *affectedness* first. In political philosophy, the all-affected principle stipulates that all those affected by a decision should have a say in that decision (Goodin, 2007; Fung and Gray, 2024). The principle thus determines *who* should have a voice in decision-making: those affected by the outcome. This voice may, of course, be proportional to the weight of one's interests; for instance, if one's interests are only peripherally affected, one should have a lesser say than someone whose interests are fundamentally impacted (Angell and Huseby, 2020).

Admittedly, the all-affected principle was developed and defended for the political realm. However, there is no clear reason why it should not extend to other domains where individuals are strongly affected by decisions – as is frequently the case for animals and nature in One Health practice. One Health research may be highly invasive for animals and the environment, such as in cases involving animal experimentation or DNA sampling of plants and animals. Further examples include zoonotic disease control, livestock management, the use of animal sentinels, infectious disease surveillance, and pesticide research (which may benefit human food security but harm animals and the environment). Thus, the *affectedness* of animals and nature provides a *prima facie* reason to more thoroughly consider the impact of interventions on animal and plant integrity when planning One Health approaches.

Second, consider procedural justice, which concerns the fairness and transparency of processes and procedures. For a process to be procedurally fair, it is often appropriate to involve all relevant parties. This suggests that top-down decision-making should be avoided in favour of involving those concerned with, or affected by, a decision. While there are various forms of procedural justice (Rawls, 2005), the model most relevant to the One Health domain appears to be *pure* procedural justice: a fair procedure must be in place to ensure a fair and correct outcome, provided the procedure is followed correctly.

In the case of One Health research, the goal is to sustainably balance and optimize the health of people, animals, and ecosystems. Thus, from a procedural justice perspective, there are strong reasons to establish procedures that ensure animals and nature are adequately considered, thereby achieving this sustainable balance and health optimisation. As One Health practice and research are highly context-dependent, there is likely no single superior model though; rather, what matters is that, at a minimum, procedures are in place to more thoroughly incorporate the potential interests of animals and the environment into decision-making processes.

Finally, let us turn to the third reason to include animals and nature more thoroughly in One Health decision-making: biocentrism. OHHLEP presents five key principles underlying One Health, the third of which stipulates: "socio-ecological equilibrium that seeks a harmonious balance between human–animal–environment interaction and acknowledging the importance of biodiversity, access to sufficient natural space and resources, and the intrinsic value of all living things within the ecosystem" (OHHLEP, 2022). The final part of this principle can be interpreted as biocentrism – the view that all living entities matter for their own sake. OHHLEP requires that the intrinsic value of all living entities within the ecosystem be acknowledged. This may be achieved through practices and interventions that are respectful toward nature and animals, optimizing their health rather than merely instrumentalizing them for human benefit. However, this biocentric commitment can be read not only as a requirement regarding the aims of One Health approaches but also as a mandate to include animals and nature more thoroughly before One Health measures are implemented – specifically during decision-making to determine which research and One Health measures are ethically sound. Thus, acknowledging the intrinsic value of all living entities implies not only respecting them during interventions but also considering their interests when planning the nature and methods of those interventions – their

invasiveness, for example. After all, acknowledging the intrinsic value of a being may imply that it should have a say in matters affecting it – that its interests are not ignored but heard. Given that animals and nature do not speak to humans, though, – or so it is often assumed – models and procedures must be in place to facilitate this inclusion. I turn to these now.

Models to include animals and the environment in One Health

While the inclusion of animal and environmental interests and needs is not an explicit requirement in OHHLEP's One Health definition – despite its commitment to transdisciplinarity and the inclusion of various perspectives – I have made a case in favour of including animals and the environment more thoroughly, not only in One Health approaches but also prior to their implementation. This includes decisions regarding which research questions and One Health interventions to pursue.

However, as animals and nature cannot voice their own interests – or so one may think – including them directly in the One Health domain may appear unfeasible. Nonetheless, this verdict is premature. Scholarship outside the One Health field has discussed ways to constructively include animals and nature in processes that affect them, such as political processes. In the following, I discuss models that seem promising for the One Health context, including: i) animals as agents; ii) representation by human groups; and iii) representation through adopting the stance of animals and the environment. I outline the potential and shortcomings of each option and conclude that the last option is the most promising one for the One Health field.

Let us discuss animal agency first. In recent years, scholars in animal ethics have explored how animals are agents capable of expressing their own interests and preferences (Donaldson and Kymlicka, 2014; Meijer, 2019; Bovenkerk and Keulartz, 2021; Healey and Pepper, 2021). Many animals can, through their actions, show assent and dissent. If humans are susceptible to animals' behaviour, then animals can, in many cases, show us their preferences and interests. However, the question arises how animals' agency can be made fruitful in One Health deliberations. Certainly, during One Health interventions, One Health practitioners may pay more attention to animals' embodied agency. For example, animals can show in interactions with humans whether they would like to participate in a sampling study, and what measures need to be taken to reduce pain, for example. However, this model also has its limits. To illustrate, consider vaccinations. While vaccination may be in an animals' interest (e.g., for rabies control) it may show strong dissent during the procedure. Moreover, animals' agency can only inform humans *during* One Health procedures once they interact with the animal; it cannot tell them much before the intervention starts (e.g., how and to what extent to consider animals' interests). Thus, while animals' agency in some situations certainly can guide One Health practice, it also has its limits.

These limits of the agency model become even clearer when considering plants, specifically individual plants. They lack the agency that many animals have (e.g., they cannot directly show any assent or dissent by, for example, moving away from humans). Thus, the agency proposal has even stronger limits when applied to nature and does not seem feasible in this context.

A further option, particularly in the case of One Health practices involving local populations, would be to consult with groups from diverse backgrounds. As OHHLEP states in its second and fifth principles, One Health should include and engage communities and marginalised voices, different sectors, and all relevant disciplines – incorporating both modern and traditional forms of knowledge alongside a broad array of perspectives. Often, the groups concerned know their environment and the living beings within it exceptionally well and can advocate for their needs. In other words, local groups often have a deep understanding of the specificities and requirements of animals and nature in a given context, and may be able to voice these in One Health deliberations. Or so one might assume. While this approach

is certainly preferable to excluding animals and nature entirely, it carries the risk of anthropocentric bias. There is a danger that local groups view nature and animals merely as components of a species, which may ultimately deny the intrinsic value of individual living entities within the ecosystem. Furthermore, the success of this proposal hinges on populations paying attention to and caring for the environment and animals, which can vary depending on the group and specific context.

A final option is the human representation of animal and environmental interests within One Health deliberations. Prior to the start of an intervention, One Health scholars and practitioners could engage in a moderated exchange – governed by strict rules regarding allotted speaking times, active listening, and the intent to understand diverging positions – to discuss the foreseen impact of a specific measure on humans, animals, and the environment. One participant could be tasked with representing the presumed interests of animals or nature: what would be in their best health interest, and how would the proposed measure align with OHHLEP's One Health definition and its five principles?

This exercise may seem demanding of one's imagination. For example, it might be argued that it is unclear what truly constitutes the health interests of animals or nature. While a plethora of views and disagreements on this topic exists, it is likely possible to reach a minimal consensus on what serves their interests in a specific case, particularly with a view toward optimising their health. Moreover, this exercise of putting oneself in the 'shoes' of animals or nature has distinct merits: thinking through the ways in which they are affected by a specific One Health intervention may reveal diverse options for optimising their health and help determine methods to consider animals and the environment more thoroughly. Moreover, this suggestion also has the advantage of ensuring the representation of the perspective of animals and the environment when balancing human, animal, and environmental health. Consequently, this option could serve to mitigate anthropocentric biases. Despite potentially being intellectually demanding, this option has the fewest downsides and seems more practical and fairer than the other two.

Conclusion

While One Health requires the inclusion of diverse perspectives and disciplines to sustainably balance and optimise human, animal, and environmental health, the active involvement of animals and nature in decision-making is neglected in OHHLEP's One Health definition. This may seem understandable at first glance; after all, animals and plants cannot directly articulate their interests. However, I have shown that there are at least three compelling reasons to include animals and nature in One Health decision-making: their affectedness by One Health measures, considerations of procedural justice, and the biocentric stance endorsed in OHHLEP's own definition.

Furthermore, I have discussed three inclusion models that appear particularly promising for the One Health context. First, animal agency allows practitioners to react directly to animals' health and integrity during interventions, yet it fails to incorporate their interests prior to a measure and is inapplicable to plant life. Second, consulting local groups (as recommended by OHHLEP) offers the hope that they might speak on behalf of animals and nature. However, as noted, this option risks anthropocentrism and hinges entirely on human attentiveness to their environment. Finally, I suggested it is conceivable to assign a representative for animals and nature in One Health deliberations to speak on their behalf. While acknowledging the intellectual demands of this option, I concluded that it is likely the fairest approach, as it ensures animals and the environment are considered throughout One Health practices. To move forward, researchers and practitioners could experiment with these three models to ensure a more comprehensive inclusion of animal and environmental health within One Health, in view of sustainably balancing and optimising their health.

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The epistemic challenges of fairly including animals in One Health decision-making

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Abstract

As food systems face growing demands for sustainability, resilience, and justice, One Health has emerged as a key framework for guiding decisions that affect humans, animals, and the environments they share. From an animal ethics perspective, One Health has been critiqued for not sufficiently accounting for animals' interests. This paper examines the *epistemic* challenges of including animals in One Health decision-making. I argue that many ethical shortcomings of One Health stem from epistemic structures that shape how evidence is produced, framed, and weighted. I discuss general epistemic challenges to including animals in decision-making and three challenges specific to One Health contexts.

Including animals in collective decision-making faces general epistemic challenges: First, animals cannot directly participate in deliberative decision-making. Second, complexity and interdisciplinarity complicate agreement about animals' interests and how to weigh against competing interests, and it remains unclear who has the unbiased expertise to settle this debate. Third, entrenched social interests in continued animal agriculture and cognitive biases allow people to distort uncomfortable truths of potential complicity in animal suffering.

One Health decision-making raises three additional epistemic challenges: epistemic framing, knowledge hierarchies, and asymmetric handling of uncertainty and urgency. First, animals are often framed as zoonotic risk-factors (e.g. as 'reservoirs' or 'vectors'), shaping what evidence is seen as relevant, obscuring animal suffering, and legitimizing harmful interventions such as culling. Second, epidemiological and biomedical knowledge tends to take precedence over welfare science and animal ethics. Finally, precautionary reasoning is applied asymmetrically, such that uncertainty regarding human harms more readily motivates intervention, while uncertainty about harms to animals is often discounted. Taken together, these epistemic features systematically undermine the fair consideration of animal interests in One Health decision-making, suggesting the need for modest epistemic reforms that reframe the role of animals in One Health governance.

Keywords: animal ethics, epistemic framing bias, knowledge hierarchies, zoonoses

Animal ethics on One Health decision-making: an overlooked critique

Indeed, the One Health High Level Expert Panel (OHHLEP) defines One Health as 'an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent' (OHLEPP, 2022). Despite this inclusive framework, animal ethicists have critiqued One Health approaches in various ways. For instance, One Health approaches receive critique for being anthropocentric and insufficiently radical in its moral concern for nonhuman animals (Rodriguez, 2024). Another critique is that they do not satisfactorily distinguish between *interconnected* and *interdependent* factors among human, non-human,

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and environmental health, thereby risking over-reaching and under-reaching practical and ethical boundaries (Beever and Morar, 2018).

Such critiques of One Health, so far, have not emphasised its epistemic underpinnings, which may play a causal role in (unfairly) decentering the interests of animals in One Health structures. Such animal ethical critiques are incomplete, I will argue, because One Health decision-making is *epistemically structured – i.e. underlying knowledge processes influence the outcome of ethical decision-making:* For one, contemporary science (in One Health and beyond) is presented as empirically grounded and value-neutral, although it may harbour ambiguous or undefended epistemic claims, pragmatic shortcuts, and be shaped by external financial, political, and social influences. Moreover, decision-making in One Health contexts relies on interdisciplinary evidence, expert authority, and probability risk assessments. What reasons or evidence receive more argumentative weight, in turn, is dependent on what research gets funded, what results gets published, and which disciplines are prioritized.

Uncovering the epistemic structures and processes which influence One Health outcomes, is crucial for at least two reasons: first, it will provide a better understanding of how animal interests may be downplayed unnoticed. In turn, this will help identify potential adjustments that would indeed make One Health as inclusive and fair towards animals as the framework (cl)aims to be. And second, the impact of faulty One Health reasoning would negatively affect the lives of countless animals. Namely, One Health is meant to provide a decision-making framework outside of academic circles as well, shaping new legal and political policies.

As such, this paper explores three *general* epistemic challenges of decision-making that concern animals, as well as three epistemic challenges of including animals *in One Health* decisions specifically. Undoubtedly, these (and other) epistemic features within One Health may play a role in the decentering of the environment's interests as well, but this lies beyond the scope of this paper. I will conclude that this largely overlooked epistemic angle must be acknowledged for a comprehensive ethical critique of One Health, as well as, to identify potential ameliorative avenues.

General epistemic challenges of including animals' interests in decision-making

Including animals in collective decision-making faces general epistemic challenges: First, animals cannot directly participate in deliberative decision-making. They cannot speak and deliberate, are not political agents, and often cannot co-exist in one room. Mechanisms for including them in (political) decision-making more directly are discussed in animal ethics (Meijer, 2017) but remain marginalized in practice. Currently, progressive accounts of giving animals deliberative agency remain limited to animal sanctuary settings, and even there, it is questionable whether human-animal interactions are indeed deliberative (or simply communicative). In any case, humans will always have to interpret the communication, agency or deliberations of animals, which brings me to a second epistemic challenge.

Namely, complexity and interdisciplinarity (i.e. different knowledge and methodologies across various disciplines) complicate agreements about animals' interests and how to weigh against competing interests. For instance, animal welfare is conceptualized in many ways, and animal welfare scientists and animal ethicists have long disagreed on how to best conceptualize their welfare (Fraser, 1999). Employing one definition rather than another impacts what policies end up being endorsed – i.e. a particular understanding of animal welfare makes assumptions about the value of the animal, assumptions about what is valuable to an animal (e.g. what is absolutely necessary or only nice-to-have), and about what actions should follow (e.g. welfarist reforms or abolition of certain practices) (Schmidt, 2011). Moreover, it remains unclear who has the unbiased expertise or final say to settle such debates. This is complicated

even further when we consider One-Health's aim of integrating indigenous knowledge systems and Western views.

A third epistemic challenge of including animals in decision-making is that entrenched social interests in continued animal use (e.g. animal husbandry and research) and cognitive biases allow people to distort uncomfortable truths of potential complicity in animal suffering. The literature has discussed this as 'motivated reasoning' (Graça et al., 2026) and 'willful blindness', 'motivated ignorance' (Abbate, 2021: Williams, 2008), and I myself as 'speciesist ignorance' (van den Brandeler, 2024).

All these epistemic challenges also apply in One Health contexts. With regard to the second challenge, for instance, just like the term 'animal welfare', it is unclear how *health* should be defined for humans, animals, and environments, and it is unclear which discipline can best settle this. Further, human interests strongly impact One Health outcomes. For instance, in 2020 the Danish Government decided to cull up to 17 million mink because a mutated Covid variant was discovered in some farms, and for fear that the *potential* of overspill to humans could reduce the efficacy of COVID-19 vaccines. Few alternatives to culling were considered, and two years later, it turned out that this order had been unlawful and that the prime minister's remarks had been 'grossly misleading' to both mink breeders and the public, causing a political scandal (Davies, 2022). This scandal exemplifies just how strong human interests can weigh in on One Health decisions and how quickly such decisions are made without due epistemic care, even in the face of much uncertainty.

Particular epistemic challenges of including animals in One Health

The abovementioned *general* epistemic challenges of accounting for animals' interests in decision-making procedures, also apply to One Health frameworks. But additionally, I propose that the One Health framework harbours inherent epistemic challenges.

First, One Health frameworks function with *epistemic framing bia*s. Namely, within One Health frameworks, animals are more readily framed as *sources of risks* (e.g. as 'animal reservoirs') or *framed by their use* (e.g. as 'production units') rather than individual sentient beings. Although use of language and framing might seem insignificant, it can help to justify harmful interventions such as culling while downplaying moral concern for their welfare and disregarding alternative courses of action (Lynteris, 2019). Consider how in India's history, it has mattered greatly whether people refer to dogs as 'strays', 'street dogs', or more recently as 'pets', in deciding on strategic policies to tackle the issue of rabies in their dog populations – impacting whether they are allowed to live on the streets or should be removed by relocation or killing (Nadal, 2019). Not just language, but also 'visual images of non-human animals have played a historically important role in their configuration as epidemic villains' (Lynteris, 2019, p. 15). Similarly, even if we refrain from framing animals as disease vectors, they remain *objects of study* rather than *contributors of knowledge*. The way we talk about animals influences how well or ill-equipped we are to take their agency and interests into account.

Second, *knowledge hierarchies* among different scientific disciplines strongly influence what research is funded, what evidence is seen as convincing, and what knowledge bears most weight in decision-making procedures. Epidemiological and biomedical knowledge tends to take precedence over veterinary welfare science and (animal) ethics. This clearly seems to be the case when we consider which experts were invited to be an OHHLEP-member. The panel in 2022 was primarily constituted by biologists, virologists, epidemiologists, biostatisticians, and completely disregarded experts from the humanities and social sciences, such as philosophers, sociologists, legal scholars, and political scientists (OHHLEP, 2022). Experts from the natural sciences and applied sciences approach One Health decision-making from their respective scientific disciplines, and therefore, emphasize the importance of topics such as food

security, biosecurity, sustainable agriculture, and disease prevention. Although this in itself is perfectly reasonable, as a result, other relevant topics such as fairness, inclusion, diversity, political legitimacy, moral permissibility – although they are mentioned in the OHHLEP reports – may not have received due attention or consideration, or at the very least not with the same rigor as when more experts from the humanities had been included. Potentially, then, decisions from this panel were vulnerable to false balancing by giving certain evidence more relative argumentative weight than is fair. And relatedly, this group with relatively uniform expertise and methodological approaches is more prone to skewing its decisions which are biased against the interests of animals. And it may even follow, that the panel's suggested One Health framework *itself* is biased against animals insofar as it was created with a certain lens. I hasten to add that I make this speculative claim with caution. Having said that, especially since the One Health framework is supposed to guide decision-making beyond academic circles and will thus impact the lives of countless animals, it matters greatly whether this framework originates from diverse backgrounds, procedurally just deliberations, and unbiased views on animals.

Third, *asymmetrical precautionary reasoning* is applied, such that uncertainty regarding human harms more readily motivates intervention, while uncertainty about harms to animals is often discounted. This shows in the general readiness of (national and local) governments to opt for culling as a preventative measure for disease (or other forms of nuisance) without ample evidence of spillover to humans or without legal grounds. The abovementioned Danish mink example illustrates this well, as does the decision of the Hong Kong government to cull up to 2000 pet hamsters to prevent spillover of the Delta Coronavirus to humans in 2022, even though there was no evidence to suggest that this variant of the virus could spill over to humans (Der Spiegel, 2022). Supposedly, there was not enough space to quarantine them, nor time to wait in case they infected people (Riordan, 2022). Relatedly, after badgers were identified as carriers of bovine tuberculosis in 1917, the UK government justified widespread culling of badgers as a measure to prevent the disease in cows through *the Badger Act of 1973*, although the first large scale scientific review of badger culling was completed in 1997 and concluded there was a lack of evidence to support this method as a control of bovine tuberculosis. Still, to this day, it remains a popular strategy amidst scientific disagreement about the efficacy of culling as a preventative measure (Arthur, 2020). These cases illustrate that given a threat to public health, practical and political limitations win out: 'Then, all talk of One Health, multispecies relationships and partnerships melts into thin air, and what is swiftly put in place, to protect humanity from zoonotic or vector-borne diseases, is an apparatus of culling, stamping out, disinfection, disinfestation, separation and eradication' (Lynteris, 2019, p. 2).

Ethical implications and conclusion

In a nutshell, not only is it difficult to know what animals' interests are, and how they should fairly be weighed in a decision with competing interests (e.g. human and environmental interests), this is even more difficult within One Health frameworks. This, I emphasized, is due to the underlying epistemic structures by which One Health decision-making operates. This paper suggests that animals' interests are uniquely underrepresented in One-Health's deliberative processes, and that animal ethical considerations are systematically deprioritized in favour of practical and political interests. This suggests the need for modest epistemic reforms that reframe the role of animals in One Health governance.

I have argued that the underlying epistemic structures inherent to One-Health frameworks impact its outcomes, often marginalizing the interests of animals as a result. Animals are not just framed as vectors or reservoirs of disease, but as the very ground where pathogens emerge, and even as an existential threat to humanity (Lynteris, 2019). Insofar as the epistemological structure with which One Health was created (and operates) is biased against giving animals due consideration, this is more likely to result in decisions that disadvantage animals. Whether this is an *unfair* disadvantage – and whether this is wrong – is a separate question that I have not answered here. Having said that, the current paper contributes

to the existing ethical critiques of One Health frameworks and would likely embolden their claims rather than undercutting them. This paper has provided further epistemological reasons why we must be critical towards One Health decisions from an animal ethics perspective.

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Animal owners as secondary patients? Applying a paediatric concept to advance One Health in veterinary practice

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Abstract

This paper explores the potential applicability of the "secondary patient" concept – originally developed in paediatric ethics to address affected family members – to animal owners within the field of veterinary medicine. It argues that the health and well-being of animals and their owners are closely intertwined. Emotional bonds, caregiving responsibilities, decision-making roles, and financial and psychosocial burdens indicate that animal disease often affects not only the animal itself but also the owner and their health and well-being. Drawing on structural parallels between parent-child and owner-animal relationships, the paper suggests that, particularly in companion animal medicine, owners can plausibly be understood as secondary patients. This implies recognising their vulnerability and considering their health-related interests – not by expanding clinical responsibilities, but through enhanced communication and a specific mindset. At the same time, tensions may arise where the interests of animals and owners diverge, requiring the distinction between primary and secondary patients to remain normatively guiding. The paper concludes that this perspective helps to foreground interdependencies and contributes to bringing the One Health approach at the micro-level to everyday veterinary practice.

Keywords: veterinary ethics, patient, companion animal medicine

Introduction

Animal owners often describe their relationship with their pets as emotionally close. Accordingly, it is not without consequences for them when their animals become ill. Rather, diseases and injuries of pets can be associated with significant emotional, psychosocial, but also financial burdens for their owners. This also has implications for veterinary practice. Against this background, the present paper examines the transferability of a concept from paediatrics to veterinary medicine. Paediatrics has occasionally provided a framework for veterinary ethics, as both fields involve a triadic relationship between a patient, a healthcare professional and a third party (Rollin, 2006 [1996]). In their article on paediatric ethics, "Parents as secondary patients: Towards a more family-centred approach to care," Eichinger et al. (2023) argue that parents of seriously ill children should be considered as "secondary patients". The starting point of this argument is the "intertwining, interacting and interdependent vulnerabilities" (Eichinger et al., 2023, p. 368) of children and their parents. Parents are not only legal representatives and key decision-makers, but are also emotionally closely connected to the child, often strongly involved in its care, and substantially affected by the temporal, financial, and psychosocial demands of the illness. These multiple interconnections mean that a child's serious illness can also significantly impair the physical and mental health of the parents. In simple terms: If the term "patient" is understood as referring to individuals who suffer as a result of illness, then parents with seriously sick children can be viewed as kind of "secondary patients". As a result, physicians should recognize parents as affected individuals, acknowledge their suffering, and actively include them in communication and decision-making. They should also attend to parents' needs and facilitate access to appropriate support. However, this does not mean treating the parents themselves but adopting a perspective that integrates their well-being into

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care. Such a "family-centred approach" (Eichinger et al., 2023, p. 368) is intended not only to benefit the ill child as the primary patient – for example, by reducing negative effects of stressed or ill parents on the course of treatment – but also to contribute preventively to ensuring that parents do not themselves become primary patients.

In the following, this approach is transferred to veterinary medicine, specifically to the context of companion animal medicine. The aim is to examine to what extent the concept of animal owners as secondary patients is viable and what theoretical as well as practical consequences arise from this for veterinary practice. To this end, the argument by Eichinger et al. regarding why parents should be granted secondary patient status is first applied to veterinary medicine. Subsequently the implications for veterinary practice are identified. To avoid any misunderstanding, it should be noted at the outset that the article uses structural analogies to examine current challenges in veterinary medicine, *without* seeking to draw any evaluative comparison between the burdens experienced by parents and pet owners.

Mapping the animal owner as secondary patient

Eichinger et al. (2023) justify the classification of parents as secondary patients by describing their deep-seated interconnection with the ill child that renders them inherently vulnerable. According to the authors, these interconnections arise among others from the strong emotional bond between parent and child, from processes of identification with the ill child, from the fact that parents are legal representatives of their children and are therefore involved in decision-making processes, and from the extensive practical effects of the child's illness on their everyday life. Comparable dimensions can be identified in the relationship between animals and their owners. This is particularly evident in the context of companion animal medicine. Many studies examine the close relationship between animals and their owners, commonly referred to as the human-animal bond. This concept describes an important relationship between humans and their animals with emotional, psychological, and physical components (American Veterinary Medical Association [AVMA], 2013) and is supported by a substantial body of research on the emotional significance of companion animals to their owners (Sable 2013; Archer 1996). For owners, pets are often perceived as family members (Walsh 2009) and as "part of the self" (Belk, 1996, p. 129). As a result, illness in the animal can be emotionally burdensome and affect owners' biographies and processes of identity. The entanglement between animal and owner is further reinforced by the fact that, in veterinary medicine, animal owners occupy a central decision-making role and hold ultimate legal authority over medical interventions (Ashall et al., 2018). The need to weigh diagnostic and therapeutic options, and in particular to make end-of-life decisions, is often experienced as highly burdensome in light of the emotional bond and can be associated with stress, uncertainty, and feelings of guilt in owners (Spitznagel et al., 2020). In addition, an animal's illness places considerable practical burdens on the owner, including significant time commitments and organizational responsibilities. It also entails financial strain, as treatment costs in the veterinary context are – in the absence of animal health insurance – typically borne by the owners themselves. Further, studies show that caring for an animal can significantly affect the owners' working life, social relationships, and daily routines (Christiansen et al., 2013). Taken together, these burdens can affect owners similarly to caregivers in human medicine: owners of ill animals report stress, anxiety, depressive symptoms, and reduced quality of life (Spitznagel et al., 2017), in some cases comparable to caregivers of people with dementia (Britton et al., 2018). Finally, the possibility should be considered that an owner's health could, in some cases, be adversely affected by contact with an ill animal. This might include injuries sustained during care or risks posed by zoonoses or antimicrobial resistance (Smith et al., 2018).

In summary, central dimensions of intertwining and interdependent vulnerabilities identified by Eichinger et al. can also be found, in modified form, in animal and animal owner. This raises the further

question of what implications extending the concept of the patient to include animal owners would have for veterinary practice.

Implications for veterinary (companion animal) practice

An extension of the concept of the patient in veterinary practice – so the argument advanced here – would have two central implications: (a) recognising animal owners as physically and psychologically vulnerable actors in their role as owners, and (b) considering their health-related in practice.

With regard to (a), recognising animal owners as secondary patients entails acknowledging them as individuals potentially affected by their animal's illness and at risk of health impairment. It also implies recognising that animal health is not an isolated phenomenon but may have implications for the health of humans as well. This understanding of intertwined and interdependent health is well established in veterinary medicine and is reflected, for example, in the One Health framework, which emphasises the connections between human, animal, and environmental health. However, the One Health discourse often shifts attention away from the individual towards collective and global perspectives, particularly in relation to animal welfare and public health (e.g. Van Herten & Meijboom, 2019), whereas recognising animal owners as health-relevant and potentially vulnerable actors directs attention to the micro-level of veterinary practice.

With regard to (b), in contrast to paediatrics though, veterinarians have limited scope to directly address human health, since they neither possess the relevant expertise nor a legal mandate to treat human patients. Accordingly, its implementation would be best situated at the level of communication and decision-making. Addressing secondary patients therefore would require creating space for owners to express their perspectives and integrating these into their diagnostic and therapy recommendations. Empirical studies indeed indicate that veterinarians' communication significantly influences owner burden (Joo et al., 2025). At the same time, this may also benefit the primary patient, as owners' lifestyles, care practices, and decisions significantly shape the animal's health (Sandøe et al., 2014; Rollin, 2006[1996], p. 247).

However, veterinary medicine is already strongly oriented toward animal owners. Empirical studies show that veterinary decision-making is shaped by owners' circumstances and the human-animal bond (Batchelor & McKeegan, 2012; Martin & Taunton, 2006), while veterinarians report being burdened by the additional emotional labour involved in addressing owners' needs alongside treating the animal (Romo et al., 2025; Owens, 2015). More fundamentally, the central ethical question of the field, whether veterinarians are primarily obligated to the animal or to the owner (Rollin, 2006[1996]), highlights that owners' interests have long been an integral part of veterinary practice, even if they are not explicitly conceptualised in terms of health. Against this background, it remains unclear whether extending the concept of the patient would bring about substantive changes in practice or merely reframe existing structures. This is further complicated by the fact that even the status of the animal as a primary patient is, in contrast to paediatrics, not always taken "for granted", (Eichinger 2023, p. 368). Veterinary practice is characterised by considerable heterogeneity in how animals are approached. As Gardiner notes, "some animals [are] effectively treated as 'infectious agents' themselves" while others "receiving a high degree of individual care and attention" (2009, p. 358). Accordingly, Grimm and Huth (2017) argue that not every animal treated by a veterinarian is automatically considered a patient. They propose three conditions (a) the animal is presented to a veterinarian; (b) there are veterinary interventions reasonably expected to provide overall benefit; and (c) the intervention primarily serves the animal's own health interests rather than those of third parties (Grimm and Huth, 2017, p. 229). This suggests that extending patient status to owners is only meaningful in contexts where the animal's status as a primary patient is given. In such contexts, however, conflicts may arise between the interests of the primary and the secondary

patient, particularly under conditions of limited resources. In these cases, there are strong reasons to give priority to the primary patient.This prioritisation is grounded both in veterinarians' specific expertise in animal health and in their specific professional responsibility for the animal, as emphasised within the One Health framework (Van Herten & Meijboom, 2019).

Conclusion

The preceding discussion has shown that the health of animals and humans is closely intertwined in veterinary practice. Emotional bonds, caregiving structures, decision-making responsibilities, economic burdens, and, in some cases, physical health risks indicate that veterinary interventions often affect not only the animal as the primary patient, but also the health and well-being of animal owners. Against this background, it seems reasonable to consider animal owners, at least in companion animal medicine, as secondary patients. Such a perspective highlights that owners may themselves be affected by their animal's disease, including in terms of their physical health. At the same time, extending the concept of the patient may intensify conflicts in practice where the health interests of animals and owners diverge. Conceptualising animal owners as secondary patients cannot – already for legal and disciplinary reasons – mean that veterinary responsibilities also include treating the health of the owners, so it does *not* imply dual treatment or a blurring of professional roles, rather it can be understood as a kind of additional "mindset" that sharpens awareness of the relational and ethical complexity of veterinary practice. Pet owners are not 'merely' accompanying persons or customers who settle the bill at the end; rather, in the event of animal's serious illness, they must be recognized as individuals possessing their own inherent vulnerability. Developing a mindset that views pet owners as 'secondary patients' underscores that veterinary care unfolds within a network of shared vulnerabilities and interdependencies. From this perspective, recognising animal owners as secondary patients may serve to operationalise the One Health approach at the micro-level of everyday veterinary practice.

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Equine euthanasia in end-of-life contexts: a triangular ethical decision-making framework

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Abstract

Veterinarians may recommend euthanasia, but the decision rests with the equine's owner. Faced with complexity in practice, especially for geriatric cases, one may wonder who really takes the decision? And who should take it? Does the veterinarian become a moral authority in such decision-making, at the cost of excessive moral responsibility? And what role should the equine play in enabling this decision process? By drawing on the analytical methods of the ethics of care and on research on equine agency, this paper presents a narrative-based, dialogical triangular euthanasia decision-making framework that situates this decision within its relational context, and adequately positions owner, veterinarian and equine as actors within this process.

Keywords: end-of-life, moral choice, ethics of care, narratives, equine agency

Introduction

Equine euthanasia gained ethical interest in past decades because it raises its own set of challenges (Merriam, 2011; McGowan et al., 2012; McGowan and Ireland, 2016). Equidae (*equus*) are a family of animals that includes horses (*equus ferus caballus*) as well as zebras, donkeys, and onagers (Thein, 2005). However, the terms 'equine' and 'horse' are used interchangeably in this text. How should we think about the decision of euthanasia for equines? Euthanasia is generally done by lethal injection administered by a veterinarian. The owner has moral and legal authority over the decision to euthanize; a veterinarian may recommend it, but does not have legal authority to decide. This paper focuses on the context in which an equine and owner have a common history and the question of euthanasia arises because of illness or geriatric decline. Convenience euthanasia and emergency euthanasia are not discussed. Understanding the experience of equine euthanasia decision-making is important because this decision often distresses owners (McGowan et al., 2012). This paper questions the legitimacy of these dyadic decision-making practices by emphasizing decisional power asymmetry that often overtax owners or veterinarians as well as silence horses. To face these worries, triangulation between (at least) three individuals (horse, owner, veterinarian) is defended as a framework to provide a fairer distribution of power, and thus better care.

Equine euthanasia in end-of-life contexts

Equine euthanasia in end-of-life contexts (hereafter EEEoL) are cases in which one thinks about euthanizing an equine because of a marked degeneration of her health or quality of life (QoL). The idea of 'quality of life' is a common evaluative concept to make sense of a horse 'doing well'. It is not co-extensive with the health condition because poor health (e.g., obesity) does not necessarily prevent a good QoL. In EEEoL, euthanasia is faithful to its etymological meaning: from the ancient Greek *eu*, meaning *good,* and *thanatos,* meaning *death, eu-thanatos* aims at giving a good death (Merriam, 2011). EEEoL differs from emergency euthanasia performed because an injury is too severe for recovery (e.g., a broken leg on a racecourse). It also sharply contrasts with convenience euthanasia based on owner relative

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reasons (e.g., the horse can no longer performs human deeds.). These forms of equine euthanasia raise different ethical questions. This paper focuses on ethical questions raised by EEEoL.

According to the orthodoxy, '*end-of-life*' is the short period when the horse becomes overtly the object of the procedure of euthanasia. I consider instead end-of-life as a period that extends in time, sometimes for many months, and that must be understood through biographical dimensions. End-of-life spans over an interval within which the horse's caretaker notices decline in health or QoL caused by old age or illness. I argue that a key event generally marks the beginning of end-of-life, as is the case within this example:

> Iduna was euthanized by lethal injection administered by the attending veterinarian at 7:30 on January 12. Iduna had drastically lost the use of her hips. It became increasingly difficult for her to get up if she layed down. M, the mare's caretaker, noticed changes for about two months previous to that day: since the first time Iduna was unable to get up on sand. On the evening of January 11, the mare went in her stable as usual where she lays on straw during the night. When M went to her at 6:00 the next morning, it was clear that she had struggled hard to get up, without success. M called Iduna's attending veterinarian. M and the owner decided that Iduna could not be left to endure another night of struggle. The veterinarian said that they were right to decide to euthanize. M said the veterinarian provided confirmation regarding the legitimacy of the decision and a sense of peace.[4]

This mare was euthanized following an end-of-life period that spanned over two months. A key event abruptly marked the beginning of this period. After which, Iduna's caretaker was more attentive to new aspects of the mare's life. Loss of mobility marks a turn in the mare's life story, but it does not, as such, declare that Iduna should be euthanized.

Problems of asymmetry and moral deference

Qualitative analysis of the lived experience of equine euthanasia decision-making in horse owners (McGowan et al., 2012; McGowan and Ireland, 2016) shows that:

- Among all the factors considered relevant to decide whether a horse should be euthanized, the advice of the veterinarian weighs more than most other factors.
- The decision to euthanize a horse companion is seen as a major and difficult decision by owners.
- Owners generally have a long history with the horse.
- Although euthanasia is intended to relieve suffering, interviews show that the process brings about more distress than relief from the owner's perspective. There thus seems to be a discrepancy between the alleged beneficence of the procedure and the owner's experience.

Following these observations, I shift attention from the role owner and veterinarian are formally expected to play in EEEoL decision-making, to the role they in fact play in this process, to raise three different, but interrelated, ethical issues. Veterinarians should give medical advice and execute the euthanasia procedure (Merriam, 2011; McGowan et al., 2012; McGowan and Ireland, 2016). However, studies show that they play a more expansive role, as they should, for instance: "Have appropriate communication" (Merriam, 2011, 169); follow up on the grief of the owner (McGowan and Ireland, 2016); give support over and beyond health-related questions: "the veterinarian is an important figure to provide active support before, during, and following euthanasia" (McGowan et al., 2012, 271). Additionally, owners heavily rely on veterinary advice. Thus, veterinarians perform medical and ethical expertise. Hence, in EEEoL

[4] I thank M for agreeing to give a qualitative interview that describes her experience of Iduna's end-of-life period.

decision-making, the owner, the veterinarian or both have agency. In contrast, self-assessment on the part of the horse is rejected (McGowan and Ireland, 2016). What should one think of this role distribution?

First, given that this decision is of major importance and can be distressing, we must question whether it is right that the owner bears the weight of the decision alone? Second, the veterinarian is implicitly given moral authority within this decision-making, which is unjustified and could be detrimental for her. A main consideration weighing in euthanasia decision-making is veterinary advice. Advice is a legitimate source of ethical knowledge if one can rely on it to critically assess a situation (Hills, 2013). It is problematic, however, when it becomes moral deference, that is forming one's moral beliefs solely on the word of another, thus outsourcing the decision to that other. This unloads the responsibility on the person deferred to. Given the seriousness of the decision in EEEoL, we might suppose that owners are prone to defer to the advisor, thus turning veterinary advice into moral deference. Taking the responsibility of the decision is beyond the duty of these medical professionals. Relatedly, I argue that this asymmetry of decisional power is reinforced given that the horse is not acknowledge as a possible source of knowledge for this decision. The view that horses are passive individuals who cannot inform their own destiny needs questioning; it is a stigma about animal agency. I thus raise a problem about the asymmetry of decisional power between the different actors involved in euthanasia decision-making. A triangular framework for decision-making grounded in care theory analysis should situate the decision to euthanize within a context, thus better situating the actors involved with regards to one another. The goal is to reach a fairer distribution of power and responsibility within EEEoL, thereby a better informed decision.

Situating choice

Ethical decision-making is generally considered as a punctual event: a decision, issued at time t, from a deliberative process, and from which an ethical action should follow. The decision follows a practical question (e.g., 'Should this horse be euthanized?'). In such representations the owner is inescapably faced with the difficult choice. These are truncated descriptions of EEEoL because they do not accurately account for the ethical experience typical of such situations. A careful observation of the way these situations are experienced disproves the adequacy of describing them as discrete choice making. This misrepresentation of the experience of EEEoL would explain some of the difficulties that arise when an owner is asked 'Yes or no?'. Thus, reinforcing the problems of asymmetry and moral deference because the owner is trapped within a position of sole authority. The ethics of euthanasia generally pertains to ways of providing a humane death (Merriam, 2016): the procedure must be as distress free as possible for the horse. Ethics thus focuses on the protocol of euthanasia significantly more than on the challenges raised by decision-making. However, in EEEoL ethical considerations emerge before and span beyond procedures.

Philosopher Iris Murdoch argues that at the time of choice the decision is already taken (Murdoch, 2002). The phenomenology of moral choice reveals that decisions build up throughout ordinary day-to-day experiences and cannot be abstracted from them. If that is the case, then what bears ethical weight comes prior to the decision itself, leaving the choice a matter of stating a verdict – making it, so to say, official – as is the case in euthanasia decision-making. Murdoch argues that choice-making cannot be disentangled from the life about which it is made because considerations pull on us from within the context in which we are embedded. Our experience is framed by this context: "I can only choose within the world that I can *see*..." (Murdoch, 2022, 35-36) Otherwise said, our capacity to judge of an ethical situation is framed by, but also informed by, circumstances that precede the judgment. If Murdoch is correct, then the decision of equine euthanasia should not be separated from the horse's life history. This favors a dialogue and narrative-based epistemology over a strictly medical epistemology to guide this decision-making. One way to address the problems of asymmetry and moral deference is thus to focus

on the question 'Who should decide?'. If life narratives and experience shape moral choice, and if choice in EEEoL is about the life of an equine individual, then the authority of decision-making should only be given to those who know the relevant narratives and have had the relevant experiences.

Equine agency

Horses are routinely depicted as passive creatures within euthanasia decision-making. Given that this decision bears existentially on their lives, should they not be involved in the process? Research on equine agency explains how the horse can decide collaboratively about her own faith. An agent deliberates, makes choices and moves toward a goal by responding to the features of her environment. Some conceptions of agency are more cognitively demanding than others. I maintain distinctions here between moral agency and social agency: horses decisively inform ethical choices as social agents, but humans make them as moral agents.

Equines are social agents: they influence their environment, relations, and specific situations both at intra and inter-species levels (Birke and Thompson 2018; Argent and Vaught 2022). These relationships are often framed by human expectations and choices, sometimes so much so that equines have little to no choices available for action. However, given the right conditions: "nonhumans also produce meanings and change outcomes in cross-species meetings [...] even within the limits imposed by [human] systems [...]" (Birke and Thompson 2018, 35) At least four dimensions of equine agency (Birke and Thompson 2018) are relevant to inform euthanasia decision-making: communication, the ability to read situations, the ability to respond, and emotionality. Indeed, understanding the social agency of equines is "centred on understanding action and the meanings we attribute to it." (Birke and Thompson 2018, 41) This attribution of meaning aligns with the central question at stake in EEEoL: is an equine's life still meaningful? The concept of QoL although it attempts to naturalize meaning, is a search for meaning. This sought after meaningfulness is reflected through cautious observation and understanding of equine agency.

Circles of care: triangulating equine euthanasia decision-making

The dyads stressed until now unite a caretaker and a care receiver: the owner is caretaker for the horse, who is receiver of care. The veterinarian is caretaker for the horse at the medical level, but the owner also becomes care receiver of the veterinarian when her authority is relied upon. Care theorist Joan Tronto argues (2009, 2013) that the dyadic model of caring creates a form of dualism, within which the caretaker finds herself not only sole bearer of responsibility but also trapped in a dominant role that risks negating her own vulnerability, incompetence and needs. This model fails to account for the broader relational character of caring. Tronto underlines for instance that although in our societies mother-child form a paradigmatic dyad of care, child raising actually involves many individuals. Deciding to end an equine companion's life is strenuous because it is relationally taxing. Recognizing caring dyads in EEEoL allows us to address problems of power arising within those asymmetrical relations. Given the shortcomings of dyadic models, Tronto argues that caring should be democratized through triangulation because many individuals ensure quality, and because flattened hierarchies improve communication, which in turn informs caring better. Not just any larger number of individuals is improvement, but the proper circles of care offer a better distribution of authority and responsibility and inform the decision better.

The method favored is collaborative dialogue between the different actors of the triangle. For EEEoL, I argue that the caretaker(s), the veterinarian(s) and the horse should form the decisional triangle. I use the term 'caretaker' to signify the individual (or individuals) who are responsible for the horse's daily care (food/water, shelter, ensuring social and emotional needs, health monitoring, exercising, etc.). Emphasizing the caretaker as a key actor for euthanasia decision-making breaks with the custom of giving

the owner decisional authority. I argue that the owner, depending on her relationship with the horse, is not always adequately positioned to inform the decision. One must be in contact with the relevant ethical considerations to be ethically justified in playing a role within decision-making.

A consensus within veterinary ethics is that euthanasia should be done to alleviate suffering (Merriam, 2011). Suffering is presented as a key consideration within this decision-making. This raises two questions: Is the horse suffering? Is the horse suffering so much so that death is justified? Crucially, these questions inquire into the meaning of the horse's predicament for her life as a whole. In EEEoL the concept of suffering is often equated with that of pain: it stands as a naturalized form of suffering that can be clinically evaluated. Hence, the statement: 'This horse has pain in her right hip.', might guide euthanasia decisions. However, this is problematic if we accept a conceptual difference between pain and suffering. Whereas the former has physiological markers, the latter, as well as the physiological markers, can only be evaluated through the lens of the *horse-self*: the meaning of her life, her desire to live and the like. Hence, the question: 'Does this horse still want to live despite the pain in her hip?' is decisive in such contexts. How does one make sense of a horse still having a meaningful life? Such meaning is revealed by all actors of the triangle who must be capable of making sense of the situation. Importantly, a horse owner qualifies as a legitimate actor in this triangle if and only if she is significantly involved in the horse's life. This would disqualify, for instance, owners who have outsourced the entirety of the care to other people, contributing only at the financial level. The triangular framework allows us to distribute responsibilities between those who are considered best candidates to make sense of death for an individual horse, including the equine herself.

The caretaker(s), then, along with the horse and the veterinarian, are best positioned to evaluate the predicament of the horse: to situate illness, injuries, loss of mobility, loss of appetite and other indicators, within the horse's story; her story in general and that specific to the end-of-life period. We ask whether this life is still meaningful. To answer this question the circle of care must ask where this life stands and where it can go. A description of a good or an ill-faring life requires fine-grained descriptions of the situation using specialized (thick) concepts (animated, lively, curious, peaceful or struggling, dejected, weary, haggard, etc.). Depicting the problem through narratives situates the horse as a key actor within the decision-making process because it is she who is best positioned to give information about her own life.

How do the four dimensions of equine agency manifest within the end-of-life period? Communication involves two other dimensions: human-horse communication implies that they are able to read each other's actions, mostly through body language and facial expressions. Was M, the caretaker of Iduna in the case introduced in Section 1, able to read her facial expression as she first struggled to stand up on sand? And how did this expression differ from other times in the day: grazing, resting or grooming with her equine companions? The ability to read equine social situations plays a pivotal role to explain how democratized caring takes place. Iduna's end-of-life lasted about two months. Within those months, the caretaker gathered, through careful attending, information about Iduna's situation. One morning it was understood that Iduna's life was no longer worth living. M relied on a species-specific understanding of the mare's predicament to draw her conclusions, as well as on individual-specific considerations. Iduna's struggle during her last night no longer fit in her life story. Even during the weeks leading up to the decision to euthanize, despite her hip degeneration, the mare was still lively. Horses are social animals who form long-lasting relationships of mutual care (i.e., friendships) (Kieson and Sams, 2021). During the weeks of decline, Iduna still spent time with her equine companions as per her usual habits; some she had been friends with for almost three decades. M needed to be able to know whether Iduna could still engage in typical equine gestures of mutual care. This, in turn, ties into the fourth dimension of agency, for emotionality implies the possibility to "form attachments, to seek out contact with others." (Birke and Thompson 2018, 38) M, most acquainted with Iduna's history, knew the equine and human

attachments she had formed, and could read situations where those relations varied because of her lack of mobility. Iduna displayed these realities. M could then convey them to the owner to motivate the fact that her life was still meaningful. The fact that Iduna could still be part of her social circle, and that M new the depth of those relations, was a key factor to cast the meaning of her loss of mobility within the right context.

As M was struck by Iduna's struggle, she understood that a certain kind of life was no longer possible for the mare. Iduna's feeble, uncharacteristic responses, were interpreted as the signal that this magnitude of struggle is too much. A night of laborious, fruitless, effort is not only suffering for a horse but implies loss of physical and mental energy because proper rest is hindered. In this story, the dialogue was first between Iduna, M and the owner. Dialogue was then issued between veterinarian, owner and caretaker, as the former arrived for the procedure. It brought confirmation, and, with it, a sense of peace. The upshot of focusing on narratives is a better understanding of an individual horse's needs, together with a possibility for shared understandings crucial to single out key considerations that underpin the decision-making.

Conclusion

This paper argued that triangulating equine euthanasia decision-making through collaborative dialogue empowers all those involved. Assessing whether an equine life is still worth living is demanding, without a doubt. This paper stresses that it is not as demanding as deciding outside of a legitimate context and adequate epistemology. This narrative-based, dialogical triangular euthanasia decision-making framework is not a paradigm shift: some of these steps are sometimes taken intuitively in practice. However, the democratization of such a decision should be institutionalized as such because it provides better care. Many features of the proposed framework will be relevant for animal euthanasia decision-making in general, especially that of companion animals.

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Provision of end-of-life care in pets: can we identify keys to success – or failure?

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Abstract:

Veterinary care for companion animals increasingly mirrors human medicine. However, even though veterinarians have an increasing set of options to treat animals, end-of-life care often involves conflicting situations regarding decision making processes as well as adverse events during the practical application of this kind of care. The occurrence of these perceived conflicts depends on multiple factors. On the one hand, professionals must navigate their own interpretation of emotion and reason and may at times struggle to determine which course of action is most appropriate. On the other hand, interpersonal disagreement may arise regarding, among other things, the preferred treatment, the ethical assessment of the situation, or the value attributed to an animal's life. Such conflicting situations can occur within the veterinary team, across the wider veterinary profession, and between the professional(s) and their clientele. Moreover, the experience or threat of disciplinary proceedings has been documented in the literature as an additional potential source of conflict.

Although these conflicts have been widely reported by professionals and discussed in literature, the underlying mechanisms of how contextual and normative dimensions play a role in these conflicts, and how veterinarians perceive them, are still in need of further research. This insight is a key step to provide veterinary professionals with the tools to recognize, prevent and deal with such conflicting situations. This paper shows the background, focus, design and methods of a study that aims to get more in-depth knowledge of the contextual aspects that influence the occurrence of conflicting views together with strategies of how veterinarians deal with such conflicts.

Keywords: companion animals, veterinarian, euthanasia, conflicts, qualitative research

Introduction

Over the past decades, major societal changes have occurred in order to improve animal welfare (Treaty of Lisbon 2007, Ministry of Economic Affairs 2013, DeGrazia 2020, Mellor *et al.*, 2020, Eurobarometer Animal Welfare, 2016 and 2023, Dutch Animal law 2024, Dutch Council on Animal Affairs 2024). Together with this, ongoing medical innovations continue to expand the possibilities for highly specialized care for animals. These advances have substantially increased animal's chances of recovery from disease and animals with incurable diseases might live significantly longer while still maintaining an acceptable quality of life (Dickinson and Hoffmann 2019, Springer *et al.*, 2019, Quain *et al.,* 2021). As more and better veterinary care becomes possible, growing attention is being paid to endoflife care of animals, as it has become more complex to determine whether an animal has truly reached the end of its life (Villalobos 2011, Persson *et al.,* 2020, Quain 2021, Cooney and Kipperman 2023). Parallel to this, challenging questions arise like: 'whether it is desirable to provide all care that is technically feasible', or 'when and how should an animal's life be brought to an end' (Peterson *et al.,* 2022). Continuing research shows that the decision-making process in the context of the end of an animal's life is influenced by numerous interrelated clinical, practical, and relational factors (Yeates 2010, Bishop *et al.*, 2016, Knesl

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et al., 2017, Fulmer *et al*., 2022, Testoni *et al*., 2023, Springer *et al*., 2024, Beirens-van Kuijk *et al.*, 2026). The discussion is no longer limited to 'should euthanasia be considered or performed?', and the transition towards contextualized care has become particularly visible in this field of veterinary practice (Benyon 2024). This trend has an impact on the responsibilities, possibilities to act, and the autonomy of all stakeholders (Christiansen 2013, Springer and Flammer 2021, Peterson *et al*., 2025). Simultaneously, it raises important concerns about the position of the animal in the end-of-life decision-making process and the care provided at its end of life.

This paper outlines the preparatory steps for a study analyzing the factors that contribute to success or failure when a veterinarian is faced with conflicting views and expectations regarding the ending of an animal's life.

Context: conflicting situations and their consequences

Discussions about what constitutes good care for animals and the corresponding human responsibilities persist. For example, what can reasonably be expected from animal owners in terms of knowledge, and in terms of their financial and practical capacity to provide adequate care? A person's own values, responsibilities, expectations, and interpretations, together with those of other stakeholders regarding the animal's best interests, inevitably lead to divergent viewpoints and, at times, conflicting situations. When for example a professional's advice is 'to end an animal's life due to poor prognostic prospects' while the animal owner 'wants to continue that animal's life', these conflicts are shaped not only by these differences in perspectives but also by the specific context in which end-of-life care occurs.

By contextual aspects we refer to whether the situation involves acute or chronic illness, the triangular relationship between owner, animal and the professional, and the legal context including the existing Dutch Code of Conduct (2022). As part of this dimension of the study, we also take the normative dimensions into account (Bakker and Coppoolse, 2022). This includes an analysis of how responsibility is distributed and negotiated, how veterinary professionals navigate uncertainty, and how they deal with moral tension and/or potential emotional burden (Knesl, 2017, Quain 2021).

For veterinary professionals, these conflicting situations can generate emotional strain. This strain may arise from concerns about the animal (Knesl *et al.,* 2017, Deelen, E., 2024), from moral dilemmas, from interpersonal tensions (Rollin 2011, Matte 2020, Testoni *et al.,* 2017; Knesl 2017, Quain 2021, Kogan *et al.,* 2023, Dürnberger and Springer 2025, Peterson *et al.,* 2025), and/or from potential consequences such as reputational damage, negative socialmedia responses, or even disciplinary complaints. Conflicts may occur in the veterinarian–client relationship or among professionals, whether within a team or in referral settings (Oxtoby and Mossop 2019, Gibson *et al.,* 2022, Gibson *et al.,* 2024).

Identifying factors that contribute to a successful outcome for stakeholders

The existing literature provides increasing insight into the circumstances under which veterinarians might face a conflicting situation during the decision-making phase regarding the possible end-of a companion animal's life. Nonetheless, in-depth understanding of the origin of such conflicts about if and when the ending of this life should occur remains limited. It is important to provide veterinary professionals with tools to recognize, prevent and deal with such conflicting situations. Therefore, this study aims to gain insight into 1) the contextual aspects affecting the end-of-life-decision-related conflicting situations, and 2) professionals' strategies in response to such conflicts.

We will focus on conflicting situations that arise between the veterinary professional and the owner and those between veterinary professionals, whether within the same team or in referral settings. These

situations are examined in the context of acute versus chronic care and are viewed exclusively from the professional's perspective.

Study design

Methodology

The study design comprises a qualitative approach and will consist of empirical work in the form of semi-structured interviews. The participants will be veterinary professionals who 1) work as general practitioner in the Netherlands, 2) primarily treat companion animals, and 3) are involved in end-of-life decision-making, as part of their clinical work. In order to capture divers and rich responses we will select participants who meet the inclusion criteria while varying in their involvement in out-of-hours or emergency services, their years of professional experience, and their position within the practice, provided that a substantial part of their workload consists of clinical duties, as required by the inclusion criteria. We will also ensure variation in geographical context by including veterinarians working in both urban and non-urban areas. The interviews will be conducted by the first author, who is a professional insider: she worked for 20 years as a smallanimal veterinary practitioner with a special interest in veterinary oncology and extensive experience in endoflife decisionmaking. In advance of the interviews, an interview guide is developed based on literature on end-of-life decision-making and professional identity. Additionally, a group of three specialists in companion animal health care has reviewed the guide. Feedback from these specialists was processed to prepare the guide for test interviews. The final interview guide includes four themes: (1) demographic information, the role the professional holds within the clinical setting, and how endoflife care is part of daily practice, (2) how responsibilities are distributed and discussed between colleagues and between professionals and pet owners, (3) how they experience and deal with moral tension, conflicting situations and emotional burden and (4) what support professionals do consider desirable in the context of their endoflife care practices. We also consider the process of "normative professionalization": how professionals color their decisions and their chosen course of action, through their own background, values, upbringing, and education. In addition, we refer to contextual factors such as whether the situation involves acute or chronic illness of the animal, and the triangular relationship between owner, animal, and professional. Finally, we will address the extent to which legislation relevant to such situations is known, and whether there is a certain need in this regard.

By exploring veterinary professional's perspectives on the contextual factors described above, we seek to understand not only when and what type of conflicts occur, but also how professionals respond to them and why they make the choices they make.

Considering the sensitivity of this subject, this study design allows for an in-depth understanding of how such conflicts arise in some situations while, under similar circumstances, they do not emerge in others (Braun and Clarke, 2013).

Ethical approval for the study has been requested from to the Ethics Review Board (ERB) of the Faculties of Science and Geosciences, Utrecht University, the Netherlands.

Methods

A first call for participants will be made in the late summer/autumn of 2026 through a snowball sampling strategy. Eligible participants will be approached by email, informed in detail about the research project, and invited to participate in a face-to-face interview. The GDPR was coordinated with a privacy officer and subsequently reviewed by the ERB. Only the necessary information (name, email address and

location where the interview will take place) is collected. Access to the data is restricted, and only the authors of this paper are authorized to access it. The recordings are anonymized after transcription. The retention period for the personal data runs until the end of 2027.

Recruitment and interviewing will continue until saturation is reached, meaning that additional data no longer generate new insights. Interviews will be scheduled at a time and location that best suits the participant, to ensure an open and safe environment. The estimated time commitment for participants will be 60–90 minutes, and the estimated number of interviews will range between 12 and 25. All interviews will be audio-recorded, and participation is on a voluntary basis.

At the start of the interview, the interviewer will discuss the outline of the interview. Any questions from the participants regarding the research will be addressed. Before the interview starts, both written and oral consent are asked.

Recordings will be transcribed using Amberscript to convert audio into text and subsequently reviewed by the interviewer and the second author to ensure accuracy. Any information related to a specific person will be replaced by a non-identifiable descriptor. Transcripts will be explored for themes using template analysis in NVivo™ qualitative analysis software (Version Release 1.5.1, QSR International Pty Ltd. (2021)). In this form of thematic analysis, the use of hierarchical coding is emphasized, balancing a highly structured approach to analyzing textual data with the flexibility to adapt the coding structure to the needs of the study (Brooks et al., 2015). A coding template for the interviews will be developed inductively to explore the transcripts. To define the initial coding template, the first and second authors will conduct open coding on a subset of transcripts to generate preliminary codes. These codes will then be revised and refined based on subsequent transcripts through an iterative and reflective process involving all three authors. We will reflect on the first author's potential biases and how these may have influenced data collection and interpretation. After this iterative reflective process, the finalized coding template will be applied to the full data set.

Future direction

This study is part of a broader project that examines how education, experience, practical skills, the personal mindset of veterinary professionals, and relevant legislation shape care and conflict management surrounding end-of-life care for pets. Building on the aims of this study (gaining insight into the contextual aspects that influence end-of-life-related conflicts, and the strategies professionals employ in response to such conflicts) the project will further highlight the influence of personal values, responsibilities, team dynamics, and veterinary–client relationships.

The project will be complemented by an analysis of disciplinary cases (document analysis). By scheduling this document analysis after the empirical component, the research question can be illuminated not only through the experiences of professionals, but also through existing jurisprudence. The combined findings from the empirical qualitative study and the document analysis will form the basis for developing building blocks for a guideline focused on intervention options. This guideline will focus on interventions at the level of the individual professional and, where relevant, at the level of the practice or the professional group. In doing so, the project aims to enhance the well-being of (future) veterinary professionals as well as animal welfare and improved collaboration with animal owners.

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Navigating transformation: why generation matters for understanding change in veterinary medicine

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Abstract

Professions can act as stabilising institutions that shape and regulate social change. This paper explores the interaction between change and the profession of veterinary medicine, a field currently undergoing significant structural and cultural transformations. Through a secondary analysis of qualitative interviews conducted with veterinarians from various working fields (N =17), we explore how these professionals perceive and engage with recent changes in their practice. Notably, the concept of 'generation' emerges as a significant interpretive framework in shaping their professional identity. Shifts in societal attitudes towards animals – including the emotionalisation of human-animal relationships, the elevation of animals as companions, and critiques of industrial animal husbandry – are transforming the veterinary landscape. At the same time, discussions concerning the 'disappearance' of traditional livestock practitioners, the 'feminisation', and technological advancement of the profession highlight internal tensions related to competence, recognition, and professional identity. Results of our study show that 'generation' functions less as a fixed demographic category than as a narrative and interpretive framework for navigating societal and professional transformations. It enables veterinarians to articulate and evaluate change by linking structural transformations, such as new job requirements and altered views on animals, with social dimensions like responsibility, belonging, and professional ethos. Further, findings indicate that generational narratives simplify complex developments, providing a way to contextualise individual experiences of strain within broader professional changes. Keeping this in mind, our study demonstrates how professionals interpret change through generational framing, rendering it communicable, negotiable and open to critique. Adopting a sociological perspective on professions, it considers change not only as external pressure, but also as an ongoing process of active interpretation, negotiation and positioning.

Keywords: empirical ethics, human-animal relations, professional identity, social chang, qualitative research

Introduction

In contemporary discourse, public debates are increasingly framed through the lens of generational differences, shaping our understanding of societal values and attitudes. Media commentary and everyday conversations frequently highlight the distinctions, e.g. between 'Baby Boomers', 'Millennials', or 'Generation Z', attributing varying work ethics, moral perspectives, and life priorities to these successive cohorts. This generational framing not only influences perceptions of individual behaviour but also reflects broader socio-economic trends and cultural shifts that merit critical examination (Bristow, 2024).

Sociological research has long emphasised that generations cannot be reduced to mere biological age cohorts. In his seminal work, Mannheim (1928) argued that generations are shaped by historical experiences, which collectively influence their attitudes toward social change. As Bude (2010) notes,

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each generation introduces unique 'world relations' that must be negotiated in relation to those of both preceding and succeeding generations. While there is a risk of oversimplification and reliance on stereotypes, generational categories serve as a potent interpretive framework within social discourse. They provide a vocabulary for individuals to make sense of societal change, articulate intergenerational tensions, and define their roles within evolving institutional contexts, such as veterinary associations, regulatory bodies, and educational institutions.

This interpretive function is particularly relevant in rapidly transforming professions, such as veterinary medicine, which serves as a compelling case. The field has undergone significant transformations, often exemplified by the contrasting images of the traditional rural male livestock veterinarian, who works independently in a private practice, and the urban female companion animal veterinarian, who is typically employed part-time in a group practice (Jones 2002). Although this portrayal may be somewhat exaggerated, it effectively highlights the stylised nature of the profession and reflects broader shifts in veterinary work, work-life preferences, professional demographics, and societal expectations regarding animals.

Three interconnected transformations are particularly relevant: *First*, veterinary medicine is shaped by changing social understandings of animals (Jones, 2002). In recent decades, there has been a notable emotionalisation of human-animal relationships, particularly with companion animals. This shift has occurred alongside a growing public critique of industrial livestock farming practices (Eitler, 2014; Settele, 2020). Companion animals are primarily viewed as patients, while livestock treatment often focuses on productivity within economic systems. Consequently, veterinary medicine is significantly impacted by broader societal shifts in human-animal relations and evolving animal roles (Bubeck and Springer, 2024). These shifts are also evident in the changing distribution of veterinary work; while livestock practice historically dominated, companion-animal medicine has expanded notably in urban areas, driven by structural pressures such as changes in agricultural systems and the decline of rural infrastructures (Jones, 2002).

A *second transformation* in veterinary medicine pertains to technological advancements. Innovations in diagnostic technologies, imaging techniques, and specialised treatment options have significantly broadened the scope of veterinary care, fostering specialization and differentiation within the profession, and departing from the traditional model of the general practitioner (Heinlein, 2026). In companion animal medicine, veterinary practice increasingly mirrors the technologically intensive care found in human healthcare. Veterinarians now navigate complex diagnostic tools, engage with well-informed clients about treatment options, and manage cases requiring advanced medical interventions. These developments have heightened internal debates regarding professional competencies, standards of care, and the role of technology in veterinary decision-making, particularly in companion animal medicine.

A *third transformation* involves changing working conditions and professional demographics. Veterinary medicine has seen substantial 'feminisation', with women now comprising the majority of graduates in many countries (Irvine and Vermilya, 2010). Concurrently, discussions around work-life balance, working hours, and mental health have gained prominence within the profession. Research consistently highlights high levels of stress, burnout, and psychological strain among veterinarians (Böckelmann *et al.*, 2024; Pohl *et al.*, 2022). These issues intersect with structural challenges, such as shortages of veterinarians in specific sectors – particularly livestock practice and emergency or night services. As a result, veterinary medicine faces tensions between traditional professional expectations, such as long hours and strong personal commitment, and the increasing demand for more sustainable and employee-friendly working conditions (Dürnberger and Springer, 2025).

In light of these transformations within the veterinary profession, this paper aims to analyse how veterinarians utilise generational narratives to reflect on these changes. We argue that 'generation' serves as a professional interpretive framework that connects factual aspects of change – such as new job requirements, technological advancements, and evolving roles of animals – with social and normative issues related to responsibility, competence, belonging, and recognition. Specifically, we pose the research question: How do veterinarians employ 'generation' to interpret and negotiate societal and professional change within veterinary medicine? By examining the role of 'generation' in professional discourses, this article contributes to sociological discussions regarding professions as active interpreters of societal change.

Material and Methods

This analysis employs a qualitative approach, involving a dataset of 17 veterinarians from various fields, including small animal (n=8), equine (n=5), laboratory animal (n=3), and farm animal practices (n=6) (since some veterinarians worked in multiple fields, this number does not equal the total number). The sample encompasses both junior and senior veterinarians, allowing for a diverse range of experiences to be captured. Data were collected through semi-structured interviews conducted between 2020 and 2022, with each interview lasting from 45 minutes to 2 hours. This data collection was part of a broader project examining different killing contexts and the working environments of veterinarians (cf. Bubeck, 2023). Participants were recruited through targeted outreach to veterinary practices and professional networks. Further details regarding participant recruitment, the study sample, and data collection methodologies can be found in Bubeck (2023).

Data analysis

The results presented in this article are based on secondary analyses of the introduced dataset. Secondary analyses are defined as a research strategy in which existing research data are employed to address a research question (Medjedović, 2014; Heaton, 2008). Unlike primary analyses, secondary analyses are characterised by the decoupling of data collection from data evaluation and interpretation (Klingemann and Mochmann, 1975; Medjedović, 2014). In these analyses, there is no independent collection of new data; rather, pre-existing research data are utilised. Despite their differing research foci, the dataset reveals a consistent trend: veterinarians employ generational narratives to interpret professional change. This recurring pattern justifies an analytical focus on generation as a shared interpretive framework. Importantly, generation is treated as an empirically grounded category that emerges from the material rather than being an a priori assumption. The material was analysed using an inductive approach, with a specific emphasis on generational aspects. This perspective ensures that the analysis is firmly rooted in the experiences and insights of the veterinarians, providing a robust understanding of how generational narratives shape their interpretations of change within the profession.

Results

Participants frequently discussed changes within the profession through the lens of 'generations'. Rather than delineating specific differences among cohorts, these references functioned as narrative devices that facilitated participants' interpretations of professional change. The analysis reveals that generational distinctions are used in four primary ways: (1) to construct professional reference figures, (2) to elucidate shifts in human-animal relationships, (3) to negotiate concepts of professional authority and expertise, and (4) to assess evolving professional values and work orientations.

Generational reference figures: the rural livestock veterinarian

The figure of the rural livestock veterinarian was a recurring theme in the interviews and functioned as a generational reference point for describing long-standing forms of veterinary professionalism. One interviewee recalled his desire to become *'a typical rural veterinarian ... with rubber boots and a green coat' (Kaufmann; equine and small animal practice, senior, m)*. Several veterinarians described this professional model as an early aspiration. Further, veterinarians also emphasised the social recognition associated with this role: *'After a difficult birth, you got cake and coffee and maybe even a schnapps ... you were respected and welcome' (Wagner; veterinary office and farm animal, senior, f)*.

In rural settings in particular, the relationships between veterinarians and clients are said to be close, personal and long-term, shaped by repeated encounters and limited alternatives. As one interviewee described, the veterinarian was *'sometimes very important... a kind of trusted person ... people would also tell him very private things ... maybe similar to how they relate to their general practitioner' (Reuter; equine and small animal, junior, f)*. In contrast, urban and clinical settings are perceived as less personal; for instance, the veterinarian described further how it felt more impersonal when *'you [as a client; M.B.] are sometimes with one veterinarian and sometimes with another' (ibid.)*.

Overall, the rural livestock veterinarian serves as a generational reference point, embodying professional authority, social integration, and recognition, against which current changes are evaluated.

Generational narratives and the transformation of human-animal relations

Generational narratives also serve as explanatory frameworks through which veterinarians interpret broader societal changes in human-animal relations and the meaning for professional expectations and roles. Interviewees often compare earlier pragmatic approaches to animals, particularly in agricultural contexts, with the more emotional and medically advanced approach to companion animal care seen today. Some practitioners offer critical reflections on this transformation, particularly in relation to companion animal medicine: *'The perverse thing about small animal practice is that animals are becoming more and more humanised' (Wagner; veterinary office and farm animal, senior, f)*. In these accounts, the increasing medicalisation and emotionalisation of companion animals is often associated with younger generations of owners or veterinarians. Veterinarians often view these developments as part of broader societal changes. One practitioner describes how, nowadays, owners often pursue extensive treatment even when the prognosis is poor: *'Today, owners are more likely to ask, "Can't you do something?", than to give up on the animal' (Kaufmann; equine and small animal, senior, m)*. A risk to animal welfare was identified by this veterinarian due to increased client demand: *'my patients generally suffer more from over-treatment than from under-treatment' (ibid.)*.

Thus, generational narratives were employed to connect evolving human-animal relationships with changing expectations regarding veterinary care, particularly regarding emotional involvement and the extent of medical intervention.

Generational narratives and the negotiation of professional authority

Another recurring theme is the shifting nature of the authority of veterinarians in relation to animal owners and wider society. Interviewees describe a shift away from traditional forms of professional authority towards more consumer-oriented relationships. One veterinarian explains: *'The veterinarian used to be more of an authority figure ... today, he is more likely to be seen as a service provider' (Bauer; equines, small animals and farm animals; intermediate, f)*. This shift is also linked to digital technologies and the increasing availability of medical information online. Veterinarians describe situations in which

clients arrive with diagnoses derived from internet research: *'First, people do some online research ... before even consulting an expert' (Bauer; equines, small animals and farm animals; intermediate, f).* Veterinarians describe how their role has shifted from that of a respected advisor to an economic cost factor: '*At the end of my large animal practice, you were only a cost factor' (Wagner; veterinary office and farm animal, senior, f).*

In this way, generational narratives were used to negotiate the transformation from trust-based authority or paternalistic communication to forms of professional expertise that were economically framed and knowledge-contested.

Generational Narratives and the Moral Evaluation of the Profession

Further, generational narratives often feature in moral evaluations of contemporary veterinary practice. Interviewees use generational distinctions to express tensions concerning professional values, work attitudes, and the future of the profession. Discussions about the feminisation of veterinary medicine and changing expectations regarding work-life balance often appear to be framed as generational conflicts. One interviewee expresses concern about the consequences of these developments: *'The feminisation ... the work-life balance ... veterinary medicine is rapid-ly going down the drain' (Wagner; veterinary office and farm animal, senior, f).* Although such statements reflect individual perspectives, they demonstrate how generational narratives provide a means of expressing concerns about evolving professional values. Other interviewees emphasise the structural pressures affecting the profession, including the increasing psychological strain and burnout experienced by veterinarians: *'Burnout among veterinarians is becoming more of a focus' (Bauer; equines, small animals and farm animals; intermediate, f).* Generational narratives act as a vocabulary for moral evaluation, through which changes in working conditions, values and expectations can be interpreted and challenged.

Conclusion

Veterinarians' self-descriptions draw on generational distinctions, for instance in the form of contrasts between an 'earlier' and a 'contemporary' understanding of veterinary work. Building on the empirical findings, these generational framings can be interpreted in three interrelated ways.

First, generational framing can be understood as a window onto processes of professional change. The figure of the rural livestock veterinarian (3.1) points to changing forms of social embeddedness; narratives about human-animal relations (3.2) highlight shifting expectations towards care and treatment; accounts of professional authority (3.3) reflect transformations in the relationship between expertise and clients; and moral evaluations (3.4) address changing work orientations and professional values. From an analytical perspective, this mode of speaking can be read as a lens through which veterinarians make sense of structural changes. By narratively structuring developments along generational divides, veterinarians simultaneously articulate perceptions of a broader transformation within the profession.

Second, generational framing functions as a form of narrative simplification. Thinking in generational terms fulfils a narrative ordering function. Complex and often difficult-to-grasp changes – such as increasing levels of responsibility or shifting client expectations – are translated into narratives that are intelligible in everyday language. Generational categories thus function as an interpretive repertoire that enables actors to render structural, multi-layered changes in a coherent and communicatively accessible form.

Third, generational framing can be seen as a coping mechanism in dealing with professional strain and ambivalence. As the results show, veterinarians face increasing demands, including heightened

client expectations, economic pressures and emotional burdens. By embedding these experiences in generational narratives (e.g., critiques of younger colleagues, changing values or shifting work ethics) individual challenges can be reframed as part of broader collective developments. Generational narratives can thus help situate personal experiences of strain within a broader professional-historical context, allowing them to be interpreted less as individual inadequacy and more as expressions of a changing professional environment.

Overall, the findings suggest that generational narratives should not be viewed as precise representations of generational differences or conflicts, but rather as interpretive frameworks linking structural changes, professional identities and moral evaluations and interpretation. These frameworks enable veterinarians to connect changes in human-animal relations, professional authority and working conditions with the question of what constitutes and does it need to be a 'good veterinarian' in the context of evolving societal conditions.

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Section 7.
Animals, ethics and technology

Lines in the sand: moving boundaries in the ethics of genome editing farm animals

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Abstract

Ethical debates on the use of CRISPR in animals have largely proceeded along separate tracks, focusing either on farm animals or on animals in the wild. We bring these discussions together in an empirical ethics study to examine how moral limits around genome editing are drawn, justified, and potentially eroded. Drawing on interview material collected in four citizen focus groups, one focus group consisting of farmers and 17 expert interviews, the article explores a recurring tension: CRISPR in production animals is often framed as a morally continuous extension of selective breeding – since the line has already been crossed, genome editing does not raise moral stakes that are principally new. Its use in wild animals, however, is approached as a more profound transgression, defensible only under conditions of ecological crisis or extinction. This contrast reveals a shifting normative landscape in which the boundaries of human control over animal life are continually redrawn. The article asks what work understandings of 'the line' does in moral reasoning about animals, and argues that appeals to continuity serve to normalize deeper forms of intervention into the lives of production animals and make us lose sight of the radical possibilities inherent in this technology.

Keywords: genome editing, bioethics, production animals, boundaries

Introduction

In 1975, a group of scientists gathered at what has since become known as the Asilomar conference to discuss the recent wave of progress in research on recombinant DNA and discuss and establish guidelines on how to deal with the risks posed by this technology. While there was widespread agreement that the promises of this research meant that it ought to be pursued, many also argued that more should be known before certain lines were crossed (Fredrickson, 1991). In the history of biotechnology governance, the conference was an important milestone, showing the importance of self-regulation in science.

Where to draw the lines, however, is a controversial question, negotiated between scientific possibility and uncertainty, and public and political opinion. This is reflected in debates about genome editing of animals. Broadly, these debates raise three different questions: Is genome editing consistent with good animal welfare and respect for animals? Are there any risks to ecosystems? Will consumers and the public accept these organisms? All of these questions are fundamentally concerned with boundaries. How far can we intervene in an animal's DNA to change their capacities with respect to animal welfare and animal integrity, and with respect to consumer acceptance? How much risk can we tolerate, acknowledging that we cannot abolish it completely? The driving question is where we should draw the line for what kind of interventions we should accept and on what grounds.

In this article, we take this lens as a point of departure for examining the question of genome-edited animals. Ethical debates on the use of CRISPR in animals have largely proceeded along separate tracks, focusing either on farm animals or on wild animals. This article brings these discussions together to examine how moral limits around genome editing are drawn, justified, and potentially eroded. Drawing

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on interview material from an interdisciplinary study on the ethics of genome editing animals, we explore a recurring tension: CRISPR in production animals is often framed as a morally continuous extension of selective breeding – since the line has already been crossed, genome editing does not raise moral stakes that are principally new. Its use in wild animals, however, is approached as a more profound transgression, defensible only under conditions of ecological crisis or extinction. This contrast reveals a shifting normative landscape in which the boundaries of human control over animal life are continually redrawn. We argue that because CRISPR upheaves the boundary between breeding and genetic modification, and a new line is drawn between animals that are bred and not, we lose sight of the radical potential of CRISPR. This helps normalizing deeper forms of intervention into the lives of production animals.

Theoretical approach: empirical ethics

Empirical ethics, as we understand it, is committed to the claim that the empirical is not only relevant because it can point to relevant issues and ground normative claims, but that it is in itself a source of morality (Musschenga, 2005, p. 468). A variety of methodologies have been proposed under the headings of empirical ethics or empirical bioethics. A central methodological question in this field is what it means that the empirical informs normative reflection, and numerous articles have been written on the relationship between facts and values and the is-ought problem (Davies et al., 2015; Ives et al., 2017; McMillan, 2017). However, this is a problem that arises from imposing a methodological standard that is imported from social science and scientific methodology onto the philosophical domain, which does not adhere to the same standards of knowledge production (Diamond, 2021). This set-up imposes a methodological demand that we do not place on other forms of philosophical inquiry. Philosophers routinely draw on literature, examples, and everyday experience without asking how such material is to be 'integrated' into normative analysis.

Our understanding of empirical ethics is informed by Wittgensteinian approaches to ethics (Christensen et al., 2025; Diamond, 1978, 2021; Linder & Grimm, 2023). Broadly described, Wittgensteinian approaches to ethics hold that it cannot be reduced to a set of moral principles, but needs to be anchored in specific contexts, and that moral norms are always articulated and made sense of within forms of life, which provide the background conditions for what counts as a reason, a concern, or a difficulty. Here, the aim is not figuring out how to proceed, but to make clear what should come into play in figuring out how to proceed (Christensen, 2026, p. 96). Furthermore, since context and moral problem are interdependent, the description of the problem and the description of the relevant context go hand in hand (Christensen, 2026, p. 96). On our approach, qualitative research does not supply data to ethical analysis but constitutes part of the very activity of moral clarification.

Applied to empirical ethics, this means that we do not treat empirical material as source of background facts or as evidence that settles normative questions. In interviews and focus groups participants express values, distinctions, comparisons, jokes, hesitations, and perceived difficulties. These discursive elements can be taken up as material for philosophical reflection – we have elsewhere described this as 'things to think with' proceeding from Cora Diamond (Winther, 2022, 2025) – much as philosophy works with concepts, cases, and counterexamples. This means considering the material as something that can orient, disturb, and refine moral reflection. On this view, there is no 'integration' of the empirical and the normative, because describing the moral problem and engaging with it normatively are not separate steps, but aspects of the same process of clarification. While we follow standard social science principles concerned with semi-structured interview guides and interviewing, research ethical principles about anonymization, and rules for transcription, we use the empirical data as things to think with in Diamond's sense. This approach differs from the empirical ethics tradition described above, where the there is a perceived gap between descriptive data and normative data to overcome. The approach we suggest is normative throughout.

Methods: Analysis of qualitative interviews and focus groups

The data presented here was collected from 17 individual interviews with experts from research, NGOs, policy and bureaucracy, in addition to five focus groups, where four consisted of citizens and one of farmers. The interviews were conducted by the first and third author. The participants were selected to reflect a range of relationships to genome-edited animals, either as scientific experts, government representatives, or consumers and citizens, thereby representing a diversity of moral contexts. A semi-structured interview guide was developed for the expert interviews, covering three contexts – genome editing animals on the lab, on the farm, and in the wild. The motivation for including these cases was to be able to compare the different sites and ask how moral stakes differ across them.

Both the interview and the focus group guides consisted of open-ended questions designed to elicit experiences, evaluative perceptions, and moral concerns, and assuming as little as possible about how people construe their experience in order to avoid substituting our own view with that of the person under study (Weinfurt, 2013, p. 51). We adopted an active and dialogical interview style, asking follow-up questions, probing tensions, and occasionally testing formulations to make sure we had understood the participant. The interview was thus approached not as a process of extracting pre-formed views, but as an interaction in which moral sense-making could become more explicit (Brinkmann & Kvale, 2014).

In the focus groups, we had prepared a group activity to get discussion going and with the aim of further comparing and contrasting the farm and the wild contexts. In the first session, participants reflected on what they considered the main issues within farming of animals, and with wild animals, respectively, with every issue being noted on a card. In the second session, we introduced the CRISPR technology and gave examples of how it can be used on animals in production and in the wild, such as increasing efficiency of production, increase weight or alter nutritional content, or create disease resistance, climate adaptation, and re-creating animals that have gone extinct. We asked participants to sort the cards with issues from session one in a yes-pile and a no-pile of what they considered acceptable possibilities for using genome editing, and prompted them to explain why they sorted their cards as they did, opening up for a discussion about arguments and feelings and disagreements.

All interviews were audio recorded and transcribed verbatim. In a first round of coding, themes and morally productive elements of discourse were identified: expressions, images, distinctions, and lines of thought that reveal how participants understand, negotiate and question ethically salient features of their world. A theme that gradually emerged was the frequency of the topic of boundaries or lines in order to delineate acceptable uses from inacceptable uses and to compare, contrast and set limits. This was in part a result of the structure the interviews had, which invited comparison, but also a central feature to how participants reasoned about the morality of using genome editing on animals. This is no surprise: Bioethics has typically focused on establishing moral limits between different types of acts (Scully, 2001, pp. 189–190). As Jackie Lee Scully has argued, the whole field can be thought of as a response to perceptions of boundaries, whether that issue regards cloning, genetic screening or surrogacy (Scully, 2001, p. 190). There are good reasons for the interest in boundaries: After all, biotechnologies have to be regulated in some way, and regulations are concerned with drawing lines between the permissible and the impermissible (Scully, 2001, p. 192). If we can draw the line between right and wrong, we can establish the point in which one becomes the other (Scully, 2001, p. 190). However, Scully points out that in the effort to establish a boundary and identifying the moral reasons of upholding the boundaries, we may ignore other morally salient points, such as which interests and power-dynamic were involved in shaping them. While our interest here is not in establishing how the perceived moral boundaries came to be, we follow Scully in using boundaries as a lens to examine the ethics of genome editing animals. Since boundary settings serve normative functions in determining what kind of intervention should be considered permissible and not, they determine what should be considered morally relevant

distinctions. This means that other relevant moral concerns risk being overlooked. Hence, we established codes concerned with boundary themes – limits; arguments for using genome editing; scepticism and arguments against using genome editing; and comparisons of CRISPR/breeding/genetic modification – and coded the transcripts for metaphors and descriptions connected to boundaries, and arguments and views for and against using genome editing in animals. The aim was not to code for frequency, seeking theoretical saturation or argumentative coherence, but to examine how participants make sense of moral difficulties and the normative role boundary setting played in participants' reasoning about genome editing of animals.

Moving boundaries and new limits

The importance – and difficulty of – establishing boundaries are manifest in remarks from both focus groups and interviews like 'how far do you go?', 'there needs to be a line', 'it's so hard to say where the line goes', and 'where to draw the line, depends on the purpose'.

In the context of livestock farming, CRISPR is often framed as a morally continuous extension of selective breeding. This is pervasive in both academic publishing and science communication (Aboelhassan & Abozaid, 2024; Paraskevopoulos & Federici, 2021; Zhang et al., 2020). It is also difficult to describe CRISPR in a way that does not place the technology within this narrative. We did this ourselves in describing CRISPR as a more efficient and precise technology in our interviews and focus groups discussions. The term 'precision breeding', which is frequently used to describe CRISPR, is explicitly suggesting that CRISPR is a kind of breeding, but better (Winther, 2026). The notion that CRISPR is morally continuous with breeding was also presented by several of our interview participants. A molecular biologist complained about the questioning of the moral stakes of CRISPR as a technology: 'this is not about genetic engineering as such, it is about how we use animals'. Both traditional breeding methods and genetic engineering, they argued, share the same aim: to evolve the genetics of animals so that they better fulfil our needs. What method we use to achieve this, is not the important moral question – what matters, is whether or not the intervention is consistent with good animal welfare. The promise of CRISPR lies in its ability to achieve changes in a more precise and efficient way, hence arguably leading to better welfare.

CRISPR has clearly shifted the moral boundaries of genetic engineering. Before the emergence of CRISPR, the moral boundary of acceptable interventions was placed at transgenetics – the process of introducing foreign DNA into an organism's genome. The morally objectionable act is crossing species boundaries, not genetic intervention as such. Since CRISPR does not rely on crossing species boundaries, it has been suggested that it could be a game-changer in terms of moral and social acceptance (Schultz-Bergin, 2018). As we have shown previously, the fact that CRISPR can sidestep transgenics does not turn it into a game-changer in terms of social acceptance (Winther et al., 2023). However, there's a reluctance about where the line should now be drawn, since it is difficult to pinpoint what distinguishes CRISPR from breeding and since CRISPR seems to offer the opportunity to do what we have already done for centuries with breeding, but in a way that is better for the animals' overall welfare. As a focus group participant pointed out – 'it's so difficult to say where to draw the limits if we start doing all of this' – 'all of this' referring to using such technologies on animals generally. A frequent argument in both interviews and focus groups was that in the case of farm animals, the bar for acceptability is judged in terms of how it can improve animal welfare. (Some participants take this argument further than others. A focus group participant, for instance, suggested that in face of diminishing food resources, genome editing can be used to alter feed needs and preferences in animals and introduce them to new foods – pommes frites was offered as a suggestion – as long as it does not affect their overall health and well-being.) Others point out that whatever alternations we do on farm animals, 'we should always consider who we are doing it for' – it's rarely for the animals themselves.

Its use in wild animals, however, is approached as a more profound transgression, defensible only under conditions of ecological crisis or extinction. Comparing genetic engineering of animals in the wild with farm animals, one of the scientists we talked to, an expert in rewilding, observed that while there are numerous issues to take into consideration concerning genetic engineering of the former, 'with livestock its different – the species is already intentionally inbred'. The use of CRISPR on animals in the wild gave numerous participants pause, although some noted that climate change is happening so fast that we may not have any other choice. While we may think that we are doing this to compensate for the harm we have caused, it was also pointed out that saving endangered animals is 'actually something we do for our sake'. The reluctance of using CRISPR on animals in the wild fall into two categories. One has to do with feasibility, with the fact that the risks are perceived to be higher, that the act itself is described as hybris, that it might not be as easy to balance ecosystem functionality as we think. The other the understanding of genetically engineering animals as a moral wrong: it means creating a 'wild zoo rather than actually having nature', as a researcher put it.

A tendency in our material is that although CRISPR is met with some hesitation and concerns, participants are having a hard time pinpointing how using this technology is any different from traditional breeding methods. While using CRISPR on animals in the wild is seen as a more radical intervention, the same does not go for farm animals, who have long been shaped by deliberate human design anyway. In other words, a new line is drawn between animals that are bred and not, with the consequence that we lose sight of the radical potential of CRISPR. The problem with this is that it helps normalize deeper forms of intervention into the lives of production animals. When such interventions are rendered morally continuous with established practices, they no longer appear as decisions that call for renewed ethical scrutiny, but as incremental improvements within an already accepted framework. What is at stake, then, is not only where the line is drawn, but how appeals to continuity narrow the space for moral reflection. By this we risk foreclosing precisely the kind of ethical attention that novel technologies demand.

Conclusion

When moral boundaries shift, our understanding of moral issues shift along with it. Here, we have shown how the boundaries of moral acceptance of genome editing have been redrawn with the emergence of CRISPR. With the issue of transgenics removed, CRISPR has increasingly been framed as a morally continuous extension of breeding. Then, the morally transgressive act is genome editing of animals in the wild, while genome editing of farm animals is seen as a more efficient and welfare-caring method. This framing, however, conceals other morally salient questions, such as what the intention behind the intervention is, what purpose it achieves, and whether this purpose is expressive of a good and respectful relationship with animals. In this shorter article, we have made this case using a limited excerpt of our interview data, and we acknowledge that this argument must still be fleshed out. We will undertake this task at a later occasion.

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Use of digital media as a decision-making tool for agricultural practices: socio-ecological atlas of Samsun, Türkiye

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Abstract

The Samsun Socio-Ecological Portal (SEPS) Project, funded by UNDP GEF-SGP, is an extensive effort to develop a digital atlas dedicated to Samsun province, the largest city on Türkiye's Black Sea coast. Located between the fertile Kızılırmak and Yeşilırmak river deltas, Samsun benefits from unique geographical and ecological features that support a broad range of agricultural production. This advantageous setting has also fostered a rich historical and cultural legacy, vibrant tourism potential, successful agricultural activities, and diverse industrial sectors. Nevertheless, the province faces complex challenges due to its varied land uses, including urbanization, farming, tourism, and environmental conservation. To navigate these competing interests and manage socio-ecological relationships effectively, the region needs an advanced tool capable of guiding, assessing, and balancing different priorities. One of the portal's primary benefits is its ability to identify Samsun's strengths, unique features, local and global vulnerabilities, threats and challenges within both social and ecological frameworks. The portal acts as an innovative bridge connecting agricultural operations and sensitive ecosystems, illustrating their dynamic interrelations within a broader socio-ecological system. The SEPS stands as a model for informed decision-making and collaborative engagement, drawing on local and global best practices to cultivate positive, sustainable relationships. Additionally, it offers analytical tools and synthesized information to guide policymakers, stakeholders, and individuals in fostering collaboration, and serves as an accessible, data-driven decision-support tool, empowering them to build resilient, equitable, and sustainable food systems. Beyond decision-makers, the portal also functions as a communication and coordination space for cooperatives, producers, local NGOs, and grassroots associations, facilitating dialogue and data-sharing across diverse actor groups. The portal's architecture is grounded in the principles of Systematic Conservation Planning (SCP) and Nature-based Solutions (NbS). It consolidates diverse spatial datasets – land use, biodiversity, water systems, and cultural heritage – into an interactive GIS platform to support evidence-based decision-making. The methodology integrates seasonal ecological dynamics, stakeholder consultations, and participatory mapping tools to visualize competing land uses and socio-ecological intersections. In doing so, the platform not only supports spatial prioritization and risk analysis, but also encourages locally grounded, ecologically coherent interventions that align conservation goals with rural development and climate adaptation strategies.

Keywords: nature-based solutions, northern Anatolian black sea landscape, participatory mapping, socio-ecological resilience, systematic conservation planning

Introduction: Samsun

The Samsun Socio-Ecological Portal Project, funded by UNDP GEF-SGP, is an effort to develop a digital atlas dedicated to Samsun, the largest city on Türkiye's Black Sea coast. Samsun benefits from unique geographical and ecological features those highly support diverse agricultural production. Within the provincial borders are the Kızılırmak (21,700 km^2) and Yeşilırmak Deltas (34,340 km^2), which form the important agricultural areas of Bafra and Çarşamba Plains. While agriculture is the

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leading sector shaping the province's economy, services, industry, husbandry, and tourism are also significant (UNDP, Türkiye, 2022).

Samsun Province covers a total area of 9,512 km² with 46% agricultural land, 40.5% forest and shrubland, and 1.7% pastures and meadow. Non-agricultural land accounts for about 11.8%. The settled area is 37,43 km² (1/100.000 Master Plan). With its history, cultural values, rich water and plant resources, and its location as a major port city, Samsun holds high potential in agriculture, tourism, and industry. (Orta Karadeniz Kalkınma Ajansı, 2019; T.C. Samsun Valiliği, 2024)

Samsun's population is 1,392,403 (2025), with women in the majority and a significant portion over 65 (Turkish Statistical Institute, 2026). Despite its strengths, the province faces challenges from competing land uses, urbanization, agriculture, tourism, and conservation – necessitating integrated tools to manage socio-ecological dynamics effectively.

This setting has also fostered a rich historical and cultural legacy, nevertheless, the province faces complex challenges due to its varied land uses, including urbanization, farming, tourism, and environmental conservation. To navigate these competing interests and manage socio-ecological interaction effectively, and to build resilience the region needs an advanced tool capable of guiding, assessing, and balancing different priorities.

Scope of agricultural products, services, and capabilities

Samsun, a major port city on Türkiye's Black Sea coast, is distinguished by the fertile Bafra and Çarşamba Plains, formed by the Kızılırmak and Yeşilırmak river deltas. Agriculture is the backbone of the province's economy with its share and by products. Samsun has three seaports one being in the centre. A sizeable portion of Samsun's exports are conducted through these ports, of which milling products, wheat flour, and fish products account for 26% of exports. The most grown crops in Samsun province are wheat, corn, rice, sunflower, tobacco, soybean, legumes, hazelnuts, and sugar beet. Agricultural land, total area being 4,373.6 km², consists of 3,784.7 km² (87%) actively cultivated land; of which, 59% is designated for field crops, 33% for fruit production, 4% for vegetables, and the remaining are left fallow (Samsun Chamber of Commerce and Industry, 2024; T.C. Samsun Valiliği, 2024; UNDP, 2022).

The sectoral distribution of gross domestic product in Samsun for 2017, agriculture accounts for 12.45%, industry for 24.22%, and services for 63.33%. In Türkiye, this distribution is 6.87% for agriculture, 32.91% for industry, and 60.23% for services. In Samsun, the share of agriculture is decreasing, while the share of industry is trending upward. In terms of production volume, Samsun ranks second in Türkiye for rice production, fourth for soybean production, sixth for tobacco production, and eleventh for sunflower production. Hazelnuts account for 97% of the total fruit-growing area. Samsun is the second largest



Figure 1. (A) Kızılırmak landscape, (B) Kızılırmak delta, (C) Yeşilırmak, wild horses

hazelnut-producing province in Türkiye and world leader in hazelnut production and trade, conducting approximately 70% of global hazelnut production and exports single-handedly. As of 2018, Samsun ranks sixteenth among provinces in terms of the ratio of agricultural sector GDP, close to share of 2% (Orta Karadeniz Kalkınma Ajansı, 2019; Turkish Statistical Institute, 2021; T.C. Samsun Valiliği, 2024).

Samsun is also an important province in terms of livestock farming. There are districts and enterprises that specialize, particularly in cattle breeding. Samsun ranks first in Türkiye for its buffalo population and leads by holding a 12.1% national share with 20,000 head of livestock. Since pasture and meadow areas are abundant along the coastal belt and on highlands of Samsun, most of the cattle in the province are found in these two regions. Fishing, both through harvesting and aquaculture, is significant in Samsun province. In 2020, approximately 50,000 tonnes of wild-caught fish and 16,000 tonnes of cultured fish production were recorded. The most produced fish species are rainbow trout, sea bass, and carp. Trout farming is conducted in the facilities established in the districts of Samsun, with a total capacity of 6,886 t/yr, and recently "Turkish Salmon" has notably increased as a fish production in the province. The marine production of sea bass and Turkish salmon are farmed out by 12 enterprises, which have a total capacity of 14,194 t/yr. (Orta Karadeniz Kalkınma Ajansı, 2016; UNDP, 2022; T.C. Samsun Valiliği, 2024).

Diverse land uses and competing interests: balancing farming and conservation, predictable encounters, and fundamental thresholds

The portal helps pinpoint Samsun's strengths, distinct features, vulnerabilities, and challenges in social and ecological contexts. By mapping boundaries, it supports the protection and sustainable use of natural resources, with a focus on agriculture. Serving as a bridge between farming and ecosystems, the portal shows their interactions in a socio-ecological system. It offers tools and information for policymakers and stakeholders to promote cooperation between agriculture and conservation. The inclusion of seasonal dynamics, traditional production practices, and stakeholder-verified spatial data further enhances the platform's capacity to illuminate context-specific land-use conflicts.

The main competing interests took place where the activities come closer physically or administratively defined by borders, ownership, and production types. That is where and when their use of land and resources intersect as regards to create a certain benefit out of a specific activity, such as harvesting, production, sales etc. Physical intersection of two natural medium, water and land, designated territories such as agriculture vs protected lands, or any social activity which dwells on and uses natural services such as soil, water, minerals, trees, land-cover might produce a competing interest either with live and ecological systems or with another activity relating to human interests and health. The portal visualizes these thresholds -administrative, biophysical, and perceptual- and invites dialogues through participatory layers and user feedback options that contextualize data with lived experience.



Figure 2. (A) Kızılırmak and water buffalos; (B) Anatolian Orchids – Orchis anatolica; (B) Medicinal and aromatic plants

In the case of Samsun several major intersections and competing interests regarding diverse land-uses and production types can be listed. Usually, these areas function as meeting points of interests where balance must be guarded between different uses and activities. E.g. the coastline, sea vs land, lakeshores, lakes/water bodies vs protected areas, transition areas from one use to another pasture vs forests, meadows vs deltas, highly consumptive uses such as settlements, services, industry which not only invade natural land but also create polluting uses and emissions beyond their existence. All these competing diverse uses could be balanced out according to each user's need, how much risk and damage they create over other entities, or depending on the carrying capacity of the media to able a sustainable and harmless continuity of its existence and this mutual relationship. In doing so, the project employs NbS (nature-based solutions) and SCP (systematic conservation planning) principles to mediate these trade-offs, relying on both quantitative GIS analysis and qualitative stakeholder input gathered through interviews, meetings, and field visits.

Therefore, Samsun Portal aims to clarify and point out specific intersection areas and uses providing complementary information and inventory for the use of decision makers to balance out conflicting interests. These actions, while protecting and guiding farmers, will implement the protection of the environmental rights and legislation, and the rights of natural entities through protective measures as well. Within the wide range of this study and many conflicting interests, this paper focuses on the cross-section of the agricultural uses vs protected areas. In this context Kızılırmak delta-pasture vs water-buffalo breeding, Nebiyan meadows and cattle raising, Ladik lake and extensive use of water by agriculture, Terme stream and wetland areas and excessive flooding of agricultural lands are some of the selected examples where socio-ecological interactions are examined which create tense oppression on each other. These cases are validated through geospatial data processing, seasonal observation, and consultation with actors such as farmers, municipal officers, and local researchers – offering a replicable model of digital environmental conflict assessment in multi-functional landscapes.

Interrelations and interactions within the socio-ecological intersections: from the perspective of socio-ecological production landscapes and seascapes – SEPLS

This paper presents the portal's findings, highlighting the interactions between farming activities and vulnerable ecosystems in socio-ecological contexts. It demonstrates how the portal serves as an accessible, data-driven decision-support tool, empowering decision-makers, and stakeholders to build resilient, equitable, and sustainable food systems. The Samsun Socio-Ecological Portal stands as a model for informed decision-making and collaborative engagement, drawing on local and global best practices to cultivate positive, sustainable relationships between agricultural and ecological systems.

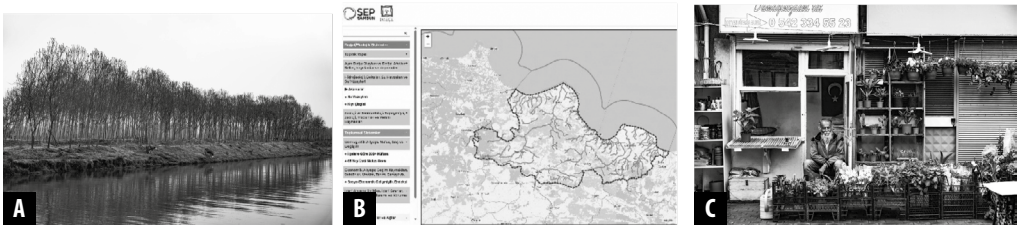


Figure 3. (A) A conventional rural landscape of Samsun; (B) The Portal: Samsun Map – Rivers; (C) A florist from Samsun streets

Using the SEPLS (Socio-Ecological Production Landscapes and Seascapes) framework, this study explores the co-evolution of agriculture and ecosystem services in Samsun's Kızılırmak and Yeşilırmak deltas, where traditional livelihoods like rice cultivation and buffalo grazing coexist with high biodiversity protected areas. Increasing land-use pressures threaten these dynamics, underscoring the need for integrated landscape governance (Orta Karadeniz Kalkınma Ajansı, 2019; T.C. Samsun Valiliği, 2024; UNDP, 2022; UNU-IAS, 2025). The SEP-Samsun visualizes these interactions through GIS-based tools, allowing users to identify spatial overlaps of vulnerability and resilience. Grounded in SEPLS principles, the portal functions as a nature-based solution (NbS), enhancing participatory environmental governance while strengthening agroecological resilience (Bélair et al., 2010; Ichikawa et al., 2012).

The socio-ecological portal of Samsun (SEP-Samsun): content, method, user guide

The SEPS Portal was developed as an open-access, GIS-powered platform to support systematic conservation planning (SCP) framework in Samsun. It consolidates diverse spatial datasets on biodiversity, land use, water systems, and socio-cultural values, and offers visualization and scenario tools to explore ecological trade-offs and co-benefits (Margules & Pressey, 2000). Designed for both policymakers and local users, the portal enables data-driven decisions aligned with nature-based solutions and ecosystem-based adaptation strategies (Bélair et al., 2010). With participatory mapping and modular infrastructure, the portal also aims to strength stakeholder collaboration and adaptive environmental governance.

Outlook: advancing digital tools for resilient socio-ecological system management

Digital tools enhance agricultural resilience by optimizing resource use, mitigating risks from climate change, and increasing productivity through data-driven decisions. Digital and data technologies have the potential to help farmers work more precisely, efficiently, and sustainably. Data-driven insights, management of data according to certain purposes, e.g. agriculture and/or conservation, at the same time can improve decision-making and practices and help increase environmental performance while making the job more attractive to younger generations. These tools are also referred to as Decision Support Systems (DSS), computer-based tools that can integrate data from sensors, satellites, and climate models, and provide actionable insights for farmers, enhancing agricultural resilience (EU-Factsheet, 2023; Sargani et al. 2025).

On the other hand, maintaining resilience in SEPLS is crucial for securing ecosystem services and sustainable production systems for the long term, which will benefit local communities and contribute to global sustainable development objectives (UNU-IAS, 2025).

In the case of SEP-Samsun, the advancement of the program in future towards establishing a multi layered model, a platform for sharing data, awareness and adaptation become important not only for the management of socio-ecological data and production vs conservation planning, but also to facilitate sharing ideas, exchanging needed products, and stimulate circular economy among farmers. Advanced digital platforms can be highly upgraded by development of a verified-subscribed membership system, of which designing a modern information management system equipped with RBAC (Role-Based Access Control), admin panel, verification standards, forum, and messaging modules. In future advanced portal systems also will enable users to add their own data sets and perform operations on them, thus encouraging data production from local to global. In addition, including women, youth, and NGOs in the process and using a citizen science approach will motivate and activate affiliation to society. This approach will address data gaps in the region and expend field research and data generation into a wider area of interest.

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Harm-benefit analysis beyond human medical research

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Abstract

The ethical debate on animal experimentation has traditionally focused on human medical research, leaving non-medical contexts (such as veterinary, agricultural, and fundamental biological studies) underexplored.

This paper argues for broadening the harm-benefit framework beyond anthropocentric medical paradigms toward a moderately anthropocentric utilitarian approach, which recognizes animals' intrinsic value while weighing cross-species costs and benefits. Such a shift exposes paradoxes: research that enhances our understanding of animal sentience and welfare often increases the severity score of experiments, and pushes the boundaries of what is considered an 'animal experiment' under EU Directive 2010/63, thereby increasing reported numbers.

Because these shifts are purely 'administrative', they obscure our view on the changing reality of animal experimentation. Moreover, and more cynically, fundamental zoological research can appear as a 'lose-lose' scenario when assessed through conventional harm-benefit metrics, as it yields no immediate human benefit and possibly constrains future practices that do benefit humans.

To resolve these tensions, we propose to adopt Koen Kramer's positive-sum principle: evaluating research outcomes across all stakeholders, including animals, humans, and ecosystems, to ensure net ethical gains, but also across research lines and types. This perspective reframes non-medical animal research not as an ethical liability but as a driver of improved welfare standards and long-term reductions in harm.

Keywords: laboratory animals, reduction, animal welfare

Introduction

Research using animals is a long-standing practice, dating back to the classic Greek times. An exhaustive overview of the history of the practice is not within the scope of this paper, but can be found in Franco (2013). The use of animals for human purposes almost always implies a difference between the (moral) value of a human and an animal. Historically, this distinction was sometimes very strict. This wasn't limited to religious arguments, such as the presence of a soul in humans and its absence in animals. Based on the ideas of René Descartes, for example, the animal was positioned as a kind of 'biological machine': an object without consciousness or a sense of pain. When an animal has no intrinsic value, but only a functional value, this means that they are not ethically relevant, and thus that animals can be used by humans, just like plants and raw materials. Ethics in such a context is purely anthropocentric, in the sense that it only considers actions by humans and their consequences for humans, directly or indirectly.

Since those times more and more evidence has been found that a hard (biological) distinction between humans and animals is untenable. It is unnecessary to summarize the entire marginal cases argument here, but the central observation is that there are no qualities all humans possess, and no animals do (or vice versa). This certainly applies to morally relevant qualities such as Singer (1975) – and others such as Bentham (1781) long before that – sees in the capacity to feel pain and to suffer. If we want to be

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intellectually consistent, this realization means that we can no longer persist in the impenetrable wall of moral relevance that we have built around humanity. We do not yet go as far as Tom Regan, who stated in The Case for Animal Rights (1985, p. 24): 'Lab animals are not our tasters; we are not their kings. [...] This is just as true when they are used in trivial, duplicative, unnecessary, or unwise research as it is when they are used in studies that hold out real promise for human benefits.', but animal testing is high on the agenda: up to 82% of people are against animal testing, even though 97% of them still consume animal products (Heyndrickx and Aerts, 2022). Increasing the (moral) importance of animals, but still allowing them to be used for human purposes, seems only possible in a moderately anthropocentric framework, in which humans no longer have the sole claim to moral relevance.

The ethical debate and legislative work on animal experimentation has traditionally focused on human medical research. This can be seen in the way the legislation is formulated, but it is telling that for example, Kramer (2024) in his advisory report for the Dutch Association for Bioethics, titled '*Ethical Issues and Choices in Animal-Free Innovation: From the Win-Win Frame to a Positive-Sum Game*' (Ethische kwesties en keuzes in proefdiervrije innovatie. Van het win-win frame naar een *positive sum* game) explicitly limits his analysis to medical research. This has left the ethical (and legal) analysis of research in non-medical contexts (such as veterinary, agricultural, and fundamental biological studies) underexplored, but has also – presumably unknowingly – made it more difficult for the non-medical research community to apply all the legal constraints of animal research. For example, working with animals that are not bred for research, that are housed in commercial contexts, or with wild animals, are all situations that regularly need exceptions under the current legislation. Although (better) solutions for the latter need to be developed, the current paper focusses on the relevance of non-medical animal research on what is considered animal research, and how it is to be evaluated. In that sense, it is a direct answer to Kramer's appeal to apply and test his hypothesis beyond medical research.

Harm-benefit analysis in animal research

In the European Union research using animals is regulated by EU Directive 2010/63. A full analysis of this Directive is beyond the boundaries of this paper, but it is important to note that it directly states 'Animals have an intrinsic value which must be respected' (pre-amble, §12), and it places great importance on the use of harm-benefit analysis (or HBA) (see Art. 38, §2.d): 'a harm-benefit analysis of the project [shall be performed], to assess whether the harm to the animals in terms of suffering, pain and distress is justified by the expected outcome taking into account ethical considerations, and may ultimately benefit human beings, animals or the environment'. Two elements are particularly important here for the analysis in this paper: not only the research animals' pain needs to be considered, but also their (possible) suffering and distress, and the benefits need not be on the side of humans, but can also be found in animals, or the environment. We shall return to those later.

In Art. 38 §2.d of the Directive, the harm-benefit analysis is directly connected to ethical considerations, although these are not further elaborated. Similarly, in the pre-amble of the Directive, ethical considerations are often cited as important reasons for the legislation, and choices therein, but it is never clearly identified which considerations (or even which type of ethics) are referred to. It seems, however, that not many ethical frameworks are fit to function within the context set forth by the legislation. If (potential) harms and (potential) benefits need to be weighted against each other in order to evaluate whether a certain activity (here: research project) is acceptable, it seems that ethical framework would need to be consequentialist, if not even utilitarian.

The position of the HBA as utilitarian, and even as a moral activity, has recently been called into question by Müller and Katz (2026). Their conclusion is grounded on three elements: that HBA ignores opportunity costs, that there is no coherent aggregation rule, and that HBA is not about moral goodness

(but about legal permissibility). Without going into a detailed discussion about these claims, it seems that the authors have impractically high expectations of HBA (or any 'real' utilitarian evaluation) if they want it to compare the suggested course of action to all other possible actions (even outside of direct research alternatives). They also seem to reduce all that is legislated to the legal realm, even if there are moral choices made. Both these claims are therefore – at this point – unconvincing. However, they are right to point out that there is no coherent aggregation rule in HBA, and that much leniency is given to speculation about positive future effects of research. Unfortunately, their discussion about how much leniency is given to speculation about possible negative effects seems speculative itself. So, there are indeed issues in how HBA is applied in practice, but the case for it to not be utilitarian *at all* seems rather weak. For now, we operate under the assumption that the harm-benefit framework is an example of a moderately anthropocentric utilitarian approach in which animals have more than purely functional value, and (potential) harms and benefits are weighted across species boundaries.

Shifting boundaries

The attentive reader may have already noticed the absence of the term 'laboratory animals' in this paper. That is a deliberate choice, as it does not do justice to the vast differences present within animal research, and it is emblematic of the incorrect equation of animal research with what could be called (human) medical research (including toxicology etc.). In discussions about animal research, one often encounters references to 'painful procedures' as a reason why animal experiments should be banned. That too may find its origin in images of animal research such as it was practiced decades ago, with mice, rats and rabbits used in toxicology research, LD50 tests, etc. Those were undoubtedly painful procedures (many of which have been phased out in Europe, or have been drastically reduced), but they are not representative of animal research in general.

EU Directive 2010/63 states that it applies to 'any use, invasive or non-invasive, of an animal for experimental or other scientific purposes' (Art.3.1), that causes 'pain, suffering, distress or lasting harm' (ibid.). In the following paragraphs we will show that the combination of these elements leads to what may seem paradoxical at first: a slower reduction of the number of animals used in experiments, and a slower reduction in research severity (of not an increase).

Over the last decades we have become more aware of the capacities of animals in the broadest sense of the word. Where in the 1970's and 1980's the capacity to feel pain may have been presumed to be present in 'all animals with a central nervous system' or 'mammals, and maybe birds', and in 2010 books were being published to answer the question 'Do fish feel pain?' (Braithwaite, 2010), there are now credible indications that such capacities are not limited to vertebrates (see e.g. Crump et al., 2022). Even if we were to reduce what is considered an animal experiment under the Directive to painful procedures, that would imply that many more research project would be subjected to overview, and be reported in the annual statistics. In specific circumstances, this could mean that research that is (or has been) performed outside of the Directive's scope leads to results that indicate that the scope should be broadened. At least, it indicates that what would now be considered research under the Directive would not always have been. This is a first instance of non-medical research impacting how we view research with animals.

Of course, this type of fundamental biological research yields more than information on pain perception. It has also led us to understand that animals are capable of much more than previously thought. Not only can animals experience (physical) pain, but many of them (the delineation of the group is difficult) have mental capacities that earlier would have been deemed 'uniquely human'. Hence the inclusion of suffering and distress in the Directive, but also the decoupling of these concepts from physical harm. Non-invasive research is indeed no longer necessarily considered unproblematic. Anecdotally, one still encounters people who incorrectly equate non-invasiveness with 'exempt from the Directive', but this

is clearly an outdated perspective. Again, animal research beyond the typical human-medical related research leads us to include many more types of research under the legal term of 'animal research'.

Expanding on the line of reasoning: it seems that research aimed at investigating animal capacities and welfare is (or should be) the reason why the number of severe animal experiments is only slowly decreasing (or not decreasing at all). This is certainly apparent in the author's country of origin. No published research supports this claim at this point (so, research in this field is certainly welcome and needed), but anecdotal evidence supports the following reasoning: at a first glance, one would expect experimental severity to decrease with increased knowledge of the impacts of research on animals. Indeed, analgesia, humane endpoints, etc. all become more relevant with increase knowledge of stress, pain and suffering in animals. Reality on the other hand, seems different: in many countries, there is no clear decrease of severity (own unpublished data). On second thought, this need not even be a problem. If one does not recognize – or chooses not to acknowledge – that animals are capable of experiencing suffering, stress, and related states, there is little basis for classifying any experimental procedure as 'severe'. However, as scientific knowledge about animals continues to expand there is increasing justification for assigning procedures to higher severity categories. Procedures that would have been considered to cause only mild discomfort ten or twenty years ago are now, appropriately, more often classified as involving moderate or severe suffering. Consequently, advances in animal research itself constitute a key driving force behind the relatively high proportion of experiments categorized as severe, as observed in regions such as Flanders and Belgium (see e.g. Departement Omgeving, 2025). For this reason, one should be sceptical when encountering statistics that report only a small number of procedures as severe.

Consequences of these shifts

All the above results in the paradoxical situation that research that enhances our understanding of animal sentience and welfare often – and appropriately – increases the severity score assigned to experiments, and pushes the boundaries of what is considered an 'animal experiment' under EU Directive 2010/63, thereby increasing reported numbers. These shifts are purely 'administrative' in the sense that real changes (reduction and refinement in experiments that should lead to lower numbers and less suffering) are offset by higher severity scores and additional reporting of animals (without changes in procedures). So, a clearer view of the reality of animal research appears to obscure our view on the changing realities of that research.

At this point, one would almost conclude that fundamental zoological research leads to a lose-lose situation: it seems it leads us to see harms were we did not see those before – of course this does not mean they were not present – , but it may even lead to disadvantages for humans as it may lead to difficulties to pursue certain research avenues (i.e. a 'loss' for humans). A classic HBA, restricted to the legal interpretation, may lead to the unwanted conclusion that we should not investigate which how research can harm animals so that we are not compelled to include that in our HBA (i.e. a 'loss' for animals).

To resolve these tensions, Koen Kramer's *positive-sum principle* can be adopted. A broader interpretation of the analysis and evaluation of harms and benefits than the legal way it is currently applied in project evaluations may give more weight and importance to basic zoological research, and may ultimately lead to more benefits (or less harms) for humans and animals. This means that we should aim to evaluate, and aggregate research outcomes across all stakeholders, including animals, humans, and ecosystems, across time, and across research lines and types. This perspective reframes non-medical animal research not as an ethical liability but as a driver of improved welfare standards and long-term reductions in harm.

Conclusion

Summarizing all this, we can say that there is a significant body of research that exists beyond the research that is related to human health. Applying a 'classic' harm-benefit analysis in that type of projects is even more difficult, but basic zoological and animal welfare research also creates knowledge that feeds back into the HBA of all types of research. Kramer's *positive-sum principle* can be used to avoid that such knowledge leads to unwanted effects (e.g. discouraging such research as it makes other research more difficult). Under that principle, research outcomes are aggregated across all stakeholders, across time, and across research types. This perspective transforms non-medical animal research from an ethical liability (in the purely anthropocentric sense) to a driver of improved animal welfare.

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A narrative review of scientific literature on the ethics of animal breeding

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Abstract

Animal breeding is facing criticism from society regarding (supposed) intent and techniques. Hence, we conducted a narrative review to explore scientific literature that addressed both animal breeding and ethics. An initial literature search resulted in 133 potentially relevant papers published between 1990 and early 2025. A further screening indicated that 73 of those addressed the ethics of animal breeding in more detail. The results indicate that the overall combined message of the publications can be broadly captured as "Involve stakeholders in developing long-term balanced breeding goals that benefit the animals and monitor selection consequences". This message includes five major aspects (in reverse order – from specific to broad): 1) monitor selection consequences, 2) benefit the animals, 3) long-term balanced breeding goals, 4) stakeholders, 5) involvement. Each of these aspects is discussed in more detail based on the selected publications. In summary, it appears that there is a clear plea in literature for improved dialogue and involvement of stakeholders (both from inside and outside the production chain) in the development and analysis of breeding goals and breeding outcomes.

Keywords: animal welfare, breeding goal, selection consequences

Introduction

Over the years, livestock production has faced increasing criticism from society, and animal breeding is no exception. The goal of animal breeding is simple; genetically improve future generations of an animal population according to a breeding goal. However, what can be considered as 'improvement', and thus should be part of a breeding goal, may differ depending on one's view (e.g., higher production levels, better able to cope with challenges) and ethical framework.

The objective of this narrative review was to catalog what animal breeding says about ethics, and vice versa. A distinction was made between animal breeding (the application of genetic selection), animal breeding technologies (e.g., genetic modification (GM), gene editing (GE), artificial insemination, genomics), and animal breeding practices (e.g., housing and management conditions concerning breeding stock). Although the focus here lies on animal breeding in the genetic selection sense, the associated technologies and practices cannot be ignored as they are an integral part of animal breeding. For the purpose of delineation and completeness, the associated technologies and practices will be acknowledged but not discussed in detail.

Material and methods

A literature search was performed in Scopus to obtain a publication database that discusses the ethics of animal breeding. The search was based on titles, keywords, and abstracts, and the search term consisted of three components:

1. **The animal part**: to capture publications on livestock species common in animal breeding programs, or those that are not species specific. Search terms: animal* OR livestock OR cattle OR cow* OR

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(pig* AND NOT pigmen*) OR pork OR swine OR sheep OR goat* OR poultry OR chick* OR turkey* OR broiler* OR layer* OR hen* OR rabbit* OR insect* OR fish OR aquacultur*.
2. **The breeding part**: to capture publications with a focus on animal breeding. Search terms: breed* OR (genetic* AND select*).
3. **The ethics part**: to capture publications that specifically mention ethics or morality. Search terms: ethic* OR moral*.

The literature search was limited to studies published from 1990 to the beginning of 2025. In total, our search resulted in 1,563 publications, based on combined searches for cattle (conducted on 9 December 2022), pigs (15 December 2022), poultry (15 December 2022), animals in general (27 February 2023), and an additional search to include newly published material (28 January 2025). Publication titles were scanned for their relevance for ethics in animal breeding. Publications were excluded if the title did not mention the animal or breeding part of the search term. Moreover, full books (not chapters) were excluded. All remaining abstracts were checked for their relevance and were excluded if there was no breeding focus or ethics were only mentioned as being relevant but were not an integral aspect of the publication. The main texts of the remaining publications (n = 132) were further examined and publications were excluded if 1) the full-source text was inaccessible or non-English, 2) publications only mentioned ethics in the abstract or the discussion (without further elaboration), 3) focused on animal breeding technologies or practices, or 4) did not focus on livestock. After the full-text screening, 73 publications were deemed relevant to catalog what animal breeding says about ethics, and vice versa, in the scientific literature. The publications were divided among three assessors to extract the main message of the publication regarding ethics and animal breeding. Each publication was assessed by at least two people, who discussed among each other to form one unanimous main message. All the resulting main messages were then brought together in one overall key message from the scientific literature.

Results

The overall key message, a combination of the main messages in the 73 publications, read as follows: "Involve stakeholders in developing long-term balanced breeding goals that benefit the animals, and monitor selection consequences". The bolded key terms in this one-liner provided the scaffold for structuring this narrative review. To maintain a clear narrative flow, the key terms are elaborated on below, in reverse order, and some key quotes will be used to express and cover the general essence of the publications.

Monitor selection consequences

A key topic in the papers concerned selection consequences. Selection for production traits (e.g., animal products, feed efficiency, number of offspring) has resulted in unforeseen consequences that affect the health and welfare of the animals (Rauw et al., 1998). It is often these unforeseen consequences that cause issues within livestock production and are the subject of societal criticism. In general, "*the dangers of overselection for a single trait have been well documented and publicized*" (Jones & Hocking, 1999, p. 344) and, in hindsight, animal breeders acknowledge the unforeseen consequences.

The unintended correlated responses in other traits than the traits selected for were often small yet cumulative and became apparent after a certain threshold had been reached. It is this slow emergence of undesired side effects that stresses the need for monitoring unforeseen consequences. For example, Fisher & Mellor (2008, p. 102) include monitoring of consequences as a key value in guiding the genetic improvement of dairy cattle, stating that "*the consequences of trait selection should be monitored, and any resultant harm minimised or avoided*". In the case of unintended, negative consequences for animals, genetic selection to reverse this may be considered desirable: "[..] *de-breeding bad side-effects of our*

previous breeding choices appears to be morally acceptable or even required" (Bovenkerk et al., 2024, p. 418). Breeding consequences are also – or perhaps even more – relevant in the context of GE, where side effects may appear more directly: "*if such unanticipated consequences can and do occur with traditional breeding, where one of necessity proceeds slowly, how much more so does the danger of unanticipated consequences loom when one is creating transgenic animals?*" (Rollin, 1996, p. 538).

Benefit the animal

A second aspect of the overall message is 'benefit the animal'. Several authors highlight that breeding – whether it be traditional selective breeding or GM – should improve the welfare of the animals (Louis-Maerten, 2023; Sandøe et al., 1996; Shriver & McConnachie, 2018). For example, Sandøe et al. (1996) argue that the limits of domestication should be drawn with the goal of optimizing the welfare of domestic animals. However, a singular focus on welfare may be considered incomplete. For example, "*Breeding pigs without tails, without biting impulses or pigs that are happy despite poor living conditions may also raise moral concerns, both from the viewpoint of welfare and from arguments beyond welfare, such as instrumentalisation, objectification, violation of integrity, and de-animalisation*" (Bovenkerk et al., 2024, p. 393). While animal welfare is an important aspect in ethical considerations, it is not all-encompassing and may result in other important ethical viewpoints being overlooked.

The reference made by Bovenkerk et al. (2024) to poor living conditions highlights a further consideration that is emphasized in the scientific literature. Sandøe et al. (1996, p. 121) state that "*selective breeding and other methods of changing animals should be considered as a tool to improve animal welfare alongside changes in management and housing systems*". In other words, selective breeding does not remove the need to (simultaneously) improve housing conditions. Changing animals to improve welfare in suboptimal environments may violate animals' integrity (D'Eath et al. 2010).

An example of a trait to select for that can benefit the animal, mentioned by several authors, is robustness. As stated by Star et al. (2008, p. 109), "*improving robustness by selective breeding will increase (or restore) the ability of animals to interact successfully with the environment and thereby to make them more able to adapt to an appropriate husbandry system*". Breeding for increased robustness of animals is furthermore in line with telos according to Kramer & Meijboom (2021, p. 16), under the condition that "*their increased robustness does not diminish their urge or ability to engage in good activities*" (in which the term 'good activities' refers to – roughly speaking – behaviours that are favourable to the animal).

Balanced breeding goal

The third aspect of the overall message is 'long-term balanced breeding goals'. Animal breeding is largely economically motivated (Gamborg & Sandøe, 2003), and *"[..] breeding optimization has to a very large extent been based on market economy*" (Olesen et al., 2000, p. 576). Indeed, breeding goal traits are often weighed using economic values (i.e., change in profit per unit of change in the trait of interest) or derived from profit equations, bio-economic models, or desired gains. However, several authors note that breeding goals should be broadened to include non-economic and societally relevant traits and be balanced to place more emphasis on these traits (D'Eath et al., 2010; Hristov et al., 2019; Kramer & Meijboom, 2022; Nielsen et al., 2011; Olesen et al., 2000; Rauw & Gomez-Raya, 2015).

Also from an ethical point of view (see Coles et al. (2015) and Kramer & Meijboom (2022)), breeding goal traits weighed with primarily economic values in mind could be perceived as an instrumentalization, seeing the animal as a means to an end. Including societal values alongside economical values "*[...] would arguably mean that the animals would be represented as more than means to human ends*" (Kramer & Meijboom, 2022, p. 607).

Broadening breeding goals with societally relevant traits would require including societal values alongside economic values, as these traits might not necessarily have a direct economic value (Nielsen et al., 2011; Olesen et al., 2000). In practice, societally relevant traits, such as health and welfare traits, are already included in breeding goals of pigs, poultry and cattle (Neeteson-van Nieuwenhoven & Hardiman, 2010). The included traits are often "win-win traits" (D'Eath et al., 2010) that benefit both economics and welfare. However, for many cases broadening the breeding goal results in less genetic progress per trait, including production traits. Consequently, societal traits may have negative economic values as progress on production traits is slower. This poses a (technical) challenge for animal breeders, regarding how to 'measure' and 'weigh' societally relevant traits (Neeteson-van Nieuwenhoven & Hardiman, 2010; Nielsen et al., 2011) to select animals and monitor progress. Nonetheless, there is potential in making selection choices based on longer-term values over short-term economic values: "*[..] if the trait values are chosen for strategic, long-term reasons, such genetic changes turn out to be more beneficial in the longer term.*" (Olesen et al., 2000, p. 579).

Stakeholders

The fourth aspect of the overall message is 'stakeholders'. Animal breeders are but one part of the livestock food system, with other stakeholders including the animals, farmers, veterinarians, slaughterhouses, food distributors, consumers and citizens, and scientists. Each of these stakeholders either directly or indirectly shaped - and continues to shape - the breeding goal set by animal breeders.

Public concern for animal welfare has increased, in part due to campaigns from non-governmental organisations (NGOs) to increase awareness on practices and issues within the livestock food system (Tixier-Boichard, 2020). There are differences between stakeholders in understanding of practices in animal breeding and attitudes towards animal breeding. The acceptability of animal breeding and associated technologies (e.g., genomics and GM) appears to depend on the moral status assigned to the animals, the intention behind selection, and the perceived outcomes and consequences of selection and the applied technologies (Coles et al., 2015; Naab et al., 2021; Shriver & McConnachie, 2018). For example, in Naab et al. (2021), consumers and citizens were reported to be more accepting if the intention behind selection was beneficial to the health and welfare of the animal or the environment, rather than intending "disenhancement" of the animals to better able to cope with existing husbandry conditions (e.g., "senseless emotionless machines" (D'Eath et al., 2010; Rauw & Gomez-Raya, 2015)). Even though selection for robustness (Star et al., 2008) is similar in concept and may target similar traits, there is a difference in the inferred intention behind selection and the perceived outcome and consequences for the animal.

Involve

The last aspect of the overall key message is 'involve', highlighting the relevance of communication and interaction with stakeholders, phrased by Neeteson-van Nieuwenhoven et al. (2006, p. 289) as: "*Careful and continuing dialogue with society will be necessary if dilemmas involved in balancing the various objectives of breeding are to be resolved.*". Besides the general term 'communication', several terms and methods are mentioned in the assessed publications, including participatory approaches, interaction with the general public, dialogues, expressions of concerns, debates, being transparent, and discussions. In such involvement, it is important to discuss and agree on a clear common language, to ensure all participants can engage on the same 'wavelength'.

Conclusion

This narrative review highlighted several key messages regarding the ethical aspects of animal breeding. Overall, stakeholder's acceptance of animal breeding and associated technologies (e.g., genomics and GM) appears to depend on the moral status assigned to the animals, the intention behind selection, and the perceived outcomes and consequences of selection. There is a large emphasis on animal welfare in the included studies. There are opportunities to improve animal welfare through animal breeding, which may be ethically and societally acceptable, if housing and management improve simultaneously and animal integrity is not harmed. Some authors emphasized the importance of monitoring selection outcomes and consequences to prevent - or correct existing - negative impacts on the animals. It appears that ethically and societally acceptable animal breeding requires long-term balanced breeding goals that include the various (moral, economic and technical) considerations. Direct involvement of stakeholders in the development of such long-term balanced breeding goals is considered necessary to capture all relevant aspects and improve the societal acceptability of animal breeding.

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Multi-objective optimization and machine learning for sustainable irrigation under drought scenarios

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Abstract

Climate change is increasing droughts in Mediterranean agriculture, threatening food security and rural livelihoods. In Hatay Province, Türkiye, the February 2023 earthquakes compound the challenge of climate adaptation and post-disaster recovery. This study develops an integrated decision support system that combines multi-objective linear programming with machine-learning-based price forecasting, embedding drought resilience in the optimisation to ensure long-term agricultural and food security. The LP model simultaneously maximises regional profit, minimises irrigation water use, and maximises drought resilience under five scenarios (0–40% water reduction from the 1,750 million m^3 baseline). These scenarios cover 228,458 ha and 14 major crops. ML models (ARIMA, Prophet, XGBoost, LSTM) trained on 32 years of FAO commodity prices (1991–2023) were combined into an inverse-RMSE weighted ensemble, achieving a cross-commodity MAPE of 23.5%. The Drought Resilience Scoring (DRS) framework was validated against FAO Ky yield response factors (Spearman $\rho = -0.977$, $p < 0.0001$), confirming its physiological basis. Four of five scenarios yielded feasible optimal solutions; the 40% reduction scenario proved infeasible, establishing a science-based critical planning threshold. Under severe drought (30%), optimised profit reached $136.6 million with $13.8 million in government subsidies. Average portfolio resilience increased from 7.10 to 7.35 out of 10. This shows that resilience-driven reallocation buffers food security even under extreme water stress. The DSS provides analytics for adaptive crop planning, subsidy policy, and post-disaster agricultural recovery in water-limited Mediterranean regions.

Keywords: agricultural drought, decision support system (DSS), food security, adaptive water allocation, post-disaster recovery

Introduction

Global freshwater resources are under severe and accelerating pressure. agriculture accounts for approximately 70% of global freshwater withdrawals (FAO, 2025), and demand is projected to rise 20–30% by 2050 as climate change simultaneously reduces availability through altered precipitation and elevated evapotranspiration (IPCC, 2022; Field et al., 2014). The Mediterranean basin warms approximately 1.2°C for every 1°C of global temperature rise, with precipitation decreasing by roughly 20 mm per degree of warming, making it a recognised climate change hotspot for drought intensification (Lionello et al., 2018; Tramblay et al., 2020).

In Türkiye, agricultural irrigation constituted 79% of total water usage in 2024, amounting to 48.73 billion m^3 (National Water Plan 2026–2035, 2026). Surface irrigation losses of 35–60% further compound scarcity pressures (Koc et al., 2022). In 2025, the country experienced its worst drought in five decades, prompting a USD 891 million World Bank-supported irrigation modernisation programme (World Bank, 2025). Hatay Province (36°N, 36°E), a Mediterranean agricultural region covering 275,578 ha, exemplifies this crisis. The February 2023 earthquakes (Mw 7.7, 7.6) disrupted

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infrastructure, supply chains, and rural livelihoods, creating a compounded need for water management solutions that simultaneously address climate adaptation and economic reconstruction.

Multi-objective optimisation (MOO) enables explicit trade-off analysis between profitability and resource conservation (Reddy et al., 2007; Li et al., 2020), and LP has been extensively applied to agricultural water allocation (Nasiru et al., 2025). Ensemble ML price forecasting frameworks combining ARIMA, XGBoost, LSTM, and Prophet have demonstrated superior accuracy over individual models (Ray et al., 2023; Sari, 2024). However, most published DSS frameworks treat economic forecasting and biophysical optimisation as separate modules (Meydani et al., 2026), and none embed crop resilience as an explicit optimisation objective linked to food security guarantees, nor address post-disaster Mediterranean agricultural recovery.

A critical but often overlooked structural constraint in Mediterranean settings is the rigidity of perennial crops (olives, citrus, grape, stone fruit), which represent 20–50-year investments occupying 43.9% of the command area and cannot be reallocated annually. Ignoring this constraint produces theoretically optimal but practically infeasible solutions. This study addresses all these gaps by developing an integrated framework in which water optimisation, drought resilience, and forward-looking price intelligence are unified in a single quantitative model with resilience maximisation serving as the mechanism that sustains agricultural production and safeguards food security under progressive water scarcity.

The aim of this study is to develop and validate an integrated optimisation- and forecasting-based DSS for drought-resilient crop planning and irrigation management in Hatay Province under multiple drought scenarios to minimize water, maximise profit and resilience of agricultural production.

Methods

The Integrated Drought Irrigation Optimisation Framework (Figure 1) combines five components. (i) a multi-objective LP model that differentiates fixed perennial and flexible annual crop areas; (ii) a DRS system validated against FAO Ky yield response factors; (iii) an inverse-RMSE weighted ensemble price forecasting model; (iv) drought-adaptive objective weights and area constraints; and (v) explicit government subsidy quantification for strategic crops.

Study area and crops

The command area of 228,458 ha (83% of Hatay's total agricultural land) was studied, with 1,750 million m^3 of irrigation water available annually under normal conditions. Five perennial species are fixed at current areas. *Olea europaea* (oil and table olive), *Citrus spp*., mixed fruit orchards, and *Vitis vinifera* (grape), totalling 100,210 ha (43.9%). Nine annual crops form the flexible allocation component. wheat, cotton, maize variants, parsley, potatoes, dry onion, and red pepper. Wheat and cotton are designated strategic crops subject to minimum area and government subsidy provisions.

Crop water requirement

Net irrigation water requirements IRR_net(c,t) (m^3/ha per dekad) for all 14 crops across 36 dekadal periods were calculated from crop evapotranspiration (TAGEM, 2017) and effective precipitation (Turkish State Meteorological Service), following the FAO-56 method (Allen et al., 1998): actual evapotranspiration AET(c,t) = Kc × PET(c,t), adjusted for canopy cover, irrigation timing, application efficiency between 0.7-0.90, (Yildirim, 2013) and conveyance efficiency (0.75).

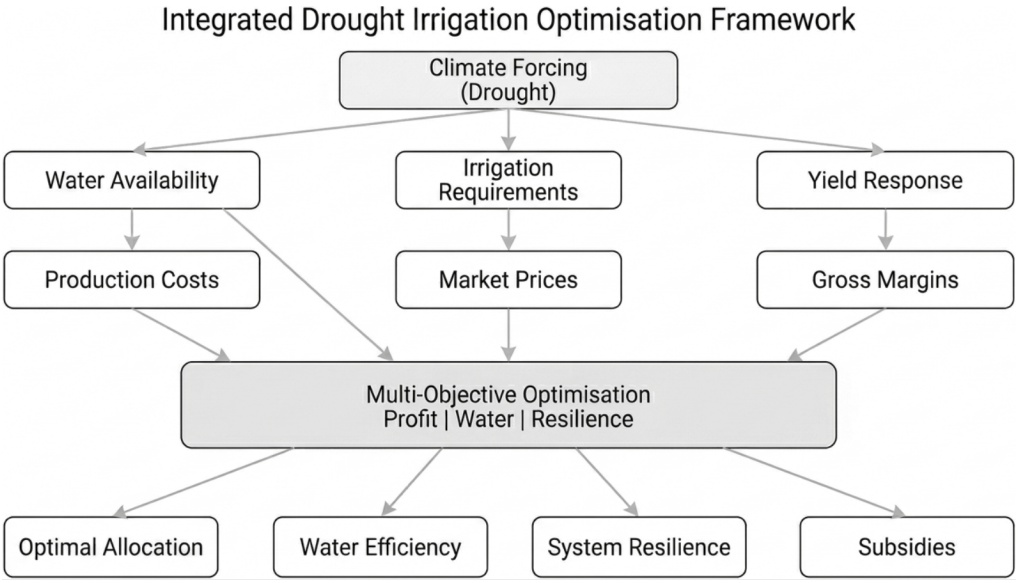


Figure 1. Integrated Drought Irrigation Optimisation Framework, linking climate forcing through water, irrigation, and yield pathways to the multi-objective optimisation model and its policy outputs.

Total annual water requirement under the 2024 baseline was 1,515.6 million m^3 (Table 1), below the 1,750.0 million m^3 available supply.

Table 1. Annual crop water requirements for Hatay command area (2024 baseline).

Crop	Ps (c) (%)	AddFact (c) (%)	AE(c) (%)	CE	PET(c) (mm/yr)	AREA_ base(c) (ha)	IRR_net (c) (m^3/ha)	T_IRR_net (c) (m^3)
Wheat	80	75	70	0.8	398	53,456	1,652	88,308,154
Oil olive	70	85	90	0.8	800	45,022	6,763	304,471,892
Cotton	85	85	80	0.8	891	34,204	13,037	445,917,905
Citrus	70	85	90	0.8	877	31,122	5,798	180,433,338
Table olive	70	85	90	0.8	800	12,205	6,763	82,535,752
Maize I	85	85	80	0.8	724	10,812	9,706	104,937,774
Fruit	70	85	90	0.8	962	7,011	8,963	62,843,831
Parsley	85	85	85	0.8	1,136	6,790	12,579	85,405,424
Sil_ maize II	85	85	80	0.8	432	5,005	7,019	35,134,548
Potatoes	80	80	70	0.8	252	4,967	121	598,513
Grape	70	85	80	0.8	774	4,850	7,656	37,128,162
Dry onion	70	80	70	0.8	452	4,622	1,497	6,918,753
Maize II	85	85	80	0.8	527	4,576	8,102	37,071,838
Red pepper	85	85	85	0.8	852	3,816	11,515	43,941,719
Total						**228,458**		**1,515,647,603**

Machine learning ensemble price forecasting

Historical farm-gate prices (USD/ton, 1991–2023) for 14 crops were sourced from the FAO Price Database and Turkish market records. Four models were combined into an inverse-RMSE weighted ensemble where the weight for model m is ωm = (1/RMSEm) / Σ(1/RMSEi). The ensemble achieved a cross-commodity MAPE of 23.5%, outperforming all individual models (XGBoost. 15.8%; ARIMA. 21.7%; LSTM. 24.1%; Prophet. 40.5%). XGBoost received the highest weight for 82% of commodities (average 30–50%). Six crops achieved high reliability (MAPE < 15%); dry onion (39.4%) and parsley (28.9%) showed low reliability owing to market volatility. Ensemble forecasts for 2024–2028 serve as exogenous price inputs to the optimisation model.

Drought Resilience Scoring (DRS)

Each crop was assigned a Drought Resilience Score Res(c) (scale 1–10), integrating rooting depth, water use efficiency, phenological flexibility, and regional agronomic evidence. Validation against FAO Ky factors (Doorenbos & Kassam, 1979) yielded Spearman $\rho = -0.977$ ($p < 0.0001$, $n = 14$), confirming near-perfect negative monotonicity. crops with high Res(c) show low yield sensitivity to water deficit. Oil and table olive score highest (Res(c) = 9, Ky = 0.30); parsley scores lowest (Res(c) = 3, Ky = 1.35). Embedding Res(c) as an optimisation objective – rather than merely a filtering criterion – is the mechanism by which the DSS links water allocation decisions directly to the sustainability of food production.

Multi-objective optimisation model

The model is formulated as a weighted-sum LP implemented in Python 3.10 (PuLP 2.7, CBC 2.10.10 solver). The decision variable AREA(c,s) (ha) is the area allocated to crop c under drought scenario s, applied to a command area of 228,458 ha and $1{,}750 \times 10^6$ m^3 baseline water supply, with a base water price of 0.05 USD/m^3 rising with drought severity. Equation 1 addresses the adaptive shift in objective weights with drought severity s ($0 \le s \le 1$):

$$\hat{W}1(s) = 0.30 - 0.25s;\ \hat{W}2(s) = 0.45 + 0.50s;\ \hat{W}3(s) = 0.25 - 0.25s \quad (1)$$

Each clipped to [0.10, 0.80] and normalised so $\hat{W}1 + \hat{W}2 + \hat{W}3 = 1.0$, progressively shifting emphasis from profit to water conservation and resilience as drought intensifies. Based on Equation 2, the objective function maximises a weighted combination of total profit (Z1), total water use (Z2, penalised via a negative weight) and total drought resilience (Z3):

$$\text{Maximise } Z = \hat{W}1(s) \times Z1/10^6 - \hat{W}2(s) \times Z2/10^6 + \hat{W}3(s) \times Z3/10^5 \quad (2)$$

The model is subject to total area and water availability limits, a minimum system resilience floor that tightens with severity (from 5.0 at baseline to 7.0 at 30% drought), a cap limiting high-water-use crops (citrus, parsley, red pepper, silage maize II) to 30% of total area, tightening further under drought, and crop-specific area bounds. When Profit(c,s) < 0 for a strategic crop, government subsidy equals the per-hectare loss multiplied by allocated area.

Results and discussion

Model validation

Spearman's rank correlation between Res(c) and FAO Ky was strongly negative ($\rho = -0.977$, $p < 0.0001$), validating the DRS framework. Four structural model tests were performed: profit monotonicity, water constraint adherence, high-resilience crop expansion under drought (Res(c) ≥ 8 share rose from 55.6% to 60.7%), and strategic crop maintenance. Three tests passed; cotton's strategic minimum was breached under severe drought, highlighting a need for government intervention rather than a model flaw.

Drought scenario results

Four of five drought scenarios produced feasible solutions (see Table 2); the 40% reduction scenario was infeasible because perennial crops used 66.3% of available water, making it impossible to meet food security, resilience, and market stability goals – defining this as a critical planning threshold. Under baseline conditions, regional profit is $334.8 million, using 1,273.5 million m^3 of water (72.8% of the supply), a 16% saving compared to the 2024 unoptimised pattern (1,515.6 million m^3). Severe drought (30%) cuts profit by 59.2% to $136.6 million and requires $13.83 million in subsidies, but resilience-focused reallocation raises average portfolio resilience from 7.10 to 7.35/10. This shows the framework helps maintain food system stability even as economic returns decline.

Crop portfolio adaptation

Perennial crop water demand escalates as a share of available supply under drought. 46.4% (baseline), 52.8% (mild), 57.8% (moderate), 66.3% (severe), demonstrating the binding structural rigidity of tree crops and validating the design choice to fix their areas in the model.

Wheat is maintained at 53,456 ha across all scenarios despite becoming loss-making at 30% drought ($Profit_{c,s} = -\$58.09$/ha), requiring $3.11 million in subsidy, reflecting its protected strategic role in food security. Cotton contracts 12% (23,950 to 21,076 ha) under severe drought, triggering a $10.72 million subsidy. Water-intensive annual crops face area reductions of 45–65%, parsley (−45%), maize variants (−45%), and dry onion (−65%), collectively freeing water for higher-resilience crops and sustaining the system above the minimum resilience floor of 7.0.

Table 2. Optimisation results by drought scenario.

Scenario	Water deficit %	Available water (M m^3)	Profit ($M)	Subsidy ($M)	Net benefit ($M)	Water used (M m^3)	Area (kha)	Avg. Res
Baseline	0%	1,750	334.8	0.0	334.8	1,273.5	207.9	7.10
Mild drought	10%	1,575	278.4	0.0	278.4	1,227.8	200.8	7.19
Moderate	20%	1,400	232.7	0.14	232.8	1,184.9	195.6	7.27
Severe	30%	1,225	136.6	13.83	150.4	1,142.0	190.4	7.35
Extreme (40%)	–	**1,050**	**Infeasible**	–	–	–	–	–

Sensitivity analysis

Sensitivity analysis at 30% drought confirmed model robustness. A ±20% variation in Res(c) values produced asymmetric results, infeasible at −20% but feasible at +20%, confirming the resilience constraint is binding rather than a soft preference. A ±30% variation in price elasticity yielded a profit coefficient of variation of 11.63% (±14% uncertainty band: $117.2–$156.1 million around the $136.6 million estimate), identifying resilience parameterisation as the critical data requirement for policy applications.

Conclusions and future perspectives

This study developed and validated an integrated DSS for sustainable agricultural water management under drought in Hatay Province, Türkiye. The key innovation is treating drought resilience as an explicit optimisation objective, linking water allocation directly to agricultural sustainability and food security. Three main policy contributions result.

First, identifying a 40% water-reduction threshold as the critical feasibility boundary provides a science-based limit for drought risk management and infrastructure investment planning. Second, ensemble ML price forecasting integrated into the optimisation objective, with commodity-specific reliability classifications (MAPE 5.2–39.4%) and drought-adjusted price elasticity, advances beyond static-price models by capturing market dynamics under climate stress. Third, explicit quantification of government subsidy requirements ($0.14 million at 20% drought; $13.83 million at 30%) translates optimisation outputs into actionable fiscal planning parameters, enabling policymakers to anticipate support needs before crisis conditions materialise.

Limitations include the LP assumption of perfect information, lack of deficit irrigation options, and omission of multi-year crop rotation. Future work should use stochastic programming for uncertainty, deficit irrigation to extend feasibility beyond 40%, and multi-year planning to allow gradual restructuring of the perennial. The open-source Python /PuLP /CBC tool is transferable to other Mediterranean regions with similar perennial-crop and price dynamics, positioning the framework as a regional rather than single-site decision-support tool for drought response and food security.

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Real world animal ethics: ethical challenges on a Scottish sheep croft

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Abstract

In 2022 we took over our family croft on the Isle of Skye in Scottish highlands. After many years considering animal ethics "in theory", in academic research, business and government advisory roles, we were brought face to face with real world ethical questions and dilemmas in the week-by-week practical management of a small flock of Cheviot sheep, outdoors in an exposed upland location. This paper reflects on some of these ethical challenges.

What are our human ethical responsibilities in managing hill sheep, bred for withstanding harsh conditions, but exposed to persistent bad winter weather or violent storms? When simply to observe their natural behaviours; when to intervene? For example, how far to leave sheep to give birth naturally, and so accept occasional deaths, how far to assist in the birthing and nurturing of new lambs? The reintroduction of magnificent sea eagles in Skye has coincided with crofters reporting 50% or more losses of hill lambs, disappearing without trace. What is a just balance?

When to use common sense when regulatory requirements, suited to lowland farming with access to good infrastructure, may not fit well in a small remote, rural situation? Support for farming rightly emphasises environmental goals such as enhanced biodiversity and reduced carbon emissions, but it can send conflicting ethical signals. A carbon audit modelled on reducing CO_2 per kg of meat puts pressure on crofters away from their typical extensive practices to more intensified production, conflicting with ethically important factors like welfare and biodiversity.

In selecting sheep to breed from each year, how far should we adapt animals to our own purposes? We seek to adopt wider goals in selecting sheep for breeding than productivity alone or a sheep's visual appearance – qualities like good motherhood, wool quality, ease of handling, which reflect the ethical values we have evolved for real world management of our croft.

Keywords: crofting, highland, naturalness, animal husbandry

Introduction: the context of crofting and hill sheep

In 2022 we moved from Edinburgh to the Isle of Skye to take over our family croft. After many years considering animal ethics "in theory", in academic research, business and government advisory roles, we were brought face to face with real world ethical questions and dilemmas in the week-by-week practical management of a small flock of Cheviot sheep, outdoors on an exposed hillside overlooking the Atlantic Ocean. This paper reflects on some of these ethical challenges.

Crofting is small scale subsistence farming, chiefly in the western Highlands and islands of Scotland, on small portions of land, which the crofter normally rents from a landowner at a low rent, and holds in perpetuity provide they keep crofting the land. The crofting system was established in the 1880s, in response to widespread abuses by landlords and their factors of already poor tenants, which led to enforced clearances and violent conflicts, notably in Skye, which remain a gross stain upon the tapestry of Scottish history.

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For our ancestors, sheep were bred as much for wool as for meat. This remarkable natural product provided much of their clothing, floor and wall covering for warmth which enabled people to survive in the harshness of the cold, dark, wet winters of the windswept northern maritime climate. It is a scandal that the product for which sheep were primarily introduced here has become worth so little in monetary terms in today's global economic situation, that it can cost more to shear than the fleeces are worth, as an expensive waste product.

Few people make money from crofting; it is generally only possible with subsidies from the Scottish Government, which considers crofting a vital part of life in the Highlands and Islands. It is seldom sufficient to sustain life without an additional job. People still croft because it is a way of life they choose and embrace, part of the identity of living, especially in the Hebridean Islands. It is closely tied to the local community, done in collaboration with neighbouring crofters in a "township" who share a "common grazing" in addition to each crofter's own land, and often carries a long family heritage and embedded culture.

As newcomers to crofting, we stepped into a long standing tradition of how things are done, and the values underlying it, learning the practical skills and judgements made when managing an upland sheep croft. But we have also departed from some of these to follow our own goals. We are not primarily crofting to maximise profits, but rather to develop a system of extensive grazing aiming to increase biodiversity and maintain a low carbon footprint.

We have reduced the number of animals per hectare, and have fenced within the croft to make small fields which the sheep graze in rotation. This allows the grass to improve and encourages flowering plants. On basalt lava, our soils are very acid but very rich in carbon. We have planted over 400 trees and encourage small areas of wetland. Our heather moorland common grazing has extensive carbon capturing mosses and peat. Our approach has some similarities with "Agricultural Rewilding" (Corson et al 2022).

How far to intervene with natural behaviours?

A fundamental ethical question about the management of sheep which live outdoors on a windswept hillside is how far should we intervene with natural behaviours? Cheviot and Blackface sheep have been bred over centuries, chosen because of the hardiness to survive outdoors in the harsh West Highland winters, grazing often quite poor quality grass, and to do so without close management by humans. There is a spectrum of management situations.

Above the area we graze are a further 900 ha (hectares) of rough heather and peat moorland, rising to a bleak mountain clifftop plateau at 600 metres above sea level. This is also a shared common grazing on to which some crofters in our neighbourhood let a few Blackface ewes, which graze for most of the year unattended, semi-feral. They are only gathered back to the valley croft land for short periods for mating, for veterinary treatments or shearing, and to take their lambs to market. They are essentially "left to get on with it", and in that sense are free to exhibit natural behaviours to a very large degree. But with such a scattered population of sheep over wild undulating moorland, problem pregnancies may lead to both ewe and lamb dying. If a weak and sickly twin is unable to keep up with its mother and elder sibling, it would be abandoned to die on a bleak mountaintop. Sheep sometimes fall down the cliffs.

Does that degree of raw "naturalness" constitute sufficient welfare? Unlike the native red deer *Cervus elaphus* which roam the area, sheep are not wild. Their owners have a duty of care towards them, but now with only a few dozen animals in a very large area, shepherding is no longer realistic. This represents one end of the management spectrum for hill sheep.

We are towards the other end of the spectrum. For a significant proportion of the year ewes are kept "in bye", on grazing pasture land close to our home, where to an extent they can be observed and interventions made if we judge it necessary. We use our hill common grazing at intervals throughout the year. During late summer and autumn there is usually not much to observe. Once winter feeding starts, we are in close daily contact. But the most critical period is during lambing, when typically one of us would go out at 2-hourly intervals during 15 daylight hours to monitor progress of each impending delivery. Most ewes do not need help and simply get on with it, but we keep a special eye on potentially vulnerable ewes. Some difficult deliveries may need direct intervention to pull the lamb out and ensure it breathes.

In the hour or two following birth, the crofter needs to make sure the lamb learns quickly to suckle its mother. This can be difficult in older ewes where the udder has drooped too low for the lamb to reach, instinctively butting upwards to find a teat. Setting the ewe on her back every two hours and holding the lamb to the teat, until the lamb has learnt to suckle naturally is not an easy task. These typical interventions are possible if sheep are outdoors yet fairly close at hand. But many ewes prefer to deliver in the dark, when surveillance is impossible.

From an ethical point of view, there is no a priori rule which sets a right degree of the synergy between human and animal. The two situations above and the very different case of indoor lambing represent three different balances in which the crofter could be judged as caring suitably for their animals in their particular environments. Indoor housing has both pros and cons. For example there is a greater risk of cross infections and potentially more antibiotic treatment. If surveillance is 24/7, interventions can be immediate, but indoor housing restricts the ewe from the natural behaviour of finding her own place to give birth. Our adoption of rotational grazing also restricts our sheep behaviour from going up the hill at night as seems to be their usual desire, but they clearly welcome moving to fresh pastures with fresh grass available, which would not be the case if they were completely free to roam.

Sandøe et al (2022) note two different interpretations of good animal welfare, and seek to find an ethical pathway that bridges them. For some, the ability of an animal to exhibit its natural behaviour in nature takes primacy over poor nutrition; animals should be allowed to die without intervention since death is natural. For others, good animal welfare requires animals to be well fed and well cared for when sick, and if in distress, to be humanely killed.

As Christians we follow an approach based on animals and everything in nature having intrinsic value because God created them (Bruce and Bruce, 1999). "Animals exist first of all to God, before any considerations of their value or use to humans." Humans are seen as being in God's image and given a role of stewardship over the rest of God's creation. We are "answerable ... to God the divine owner for how we have looked after his estate." The key is what is a reasonable responsibility of our management, and how does that lead us to make the judgements to intervene in one situation and to "leave be" in another.

In Livestock Ethics (Gatward, 2001), Gatward has a similar Christian ethical basis for livestock production, including some guiding principles of respect for the animal for what it is, good stockmanship, and stewardship, derived primarily from Old Testament principles, for example, "do not muzzle an ox while it is treading out the grain" (Deuteronomy 25:4, 14:21). Such principles have to be applied case by case, in the decisions and dilemmas facing the crofter week by week. Gatward stresses the important role of a good stockman's knowledge, with which we would concur on our crofting learning journey. In ethnographic work, Fry noticed crofters' nuanced appreciation of changes in ewe condition or behaviour. He concluded "it is striking the extent to which their farming practices are affected through an embodied attachment to animal presence." (Fry, 2023, p.2506).

Sea eagles and lamb predation

In the context of how far natural behaviours should be balanced against other animal ethical criteria, the controversial reintroduction of White Tailed Eagles (Sea Eagles) *Haliaeetus albicilla* in parts of Scotland adds another dimension. The last breeding pair of Sea Eagles was present in Skye in 1916. From 1975-83 a reintroduction programme on the west coast island of Rum released 82 birds from Norway, and they are now breeding in Skye and Mull. Their diet is wide, including fish, seabirds and small mammals such as rabbits but also lambs. Some crofters are suffering severe losses due to Sea Eagles, to the point that some are no longer prepared to place sheep on the hill. One crofter on Skye said he had lost 276 lambs out of 411 in six weeks on the hill. Several referred to no longer being able to rear enough replacement ewes. A veterinarian confirmed that he has seen damage to adult sheep consistent with an eagle attack (Bruce, 2020). A neighbour who breeds sheep dogs has a video of one of his dogs being attacked by a sea eagle. For some time public statements of conservation bodies stated that sea eagles took only sick animals or carrion, but not healthy lambs, until the accumulated evidence became too great to deny. It is now belatedly acknowledged that in some locations sea eagles predate healthy lambs, and can cause significant losses on farms and crofts. This issue has not so far affected us greatly, but we are part of a community which feels these things deeply.

In recognition of these issues, the Sea Eagle Management Scheme was established to help farmers and crofters experiencing the greatest impacts. It gives financial support for adopting mitigation measures but does not compensate for losses. On hill land eagles tend not to leave a carcass to provide evidence of the crofter's loss. The animals simply disappear, unlike fox predation which usually leaves part of the carcase behind, or if a crow or raven takes a lamb's eyes. Mitigations might include keeping lambs in-bye for longer, perhaps sacrificing a field intended for silage, indoor lambing if a crofter has the necessary barns and handling facilities, or a shepherd walking the hill land more often. But these do not address either the economic impact of lamb losses or the emotional effect of "seeing your work, the livestock damaged and killed and injured." One crofter noted that "If you said you can have £5,000 or no eagles, I'd still say take away the eagles please" (Bruce, 2020).

The affective loss is also to the crofter's ewe. To see a mother wandering around the croft searching and baa-ing for her lost lamb is always distressing, with predators which are natural to Skye. Crofters may be allowed to control their numbers, but not sea eagles, which were introduced without consultation with crofters, with much resentment (Whitehead and Hare, 2025). The scale on which sea eagles seem to be taking lambs goes beyond predation losses during the generations since sea eagles last bred in Skye. This degree of loss is a consequence of a choice made by humans to restore the presence of sea eagles in crofting counties, but into an environmental context different from that in which the birds became extinct.

How one sees this controversial issue depends on the value priorities and/or social group through which one sees the question. Which values underlay the human intervention in nature of reintroduction of a species made extinct by past human intervention? The ecological values associated with conservation groups carry engrained principles of protection, in a climate of global losses of species on a terrible scale. But human reintroduction into a habitat is more complex. These values have so far predominated over those of the farmers over a century ago who saw predators as a threat to their livelihoods and even their own precarious survival in the often acute, unmitigated poverty of crofters of those times. It is easy to cast moral blame on these past unknown humans, when they and their situation are far away and they aren't here to answer for themselves. Contemporary humans suffering from serious predation of their flocks embody the problem, but if they are not in the decision-making room, their moral voice is not heard. Interviews with crofters about sharing crofts with wildlife (Fry, 2023) more generally revealed resentments that rules are being developed by outsiders, mostly in cities, paying no attention to the indigenous knowledge of crofters.

Human introductions of species foreign to the local environment have a bad history also. In Scotland, for example, Himalayan rhododendrons now cover whole swathes of hillside in the Great Glen, and hedgehogs introduced into the Uist islands eat the eggs of previously untroubled ground-nesting birds. If the natural behaviour of white tailed eagles is primarily catching fish but also small land mammals, one may question the wisdom of reintroducing them in islands whose seas now have very few fish through over-fishing. If there are insufficient fish a raptor will find animals on land, and if their offspring fledge following their parents' example, then predation of lambs becomes the primary "natural behaviour" that might not be if birds primarily fished for food.

A relative saw a golden eagle take one of his lambs and commented to us that they are magnificent birds and that is their natural behaviour. To be resigned to losing an occasional lamb is one thing, to lose half a year's flock of lambs is another. Crofters do not breed sheep to contribute to the restoration of sea eagles to these islands but that is an unintended consequence of their reintroduction by conservation bodies.

Carbon audits depend on the criterion their model is attached to

A wider issue is that regulatory agricultural requirements are generally framed around criteria suitable for lowland farming, and may not fit a small remote, rural situation. One such a case is carbon audits. Belatedly, the reduction of greenhouse gas emissions has become an imperative for action in agriculture. Performing a carbon audit now forms one of the conditions in Scotland for receiving the annual subsidy, but this admirable aim can in practice send conflicting signals. We tried one tool and found its results inappropriate for our croft.

The main problem is the dominant criterion for calculating carbon emissions is not the simple sum of CO_2 equivalent but CO_2 per kg of meat produced. This is based on the concept that the faster an animal is brought to its final slaughter weight, the less emissions it will have produced in its lifetime. In a previous EurSafe paper in 2012 (Bruce, 2012), we noted that this set up a clash of values with the ecological criterion of extensification in agriculture. This is especially problematic for an already extensive system like ours and many other crofters. The model output recommended us to "increase livestock productivity and lambing percentage". This would mean aiming for more twins and even triplets. On a hill croft where we lamb outdoors, this conflicts with animal welfare, and would also entail more external feed inputs, increasing our carbon footprint, and would mean more time spent or more people to work, lowering our productivity per person.

The assumptions of the model press crofters towards more intensive management in order to reduce CO_2 per kg of meat. We run an extensive upland croft with a deliberate focus on environmental and carbon reduction goals, with low stocking density, rotational grazing aimed at minimising feed inputs. We have an electric car, solar panels, and consume petrol only in our quad bike. We have planted over 400 native trees in an area of the croft less suitable for grazing, but these are not taken into account. Notwithstanding, the model concluded we had a higher than average carbon footprint, because of its production based criterion. Other inadequacies with the model included outdated measures of the CO_2 equivalence of methane, and failing to account for carbon sequestration by grassland habitats. We conclude that the model was not fit for purpose for our extensive upland sheep croft.

It raises a wider ethical question about the signals being sent by models based on analytical criteria which fail to reflect the diversity of goals in contemporary farming. A carbon audit modelled on reducing CO_2 per kg of meat puts pressure on crofters away from their typical extensive practices to more intensified production, conflicting with ethically important factors like welfare and biodiversity. There is no criterion for CO_2 emissions per weight of wool produced, and thus a crofter whose primary goal is wool is sidelined, or one who keeps sheep to maintain a vibrant biodiversity on grazed land. Different metrics

for greenhouse gas emissions have been suggested, such as maximum nutrition for minimum greenhouse gas levels, and taking into account that ruminants can eat grass unsuitable for growing crops and which humans cannot consume, to make food for humans (Garnett, 2011, Gill et al., 2010).

Hill sheep breeding ethics

Our 35 Cheviot ewe sheep are the progeny of generations of sheep that have existed on the same piece of land for decades, if not longer. Each generation of sheep teaches the next how best to thrive on this land, where to find the best grass, and where to find shelter, giving the flock a collective behavioural memory called "hefting". Each year all the male and many female lambs are sold as "store lambs", for finishing in richer lowland pastures, before being sold for meat or breeding. We keep selected female lambs to replace older ewes, to maintain a healthy flock. A different ram is rented each year from a local farmer to mate with the ewes and the cycle is repeated. Sales of the sheep constitute a major part of the income of the enterprise, but as noted above, wool sadly does not.

Every crofter selects sheep according to some values. In most upland sheep breeding in the UK, explicit genetic selection is not generally practised (with a few notable exceptions). Most selection is done on the basis of external appearance, and by selecting out animals with poor functional characteristics such as susceptibility to disease, or a sunken udder, or being difficult to manage, or simply being considered too old for another lambing. Very few measurements tend to be made, and family relationships are not generally recorded.

In our selection of animals to keep or to sell each year, we are focusing on maintaining good mothering ability, reducing the length of tails (to avoid having to dock tails against maggot infestation), and going for good wool quality, with a view to locating better markets for it. We would wish to select for reduced methane emissions but the means to measure emissions on a croft do not yet exist. Thus we record family relationships, animal weights at various ages, and keep note of behaviours we consider good or detrimental to how we manage the flock. Increased growth rate is not an aspiration for our sheep as smaller animals are easier to handle, and better suited to our relatively sparse winter grass. We do not see a value in selecting animals to enter competitions at agricultural shows, as the culturally inbred values as what constitutes a "good" sheep are not ones we necessarily share.

We are selecting according to what we think is important by our own underlying ethical values of respect, welfare, compassion and good stewardship. Our management ethos aims to ease or reduce the need for handling, reducing stress to the sheep and also muscle strains to ourselves as we age. We are a long way from the intensive selective breeding in large livestock farming. Our approach has resonances with such as Sandøe et al. where important wider criteria include quality of life with good functioning, including health, pleasure and avoidance of pain, and satisfying animal preferences (Sandøe et al, 1999).

Conclusions

In taking on our family sheep croft we have found ourselves confronting a surprisingly wide range of real world ethical issues, some which have relevance far beyond our 7 hectares and 34 sheep. These include how far to intervene with natural behaviours in managing hill sheep, unintended consequences of re-introducing predators into a different environment from that from which they became extinct, the failure of carbon emission audit models to take account of wider environmental farming goals, the degradation of the value of wool, and what ethical goals should be the uppermost in continuing to keep hill sheep on our land. We resonate with the Gaelic word *dùthchas* which conveys a sense of place and belonging to the land, humanly and ecologically, with a responsibility for the stewardship of that land for future generations.

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Section 8.
Animals use and governance

Knowledge does not influence attitudes towards animal experiments

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Abstract

Animal testing remains an essential component of biomedical and scientific research, despite ongoing efforts to develop alternatives. This study aimed to assess the knowledge of the Flemish public regarding laboratory animals and animal experiments. A digital survey (n = 275) was conducted, including knowledge questions, true-or-false statements, and attitude-based items.

Findings indicate that respondents possess a reasonable basic understanding of animal experimentation, yet misconceptions persist, particularly concerning species used, and the legality of certain experiments. For example, animals such as dogs and cats were less often recognized as laboratory animals (despite being prominently displayed in anti-experimentation campaigns), while less emotionally charged species such as mice and rats were mentioned more often. Knowledge scores were significantly higher for younger participants and those with higher education levels, while gender showed no effect. Notably, knowledge level had no correlation with opinions, with one exception: people with higher knowledge scores were more likely to support animal experiments for drug development.

These results are relevant to governments, scientists and NGOs alike; there is a clear knowledge gap, and all three stakeholder groups have a role to play in filling that gap. On the other hand, increasing citizens' knowledge about animal experimentation is not likely to significantly change their opinions. This may be reassuring to scientists, as well as frustrating to anti-experimentation activists.

Introduction

In Europe, the animal research sector is legislated from the European level (through Directive 2010/63) to the national level. There is a considerable amount of information available to the general public about the number of projects conducted, the number of animals used, and the type of projects. All this can be found via the Alures database.

There is some research on the public acceptance of animal research, for example in Belgium (GAIA, 2016) and Sweden (Swedish Research Council, 2024). There is considerable variation in how many people find research on animals acceptable. Depending on the country and how the question is phrased, this may vary between a strong opposition (over 80 % against, see Aerts & Heyndrickx, 2022) and a strong support (over 80 %, see Swedish Research Council, 2024).

Importantly, most of these reports address the opinion of the public on animal research, but little attention is given to the actual knowledge of about animal research and experimental animals. This paper reports on a study into the knowledge of the Flemish public on these matters, its influencing factors, and on the correlation between knowledge and opinions.

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Materials and methods

This study was conducted between January and March of 2025, via a digital survey using the Qualtrics software. It was circulated through social media and email. This resulted in 275 fully answered questionnaires. Of the respondents, 62% were women, and 2 identified their gender as "other". Within the respondents, those in their early 20s and people from 40 to 60 years old were overrepresented, and the data was geographically skewed within Flanders, but the sample was educationally representative for the Flemish public.

The survey asked 7 short introductory questions (such as demographical data), 17 knowledge-related questions and 8 opinion-based questions (scored from 'Totally disagree' to 'Totally agree'). To improve engagement and willingness to complete the survey, the respondents received a score after submission, with feedback and additional explanations.

Results

We will not go in detail about the specific items in the knowledge test, but two elements merit some attention. When asked which species are used in research, species often used in communication about lab animals (by e.g. animal welfare and animal rights organisations), such as dogs and primates, were not as often identified as possible lab animals. Rodents were. In general, it appeared that the public has a better knowledge of what is legal in animal research (these items were identified correctly in most cases) than of what is not allowed (these items were often also identified as legal).

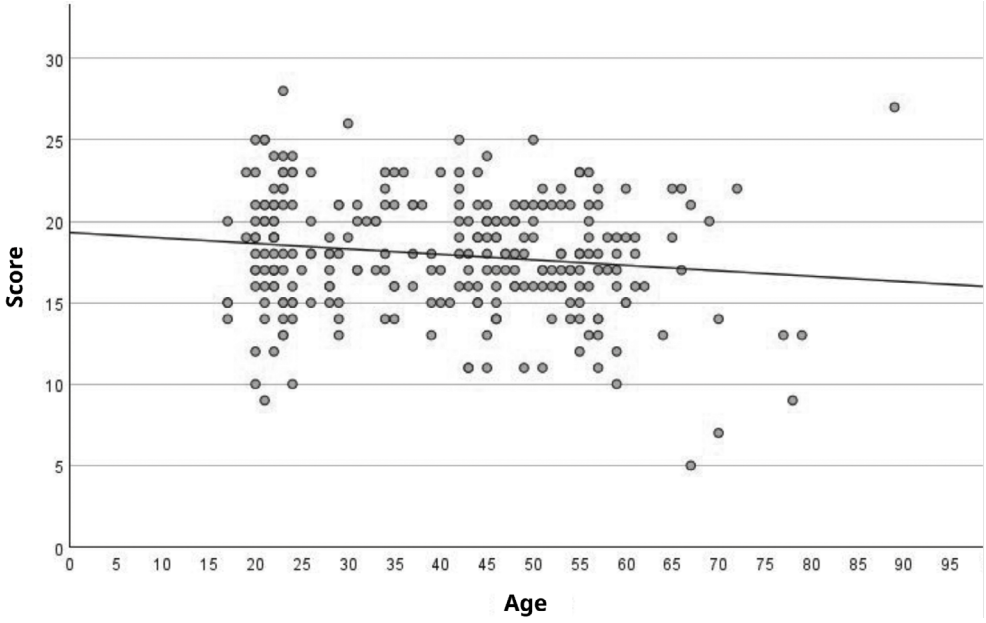


Figure 1. Effect of age on knowledge about animal research (maximum score = 28). A small age effect was identified (R^2=0.02) with older people appearing less knowledgeable about animal research (see figure 1). Across all age groups differences were considerable. In general, scores were relatively high, with most people getting over half of the questions right. Of course, this observation is highly dependent on the questions asked. In this survey, we probed for relatively basic knowledge.

Not surprisingly, there was an effect of the level of education ($P<0.001$): higher educational levels coincided with more knowledge about animal research.

Importantly, there was no gender effect with respect to knowledge ($P = 0.19$). On the other hand, there was a gender effect with respect to opinions about the use of animals. Maybe unsurprisingly, men were typically more in favour of research, and less likely to prioritize animal welfare over research. This was apparent in all opinion questions, of which we show one in figure 2.

Age also affect opinions. In all questions where the use of animals and animal welfare were in opposition, a P value of <0.01 was observed. In general younger people are more critical for the use of animals in research (also in medical research), and place more importance on the welfare of the animals in research. This effect is strongest (and most linear) in the question where experimental goals and animal welfare were opposed most clearly (see figure 3).

Only one opinion question showed a correlation with knowledge about animal research: using animals in medical research was accepted more by people with more knowledge ($P<0.01$). all other opinions were not influenced by knowledge ($0.07<P<0.51$).

Conclusion

Findings indicate that respondents possess a reasonable basic understanding of animal experimentation, yet misconceptions persist, particularly concerning species used, and the legality of certain experiments.

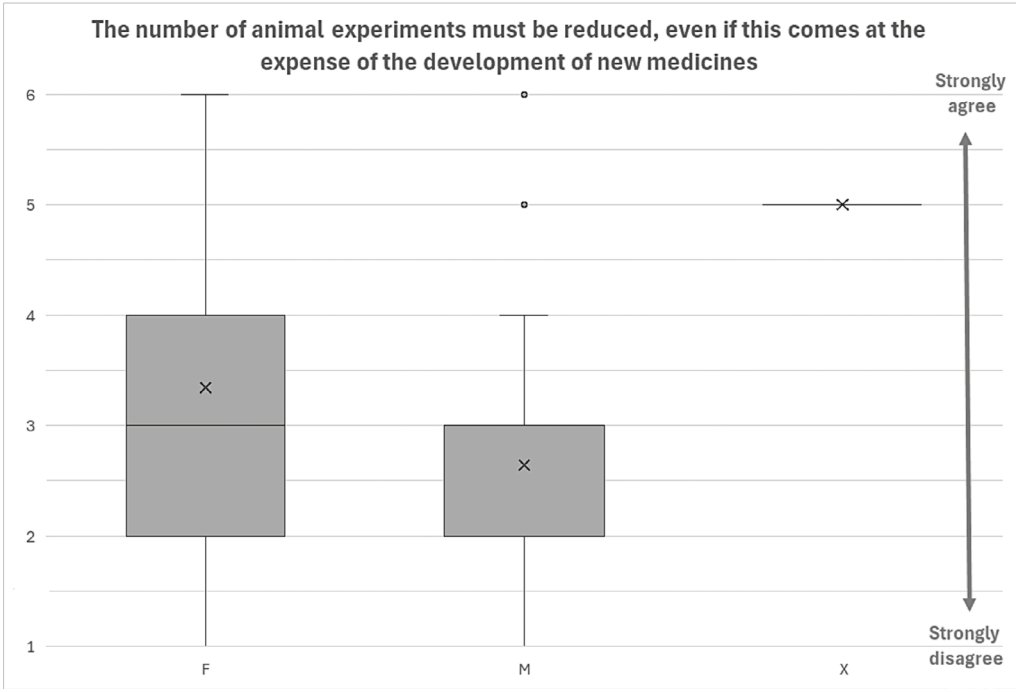


Figure 2. Gender difference with regard to support for animal research based on the willingness to compromise between animal welfare and research.

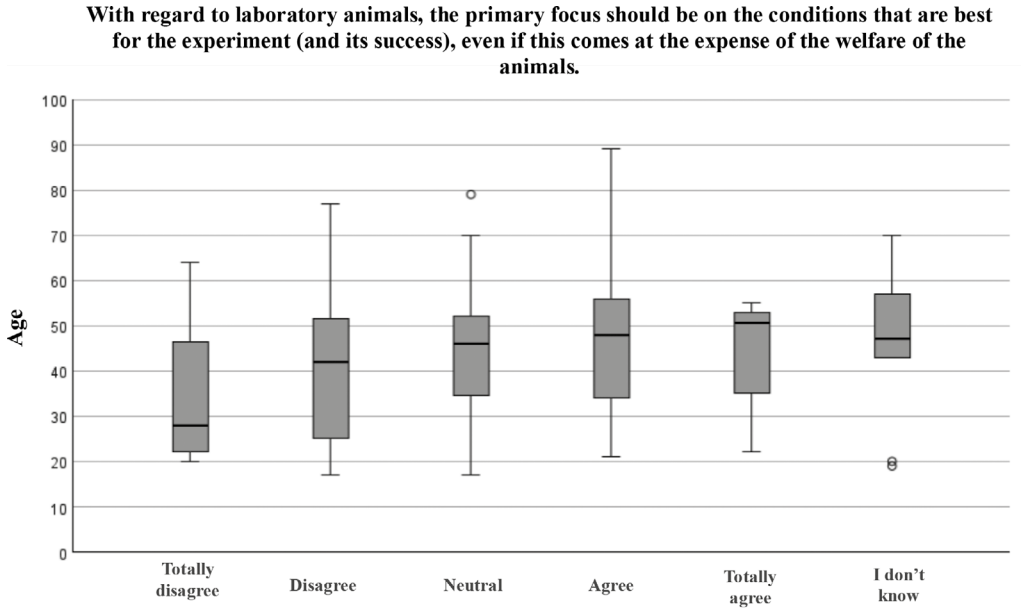


Figure 3. Effect of age on the opinion whether experimental goals have priority over animal welfare

For example, animals such as dogs and cats were less often recognized as laboratory animals (despite being prominently displayed in anti-experimentation campaigns), while less emotionally charged species such as mice and rats were mentioned more often.

Knowledge scores were significantly higher for younger participants and those with higher education levels, while gender showed no effect.

Strikingly, in this study, there is no significant correlation between the opinions expressed and the knowledge score achieved by the respondents, with one exception: people with higher knowledge scores were more likely to support animal experiments for drug development.

These results are relevant to governments, scientists and NGOs alike; there is a clear knowledge gap, and all three stakeholder groups have a role to play in filling that gap. On the other hand, increasing citizens' knowledge about animal experimentation is not likely to significantly alter their opinions. This may be reassuring to scientists, as well as frustrating to anti-experimentation activists.

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Applied ethics in public policy: competences for ethics advice in public administration

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Abstract

In order to address the regulatory challenges arising from technological change, environmental transformation, and evolving societal expectations adequately and effectively, public administrations should also take ethical considerations into account alongside political and legal ones. However, they generally lack the necessary expertise and rely on advice, which usually comes from institutionalized advisory committees. One might think that the ethical expertise required for this kind of advice is taught at universities. Unfortunately, though, the competences required for providing such advice remain only weakly addressed in academic training. This paper presents initial findings from the project *Applied Ethics in Public Policy*, which examined the forms of knowledge, competences, and skills that are needed for ethics advice in public administrations and how university teaching can contribute to their development. Drawing on discussions from two stakeholder workshops involving practitioners and scholars, the paper identifies key competences across four domains: subject competence, methodological competence, social competence, and personal competence. The analysis suggests that effective ethics advice requires not only familiarity with ethical theories but also the ability to reconstruct arguments, work across disciplinary boundaries, and translate ethical reflection into policy-relevant guidance. The findings suggest that preparing ethics advisers requires educational approaches that extend beyond traditional philosophy curricula and involve cooperation with other academic fields. Moreover, attention should also be given to the competences of those who receive ethics advice within public administration. Finally, the paper highlights the potential role of academic societies in supporting training, exchange, and dialogue on ethics advice. Strengthening these capacities can enhance the contribution of academic ethics to governance and public decision-making. The paper also highlights the role academic societies can play in supporting training, exchange, and dialogue in this area.

Keywords: ethical judgement, ethical competence, ethics education

Introduction

In order to address the regulatory challenges arising from technological change, environmental transformation, and evolving societal expectations effectively, public administrations must complement political and legal considerations with explicit ethical reflection. This, in turn, requires dedicated ethics expertise. Ethics advice for public policy involves identifying the central normative issues within policy debates and assessing them in a careful and disciplined manner. It further presupposes familiarity with the legal frameworks within which policy decisions are taken, as well as an understanding of the institutional dynamics that shape policy-making processes. Ideally, ethics advisers remain attentive to broader social developments and are able to anticipate the emergence of new ethical challenges. Yet the

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combination of knowledge, expertise, and practical skills required for this work is not typically a central focus of standard academic training.

Against this background, the project *Applied Ethics in Public Policy* addressed two questions. First, which forms of knowledge, competences, and skills are required by those who provide ethical advice within public administrations? Second, how can university teaching in ethics contribute to the development of these capacities? These questions bear not only on the training and recruitment of individuals who work in ethics advisory roles within public administration and/or legislation processes. The project is also guided by the view that engaging with such practice-oriented questions within universities can enhance both the practical relevance and the intellectual quality of academic ethics education (Fehling and Meisch, 2009).

The project was conducted at the University of Tübingen (Germany), in cooperation with the Swiss Federal Ethics Committee on Non-Human Biotechnology (ECNH) and the Chair of Applied and Normative Ethics at the University of Zürich (Switzerland). As part of the project, two lunch-to-lunch workshops were organised in June and November 2025. They brought together practitioners involved in ethics advisory bodies and committees, as well as scholars working in university ethics teaching and higher education didactics.

The paper proceeds as follows. First, we outline the specific challenges that arise in ethical judgement within public policy contexts and discuss the institutional conditions under which ethics advice is provided in public administrations. We then present the results of stakeholder workshops identifying key competences required for effective ethics advice. Building on these findings, we discuss implications for university teaching in ethics and consider the potential role of academic societies in supporting the development of these competences.

Ethics advice in public administration

Ethics advice within public administrations faces two key challenges: the competent handling of the complexities of ethical judgement (cf. figure 1) and the skilful exercise of this capacity within institutional constraints and legal frameworks.

If the practical syllogism is taken as a basic model of ethical reasoning (Dietrich, 2009), ethical judgement can be understood as comprising three elements: a descriptive premise, a normative premise, and a conclusion derived from their conjunction. A central competence lies in relating these premises coherently to arrive at a well-founded conclusion, which also requires critically scrutinising each component. Reconstructing such reasoning is demanding, as both descriptive and normative premises may be contested. Where tensions arise, those engaged in ethics advice must make underlying assumptions transparent, assessing the epistemic status of both normative and descriptive claims. Normative premises must be situated within a metaethical perspective, while descriptive premises require evaluation against standards from philosophy of science (for an illustration of the practical relevance of these perspectives, see Kalfagianni and Meisch, 2020). In practice, analysing and reconstructing ethical reasoning is more complex than this simplified model suggests. Figure 1 differentiates the challenges involved and highlights both the need for expertise in problem exploration and reflexive analysis and the mastery in translating ethical assessment into action-guiding recommendations.

Beyond these analytical challenges, ethics advisory in public administration faces additional structural difficulties (Willemsen and Bachmann, 2024). First, ethics is often misunderstood as moralising rather than as a systematic academic discipline, which can generate critical thinking within institutions. Second, ethical analysis operates in a complex relationship with law and politics: administrations are

bound by legal frameworks and political mandates, while ethics addresses normative justification. Third, ethical reasoning must be translated into accessible language and integrated into interdisciplinary policy processes. Fourth, administrations require timely, practically applicable guidance, which external academic ethics cannot always provide. Finally, ethics advice must remain independent while operating under political pressures and expectations for clear solutions to complex value conflicts (cf. also Majone, 1989; Gluckman et al., 2021).

Results

The project's stakeholder workshops explored the competences required for effective ethics advice in public administrations. The discussions proceeded in three stages. First, participants engaged in a brainstorming exercise to identify competences relevant to ethics advice in public administrations, with due regard both to the complexity of ethical judgement and to the practical contexts of decision-making. Second, the competences identified were grouped under recognised competence categories: subject competence, methodological competence, social competence, and personal competence. Third, participants considered whether any important competences had been overlooked. Table 1 summarises the main findings (based on BLK, 2007).

Discussion and further steps

The project *Applied Ethics in Public Policy* takes as its starting point two questions. First, which forms of knowledge, competences, and skills are required of those who provide ethical advice within public administrations? Second, how can university teaching in ethics contribute to the development of these capacities?

Over the course of the project, an overview of the competences, skills, and forms of knowledge required for ethics advice was developed. This overview was presented to members of the ECNH and regarded as helpful.

The workshop discussions also showed that many of these requirements extend beyond a purely philosophical or ethics education. Some correspond to classical key competences, including those listed

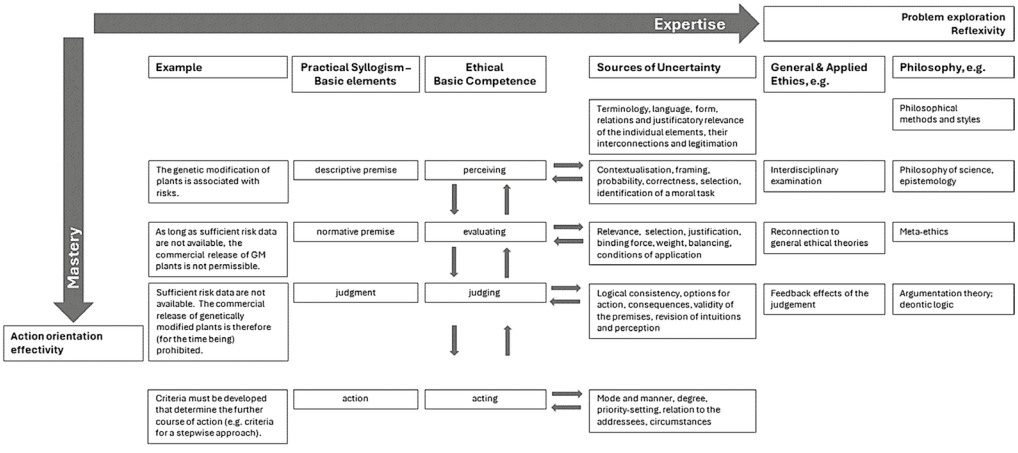


Figure 1. Elements and complexities of ethical judgement (based on Dietrich, 2009, p. 67)

Table 1. Selection of key competencies for ethics advice in public administrations

Subject competence
= Ability to acquire, understand and apply knowledge and skills to recognise relationships and to analyse and evaluate issues or developments in an informed manner.
Knowledge • Ethical approaches • Philosophy of science and epistemology • Administrative procedures; regulatory and advisory contexts
Skills • (Re)constructing arguments • Formulating, justifying, and prioritising alternatives
Methodological Competence
= Ability to select and apply appropriate methods and strategies to obtain information, analyse issues and develop solutions.
• Working in inter- and transdisciplinary settings • Translating knowledge across disciplinary boundaries • Analytical thinking • Identifying and communicating uncertainties • Anticipating critical issues at an early stage • Making regulatory needs transparent
Social Competence
= Ability to communicate and cooperate responsibly with others while recognising and considering different perspectives and interests.
• Capacity for dialogue and attentive listening • Curiosity, empathy, and perspective-taking • Encouraging others to articulate their arguments • Diplomacy and the ability to work in committees
Personal Competence
= Ability to reflect on one's own attitudes and actions, assume responsibility and make considered decisions based on personal values.
• Dealing with disciplinary arrogance (one's own and others') • Perseverance • Building trust and credibility • Making one's own standpoint explicit • Maintaining critical distance from the issue and the process

under social competences (cf. table 1). This observation shifts the project's focus beyond interdisciplinary ethics teaching. Preparing students for roles as ethics advisors in public administration therefore requires cooperation with other fields within the university.

The discussions also revealed a further point that had not been anticipated at the outset. Attention must also be given to the capacities of those who receive ethics advice. They must be able to understand and critically engage with the analyses offered by ethics advisers. This led to a third guiding question: which forms of knowledge, competences, and skills are required of those who seek or receive ethics advice?

This suggests a differentiated approach to university education. One track should prepare students who may later provide ethics advice in public administrations. Another should address those likely to occupy positions in which they themselves will be advised. The next step is therefore to develop teaching formats that take both perspectives into account. In doing so, it is important to distinguish between what can reasonably be taught at the university and what must be acquired through professional practice in ethics advice within public administration.

Finally, the project also raises questions about the status of applied ethics within academic philosophy. Courses designed to prepare students for ethics advice in public administrations have a potential that extends beyond this immediate purpose, as they also demonstrate to students the practical significance of ethical reflection. At the same time, applied work still appears to receive less recognition within academia than research primarily oriented towards the internal debates of the philosophical discipline.

Relevance of academic societies

Academic societies such as EurSafe can play an important role in strengthening the capacities required for ethics advice in public administrations. Their contribution relates to the forms of knowledge, competences, and skills identified in the project *Applied Ethics in Public Policy*.

First, academic societies contribute to the development and consolidation of subject competence. By organising conferences, supporting scholarly publications, and fostering international research networks, they help structure and advance knowledge on ethical questions in agriculture, food systems, and environmental governance. In doing so, they provide a forum in which ethical approaches, conceptual frameworks, and interdisciplinary perspectives can be critically discussed and further developed, thereby strengthening the knowledge base required for reconstructing and assessing ethical arguments in policy and legislation contexts.

Second, academic societies create spaces for methodological learning and exchange between disciplines and professional contexts. Conferences, workshops, and thematic working groups enable scholars, practitioners, and policymakers to discuss emerging ethical challenges and reflect on suitable analytical approaches. Such encounters facilitate the translation of knowledge across disciplinary boundaries and increase awareness of the uncertainties and complexities inherent in ethical judgement within policy and legislation processes.

Third, academic societies can support the training and professional development of future ethics advisers. Through summer schools, early-career networks, mentoring activities, and collaborative teaching initiatives, they complement university curricula and expose students and early-career researchers to the practical contexts in which ethical expertise is applied.

Finally, academic societies provide an important arena for deliberation and dialogue. By bringing together scholars from different countries and disciplines, as well as stakeholders from policy and civil society, they foster discussion of normative conflicts and emerging issues. In this way, societies such as EurSafe strengthen the interface between academic ethics, policy processes, and societal deliberation.

Given EurSafe's aims – to promote international research and teaching in agricultural and food ethics, to facilitate the exchange of experiences in addressing ethical issues, and to encourage training and education in this field – a stronger focus on ethics in public administrations appears a particularly suitable way of advancing these goals. Addressing the competences required for ethics advice would not only support research and debate but also contribute to the training of scholars and practitioners capable of engaging with ethical challenges in governance.

Conclusion

This paper has examined which competences are required for the provision of ethics advice in public administrations and how academic education may contribute to their development. The analysis indicates that effective ethics advice requires not only philosophical knowledge but also subject-specific, methodological, social, and personal competences that enable engagement with complex policy and

legislative processes. Ethics advisers must be capable of analysing arguments, communicating across disciplinary and institutional boundaries, and translating ethical reflection into practically relevant guidance. Strengthening training in these areas, and fostering collaboration between universities, practitioners, and academic societies, may help to prepare both ethics advisers and decision-makers to address emerging ethical challenges in governance contexts. Future research should further examine how these competences might be systematically integrated into curricula and evaluated in practice.

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What good is basic animal research?

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Abstract

Basic research with animals and its regulation is plagued by the paradox of justifying harm to animals by the societal benefits of basic research, which nevertheless are not insight and might never be generated. It has been proposed to limit assessment of basic research's benefits to *knowledge* benefits. Yet, this raises the question what good basic research is, and whether and why knowledge and knowledge acquisition as such can justify (what) harm to animals. To come to a better appraisal of basic research, it is pivotal to lay bare two presuppositions of harm-benefit analysis (HBA) in the regulation of animal research. First, HBA is fragmentist because it focuses narrowly on single experiments or projects, while scientific breakthroughs commonly come about after years of experimentation and failures, and in a serendipitous way. Second, HBA is instrumentalist because it is premised on a means-ends relationship that blurs the significance of science to human life and society. Therefore, LaFollette and Shanks' 1996 suggestion that animal research should be considered as an *institutional practice* is caught up with. Conceptualizing (animal) research as a practice has two distinct advantages. First, it emphasizes that animal research is something that people *do,* where what they do builds on the work of those that went before them and the technical artefacts and conceptual models so far developed, constituting *research traditions*. This challenges the fragmentist nature of HBA. Second, practices have a *teleological* structure and are directed at goods, one of which provides the *telos* of that practice at that time. Animal research as a (natural) science is directed at understanding and explaining phenomena related to animals in cause-effect relations. This telos orders the practice of animal research, such that students are habituated and enculturated into the craft and mores of the scientific community. As such, animal research represents an 'irreducibly social good' (C. Taylor). HBA is therefore unfit for the assessment of basic research. It is concluded that we have to shift from an act-consequentialist framework of HBA to one in which the deontological perspective can be incorporated.

Keywords: harm-benefit analysis, fragmentist, instrumentalist, practice

Introduction

In the EU-27 and Norway together almost 8 million animal experiments are performed annually (European Commission 2023). All these animal experiments have been subject to project evaluation as laid down in the relevant legislation, most important of which is the Directive 2010/63/EU (The European Parliament and The Council Of The European Union 2010). Only when research projects are judged to comply with the principles of Replacement, Refinement and Reduction and yield more benefits for human beings, animals or the environment, than they will cause harm to the animals – the so-called harm-benefit analysis (HBA) – animal research is legally allowed within the European Union (The European Parliament and The Council Of The European Union 2010, arts 38, §2).

Basic research is considered to be 'be a suitable objective in its own right' for animal research (Expert Working Group for Project Evaluation and Retrospective Assessment 2013, 11). Yet, 'wherever possible, 'increased knowledge' as the primary benefit should be linked to a more tangible strategic goal, even though any wider benefits may be much further in the future and less predictable' (Expert Working

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Group for Project Evaluation and Retrospective Assessment 2013, 21). Benefits that potentially justify animal research therefore have to go beyond a 'it would be nice to know'.

Harm-benefit analysis: fragmentist

There are several problems with HBA though, which come to the fore in relation to basic animal research. The first is that HBA is *fragmentist* because it focuses narrowly on single experiments or projects. It presupposes that an individual research project potentially leads to tangible benefits for society. Yet, research projects build on each other's results and insights in the development of theories and artefacts like drugs. A particular research project may be the final step before proving the safety and efficacy of a drug, but this is not sure beforehand. There is uncertainty with regard to the specific outcome of the research project, precisely because it is experimental research. This can be called *scientific* uncertainty which is inherent to every scientific endeavour (Niemi 2021; Eggel et al. 2020; Eggel and Grimm 2018; Grimm and Eggel 2018, 2017; Grimm et al. 2017). However, there is also uncertainty with respect to non-scientific factors, such as market potential of a product, end user adoption and compliance, lobbying, and Intellectual Property issues. All these latter factors might prevent the successful practical implementation and use of products that come out of a research pipeline. This can be called *practical* uncertainty (idem).

Furthermore, an important role is also provided for serendipity within basic animal research. In a special issue in the ILAR Journal on serendipity within laboratory animal research, serendipity is described as referring to events that are unanticipated, anomalous and strategic (Morton and Swindler 2005). One of the examples mentioned is Harry Harlow's (infamous) studies of attachment and mother love with resus monkeys. Those studies were not initiated based on theory or prior investigations. They rather originated from the unhappy event that a shipment of pregnant resus monkeys – bought for the purpose of work on brain and intelligence – were found out to be infected with tuberculosis, were killed to prevent infecting the rest of the colony, and subsequently observing unusual behaviours in the motherless infants. This was not anticipated, deviated from what the researchers expected in terms of behaviour, and was strategic to subsequent studies into infant development and socialization.

Had Harlow's initial work on brain and intelligence in resus monkeys been subject to HBA, serendipitous knowledge and potentially societal benefits related to subsequent studies into infant development and socialization would not have been part of the HBA, even though, retrospectively, those benefits might have been considerable.

Harm-benefit analysis: instrumentalist

It was already noted that in the regulatory prescribed HBA, basic research is a suitable objective in its own right, even though were possible it should be linked to a 'tangible strategic goal'. More specifically, the Expert Working Group (2013, 21) writes that 'assessment of projects with early applied benefits ... lend themselves much more readily to a harm/benefit assessment than a project where advancement of knowledge in a particular scientific discipline is the primary benefit expected.' As such, the regulatory prescribed HBA is *instrumentalist*: the value of animal research derives primarily from the societal benefits it might generate.

As an alternative to HBA, it has been proposed to limit assessment of basic research's benefits to knowledge benefits specifically (Grimm et al. 2017; Grimm and Eggel 2018, 2017; Eggel and Grimm 2018; Eggel et al. 2020), also coined 'harm-knowledge analysis' (HKA) (Grimm and Eggel 2018). The focus of HKA is on evaluating the expected knowledge contribution of a project to a research field, as appears from 'scientific merit, strength of the hypothesis, experimental setup, among others' (Grimm

and Eggel 2018, 410). This tackles the issue of practical uncertainty, because the assessment of benefits is limited to knowledge benefits. The scientific uncertainty remains because prospectively it is unknown what the *extent* of the knowledge gain will be. Still, every animal research project can be considered to have *epistemic value* because whether a hypothesis is verified or falsified, more is known after than before the project.

Eggel et al. (2020, 137) note that 'the most obvious cases of 'knowledge worth having' will be cases where the value of knowledge is that it is a means to an end.' So here, epistemic value is again derivate from any societal benefits that might be generated. That is also why Eggel et al. (2020) propose to perform *HKA* on individual project level, and *HBA* on the level of whole research fields because it is whole research fields that generate scientific and societal benefits rather than individual projects.

Still, Eggel et al. (2020, 137) do allow 'that some people have an interest in generating knowledge for its own sake, and so an argument could be made that some knowledge is intrinsically valuable.' But what could such an argument look like?

Animal research as practice

Also Hugh LaFollette and Neill Shanks (1996) have observed that animal research as a whole can benefit humans, but that no isolated experiment can. They argue therefore that 'animal experiments are part of a pattern of activity – an institutional practice' (LaFollette and Shanks 1996, 250). Conceptualizing basic animal research as a practice, challenges the fragmentist nature of regulatory prescribed HBA. Animal research is something that people *do*, where what they do builds on the work of those that went before them and the technical artefacts and conceptual models so far developed, constituting *research traditions*. These elements have been elaborated as to its cognitive aspect by Larry Laudan who describes research traditions as 'a set of ontological and methodological 'do's' and 'don'ts'' (Laudan 1989). With Alasdair MacIntyre such do's and don'ts can also be called 'standards of excellence' (MacIntyre 1985). It is on the basis of these standards that scientific practitioners judge each other's work.

Bruno Latour (1993) has especially emphasized the role of technical artefacts in the production of theories, such as Boyle's air pomp in physics. The do's and don'ts and technical artefacts connect current scientific practice to the past and previous and present scientific practitioners. This challenges the fragmentist presupposition of regulatory prescribed HBA.

LaFollette and Shanks add that with conceiving of animal research as practice, the *moral* question shifts from evaluating individual research projects to: "should we continue the practice of animal experimentation?" (LaFollette and Shanks 1996, 250–51). Conceiving of basic animal research as practice provides guidance in response to this latter question too. Vis-à-vis the instrumentalist nature of regulatory prescribed HBA, conceiving of (basic) animal research as a *communal practice* foregrounds the 'teleology internal to praxis' (Ricoeur 1992, 173) with 'shared goods seen as having intrinsic value' (Hicks and Stapleford 2016, 454).[5] That is, goods of animal research practice are 'irreducibly social' (Taylor 1995, ch. 7) and directed at understanding and explaining phenomena related to animals in cause-effect relations. Practices are only possible because there is a common understanding of what is at

[5] MacIntyre speaks of 'social practices', but Hicks and Stapleford make a good case that we rather should be speaking about 'communal practices': "Driving a car (though surely a social practice) would not constitute a communal practice for MacIntyre, but playing chess is one of his favorite examples. Both drivers and chess players are accountable to social norms (instantiated in the rules governing each activity), but chess players form a community in which they not only compete with each other but also work together to advance shared goods seen as having intrinsic value – namely, the art of playing chess" (Hicks and Stapleford 2016, 454).

stake within that practice and what standards of excellence apply. And the value of scientific practice, at a very basic level, is part of the common understanding carried by scientific practitioners.

An example to illustrate this point is the idea, articulated by Trevor Poole (1997), that 'happy animals make good science.' The attention to animal welfare within laboratory animal research is framed here, not only as ethically imperative, but as being instrumental to doing good science. There is thus a certain conception of what counts as good science, and, in this specific case, a particular standard of excellence in relation to housing animals is being challenged in the name of doing good science. And, most importantly, the value of doing science is not questioned but rather presupposed.

This is not to deny that 'if a practice has goods with intrinsic value, that can only be because practitioners embed those goods within broader views of what constitutes a meaningful life or way of being in the world' (Hicks and Stapleford 2016, 469). There is here a 'finality within finality' where 'a vocation confers upon the deeds that set it in motion this very character of an 'end in itself'; and yet we never stop rectifying our initial choices' in light of ideas about the good life and standards of excellence for human life as such (Ricoeur 1992, 178–79). That is, animal research is not merely good because it might provide epistemic and societal benefits, but, on a more basic level, is a 'human good' (Pollo and Vitale 2020, 199, 210). Such a virtue ethical outlook departs from the instrumental utilitarianism that characterizes regulatory prescribed HBA and aims to articulate why basic animal research might be a worthwhile endeavour apart from its potential instrumental benefits. This would also do justice to the recognition within the regulatory framework of basic animal research as valuable objective in its own right.

Conclusion and implications

In this paper I have tried to articulate why the regulatory emphasis on societal benefits of animal research in the form of HBA is both fragmentist and instrumentalist. Least controversial is the claim that HBA is fragmentist, and that for a good appraisal of the epistemic and societal benefits of animal research, a much broader perspective is required that the individual project level. More controversial is the claim that (animal) research has value in itself, apart from any instrumental societal benefits that might or might not result. The virtue ethical tradition provides a vocabulary to articulate the inner teleology of animal research, and its relationship to ideas of the good life.

What follows for the regulation of animal research? Given the importance of standards of excellence in a conception of animal research as practice, an act-consequentialist framework of HBA can no longer be maintained. With Pollo and Vitale (2020) I would propose a virtue ethical recognition of the significance of (animal) research for human life and society in terms of being a locus of living the good life. Recognizing this, however, forces on us all the more the importance of the deontological perspective, because communal practices are historically tight up with *violence*. In this line, Paul Ricoeur reads Rawls' difference principle as a deontological principle at the institutional level, which refuses 'to sacrifice some unfavored individuals or groups if that is required by the good of the greatest number' (Ricoeur 2000, 52). It is a matter of further investigation whether, and in how far, such an approach can be made fruitful for the regulation of animal experimentation (compare Tanner 2011).

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Can some nonhuman animals be considered epistemic agents? Conceptual analysis and ethical implications

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Abstract

It is historically assumed that nonhuman animals lack – or have a very low level of – multiple complex psychological capacities, such as autonomy, mindreading, beliefs, language, intentionality, rationality, consciousness or metacognition. This view has perpetuated the idea that nonhuman animals are epistemologically inferior to humans, building an artificial scala *naturae* and justifying their use, exploitation, and lack of rights. In this article I challenge this statement. To do so, I want to answer the question of whether nonhuman animals can be considered epistemic agents, or whether this characteristic is exclusively human. In order to answer this question, I develop a methodological and conceptual analysis to determine whether animals can possess epistemic agency. I argue that, in the relevant sense and using a specific theoretical framework, animals can also be epistemic agents. To justify this claim, I argue that while neurotypical humans are the paradigmatic case of epistemic agents, this does not preclude a gradual epistemic continuity towards other species. I maintain that epistemic agency is expressed gradually and not as an all-or-nothing trait in other species or neurodivergent humans. My purpose, therefore, is not to determine which species can be considered to possess epistemic agency, but to develop a criterion and establish a new conceptual framework to determine how nonhuman animals can be genuine epistemic agents. The paper proceeds as follows. First, I develop a conceptual analysis to define what it means to be an epistemic agent. I then identify different necessary capacities for such attribution. This allows me to elaborate a minimal notion of epistemic agency based on different capacities. Later, I review some observational and empirical evidence to illustrate the applicability of my proposal, arguing that at least some particular animal species are capable of exhibiting the aforementioned characteristics and, therefore, can be considered epistemic agents. I also offer counterexamples in which some species do not fulfill the presented criterion or the evidence we have is not yet conclusive. I conclude by articulating two possible criticisms, and the benefits and ethical implications that arise from studying the existence of epistemic agency in animals.

Keywords: animal ethics, epistemology, agency, comparative psicology, epistemic injustice

Introduction

Could a creature be considered an epistemic agent if it is incapable of operating with propositional content? What kinds of thought and psychological capacities allow us to attribute this agency to a creature? Are there empirical evidences to support attributing epistemic agency to specific nonhuman animal species? Beyond these questions that will be addressed in this article, many philosophers currently agree that the sophisticated and flexible behavior of certain nonhuman animals (hereafter animals) gives us sufficient good reasons to be explained by attributing complex mental states to them (Glock 2000, 2009; Andrews 2020). Beyond this common ground, a debate continues regarding what kind of thought, and if some type of knowledge, can be ascribed to animals and how their minds operate. In this article, I will delve deeper the following question: are there animals that can be recognized as epistemic agents?

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Prima facie, it would seem plausible to delineate a difference of type between humans and animals in relation to the mental content they have to act driven merely by behavior or by actions. Despite this intuition, I will argue that, while neurotypical humans are the paradigmatic case of epistemic agents, there are multiple ways to define this attribute, making it possible to include animals as epistemic agents given an alternative understanding of this type of agency. My aim is to propose a conceptualization of epistemic agency that neither considers excessively strict conditions in terms of the psychological requirements that it demands nor is it deflationary and overly permissive. These difficulties require a conceptual clarification of what is meant by agency and epistemic agency, given the current debate, both in the philosophy of the animal mind and, also, in the philosophy of artificial intelligence, where these notions have taken on a relevant role and can offer me some guidance (Coeckelbergh 2026; Schlosser 2019).

The motivation for undertaking this task is multiple. First, I recognize a gap in the literature regarding the conceptualization of epistemic agency in animals. Although philosophers such as Ernest Sosa (2013), Nikolaj Nottelmann (2016), and Lauren Woomer (2019) have theorized about this type of agency, their analyses either fail to establish a current and rigorous definition of epistemic agency, or they mention it without paying sufficient attention to its constituents, treating it as a secondary resource for their main work, or they do not consider that such agency can be applied beyond the human paradigm. Second, I maintain that deepening and clarifying epistemic agency in animals offers new tools for overcoming the problems inherent in, for example, following a sentientist approach (Monsó and Hintze 2023). Third, in a epistemic injustice context, I consider that offering an analysis of epistemic agency that takes into account animals as a central case study opens the door to theorizing about the existence of this type of injustice from a dimension of their psychological capacities that has not yet been explored by the philosophers who have expanded Miranda Fricker's (2007) conceptual framework to animals (Dotson 2011; Lopez 2023; Podosky 2018; Skretta 2025; van den Brandeler 2024).

Epistemic agency

Before answering my research question, I need to clarify some concepts regarding epistemic agency. To this end, I will first clarify the meaning of three terms that I consider relevant to my argument and that may cause confusion: agency, modest propositional contents, and perceptual agency. This, at the same time, will allow me to justify why epistemic agency is restricted to access consciousness without depending on phenomenal consciousness.

A given subject S is understood to be an agent if that being has the capacity to act, and its agency refers to the capacity to carry out that capacity (Schlosser 2019). This definition allows many beings to be considered agents, regardless of the species to which they belong. Simply put, what is necessary and sufficient to be an agent is having the possibility of acting, regardless of the mental processing taking place and the mental content involved. Jeff Sebo (2017) understands agency in a more restrictive way. For him, "you are an agent if and only if you have the capacity for propositional thought" (p. 1). This more demanding definition is also ascribed to Harry Frankfurt in which agency involves acting for reasons. That is, it involves propositional agency from which the subject acts "based on judgments about what we have reason to belive, desire and/or do" (p. 4). Following Sebo's definition, Bermudez (2006) argues that propositional thought requires propositional language. However, Dorothy Cheney and Robert Seyfarth (2007) argue against this. Indeed, there are animals that think and act propositionally, regardless of whether they can speak propositionally (Sebo 2017, p. 5). This is why Sebo introduces a particular type of agency that allows us to explain subjects' actions without resorting to propositional thought: perceptual agency. Sebo defines this agency as psychological dispositions that shape our perceptual experience, causing us to treat certain objects and motivating us to treat them in a particular way (Ibid., pp. 6-7).

Sebo's proposal offers me a minimal starting point for situating epistemic agency. On one side, there is sensory agency, and on the other, propositional agency. While the former establishes a minimum limit that a large number of animals can satisfy, the latter marks a threshold beyond which the demand is too high to leave room for animals. Thus, Laura Danón's (2022) proposal of modest propositional content (MPC) would fall between the two aforementioned agencies, allowing epistemic agency to flourish. To explain this, I must first clarify what Danón means by MPC. According to her, a creature demonstrates that it operates under modest propositional content if:

1. Sometimes, her behavior shows common elements which can be explained by the fact that she is deploying the same property concepts in different situations.
2. Other times, her behavior shows variations from one situation to another which are explainable by the fact that she is attributing different properties to each of them.
3. Both in (1) and (2), there are other aspects of the creature's behavior that depend on whether she is attributing the relevant properties to the same or different particulars. (p. 12)

Her definition allows, on the one hand, structural content, that is, that the subject has thought composed of redistributable and recombinable representational units, and that she is able to re-identify the same details over and over again and attribute to them, in different situations, different properties (p. 5, 15).

Thus, having established the two boundaries between perceptual and propositional agency, and having shown that the MPC lies between the two – being more demanding than the former but less so than the latter – I can define and propose a notion of epistemic agency. I define epistemic agency as the capacity of a subject S to form and revise beliefs through reflective rationality. Therefore, this agency refers to a subject's ability to control certain beliefs by evaluating evidence as evidence, consciously investigating it, and using reasoning for its evaluation (Korsgaard 2018). In other words, it requires that subject S have a certain degree of consciousness and, at the same time, be capable of responding reflectively to evidence, i.e. reflective rationality (Melis and Monsó 2023).

In conclusion, and briefly due to space limitations, this definition allows us to encapsulate epistemic agency strictly within access consciousness without having to postulate phenomenal consciousness in the study. Access consciousness is then understood to be defined, following Block's (1995) work, as follows:

> A state is access-conscious (A-conscious) if, in virtue of one's having the state, a representation of its content is (1) inferentially promiscuous, that is, poised for use as a premise in reasoning, (2) poised for rational control of action, and (3) poised for rational control of speech. (p. 231)

Empirical evidence of epistemic agency in nonhuman animals

Up to this point, I have attempted to clarify the concepts I am using in order to offer a definition of epistemic agency and, finally, to identify two cognitive capacities – consciousness and reflective rationality – as minimal constituents of such agency. In this section, I want to go a step further and offer examples of empirical evidence showing that at least adult mammals over one year of age can potentially be categorized as epistemic agents. To this end, I briefly analyze two cases: dogs (*Canis familiaris*) and vervet monkeys (*Chlorocebus pygerythrus*).

There is evidence suggesting that dogs modify their behavior and evaluate the trustworthiness of the person offering them a reward or information if they have been deceived by that person before (Takaoka et al. 2015). This shows that, on the one hand, dogs have a certain degree of consciousness and, on the

other hand, they show reflective rationality to evaluate their situation These facts make it plausible to consider dogs as episystemic agents.

Another example of the possible emergence of epistemic agency is that of vervet monkeys and their alarm calls. Studies conducted by Cheney and Seyfarth (1988) showed how vervet monkeys can epistemically evaluate and modify their behavior depending on the subject emitting an alarm signal and their truthfulness. This flexibility suggests, although it is debatable, that these monkeys are potential candidates for epistemic agents, possessing a certain degree of consciousness and possibly exhibiting reflective rationality.

Ethical implications and epistemic injustice

Theorizing the possibility of attributing epistemic agency to animals has ethical implications. On the one hand, recognizing their capacity as knowers opens up a whole new debate on the multiple ways in which a dimension beyond sentience can be harmed, taking into account the complex psicological capacities of animals. Thus, given the rise of the Effective Altruism (EA) school of thought, it can be argued against them that the ways in which an animal can be harmed go beyond its capacity to experience pain. The fact that animals can be genetically modified to not experience pain (Shriver 2009), if we recognize them as epistemic agents, opens the possibility of harming them in a dimension that these philosophers do not consider.

On the other hand, proposing that certain animals can be considered epistemic agents offers tools to expand and refine the applicability of Miranda Fricker's proposal on epistemic injustice (2007). If certain animals that are exploited and silenced in Western society are recognized as epistemic agents, it becomes more difficult to overcome the alienation that exists between subject and object when an animal is reduced to a consumer product (Adams 2010). It is possible to apply the concepts of testimonial injustice and hermeneutic injustice to those epistemic agents whose needs are not taken into account or considered seriously when it comes to flourishing according to their needs (Nussbaum 2022; Webb 2025, p. 89).

Criticisms

Up to this point, I have offered a framework for the applicability of epistemic agency to a very limited number of animals: adult mammals. This is open to criticism, and it is possible to argue that this choice is conservative and remains a minimal proposal. I want to respond by offering the same answer given by Tom Regan in his book *The Case for Animal Rights* (2004), arguing that given the lack of theorizing on epistemic agency in animals and the difficulty of drawing a line that strictly delimits one animal from another. This work offers a first approach to the case in question and allows, if argued in its favor, the scope of applicability of the initial proposal to be broadened. At the same time, one can criticize the absence of the speech component that constitutes point (3) of the definition of access consciousness. I believe that although from an evolutionary and non-logocentric perspective one can argue that certain species possess complex communication (Meijer 2019, 2019a), this capacity is irrelevant for ascribing epistemic agency to them in the sense I have been arguing here. Their communication skills are important to them, but they are neither necessary nor sufficient for the analysis of this work.

Conclusions

Regarding the question this paper sought to answer: can some nonhuman animals be considered epistemic agents?, I can conclude that, given the conceptual analysis and theoretical framework based on the work of Sebo (2017) and Danón (2022), it is plausible to consider at least some animals, such as

adult mammals, as epistemic agents. I have defined epistemic agency as the capacity of an individual to control certain beliefs by evaluating evidence as evidence, consciously investigating it, and using reflective reasoning to assess it. Finally, I have offered empirical evidence supporting the satisfactory applicability of this criterion to at least dogs and vervet monkeys.

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Intervening in the carnist bias to encourage compassion for farmed animals

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Abstract

Because we are born and raised into the violent ideology of carnism most of us consumers form and internalize all sorts of beliefs that we unconsciously apply as rationalisations to solve the cognitive dissonance caused by the meat and dairy paradox. These paradoxes imply that even though consumers do not want animals to get hurt, they still want to continue consumption. We define these rationalisations as the carnist bias: *"the beliefs and associated attitudes in favour of the interest and desire of humans to consume animal-source foods over the interest and desire of farmed nonhuman animals not to be harmed"*. Most of these beliefs are prejudices allowing consumers to suppress their moral virtue of compassion towards farmed animals while at the same time maintaining an image of oneself as a morally good person. In this paper we argue for an intervention inspired by the Socratic Method and Visual Thinking Strategies that could encourage this compassion by motivating the intellectual virtue of *phronesis*, with the hopes of reducing meat and dairy consumption.

Keywords: meat and dairy paradox, prejudices, *phronesis*, Socratic method, visual thinking strategies

Introduction

Most humans, in particular in Western societies, have a cultural belief that it is acceptable to use farmed nonhuman animals (henceforth animals) to satisfy their desire for meat and dairy. To keep up production and meet consumer demand, most animals are kept in factory farms, causing severe harm. For example, to produce pale-coloured flesh, 'veal' calves are deliberately kept anaemic by feeding them an iron-deficient diet which can result in reduced consciousness (Singer, 2009). Joy (2020) argues that we form this collective belief because we are born and raised into the violent ideology of carnism: 'carn' for flesh or of-the-flesh and 'ism' referring to a belief system. The meat and dairy industry teaches consumers to believe and accept certain justifications for meat and dairy consumption, which Joy defines as the three N's. Consumers come to believe that consumption is *normal* – it is the dominant societal norm as most people in Western societies do it; *natural* – it has a (bio)logical basis as it refers to the natural superiority of humans over animals; and *necessary* – we need animal-source foods for our health and existence. Moreover, from an early age we are taught to classify animals into those we love as family members and those we eat, allowing us to see the latter as objects lacking individuality rather than beings who deserve moral consideration (Joy, 2020; Rothgerber, 2020). Consumers unconsciously apply these learned justifications as rationalisations to cope with the cognitive dissonance caused by the meat and dairy paradox (Loughnan *et al.*, 2012; Kunze, 2026). These paradoxes imply that even though consumers are worried about harmful practices against animals, they still want to continue consumption which causes them to feel morally conflicted about their eating behaviour. Applying rationalisations, especially the three N's, reduces a sense of personal choice and responsibility which makes consumption appear less problematic (Piazza *et al.*, 2015). Or consumers might revoke their personal agency and shift their responsibility by blaming third parties, such as farmers, for animal suffering, another known rationalisation (Nijland, 2019; Rothgerber, 2020). Next to evading responsibility another effective way for consumers to reduce cognitive dissonance is fooling themselves into believing that the animals have

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lived a good life or that they cannot suffer the same way humans do (Nijland, 2019). In order to keep these beliefs consumers choose to strategically ignore information, especially about the suffering that is really inflicted upon farmed animals (Onwezen and Van der Weele, 2016; Rothgerber, 2020). Moreover, the meat and dairy industry makes sure that these animals are kept out of public consciousness. They live and suffer behind closed doors, far away from the public eye causing consumers to dissociate from the animals and to forget about them as a once present (id)entity (Adams, 2015).

Following Regan (2004, p.128-129) in his explanation of the *"formal principle of justice"* we believe these rationalisations can be seen as *"a symptom of prejudice or bias", "showing unquestioned partiality for the members of one's own species"*, resulting in the negative treatment and judgment of animals. Therefore we define these rationalisations as the carnist bias: *"the beliefs and associated attitudes in favour of the interest and desire of humans to consume animal-source foods over the interest and desire of farmed nonhuman animals not to be harmed"*. This bias allows consumers to suppress their moral virtue of compassion, meaning the willingness and intention to take action to alleviate animal suffering, while at the same time maintaining a positive image of oneself as a morally good person (Hursthouse, 2011; Piazza *et al.*, 2015; Nijland, 2019; Pohlmann, 2022). In this paper we argue for an intervention inspired by the Socratic Method and Visual Thinking Strategies to motivate compassion for animals by addressing this carnist bias, with the hopes of reducing the consumption of meat and dairy.

Tackling the carnist bias through phronesis

Essential for practising the moral virtue of compassion, is the intellectual virtue of *phronesis*, also known as *prudence* or *practical wisdom* (Aristotle, 2019). *Phronesis* is being able to *'deliberate finely,'* through intelligence and practical reasoning, and *'in a state grasping the truth'*, the effective means to pursue moral virtues appropriate within the particular context (Hursthouse, 2011; Aristotle, 2019 p.105-106). In case of the meat and dairy paradox *phronesis* can be seen as the critical rational deliberation on how to practice compassion towards animals, depending on the particulars of the specific circumstance in which it is decided whether or not consumption can be justified and continued, and to effectively translate this into concrete daily actions (Hursthouse, 2011; Aristotle, 2019). *Phronesis* is especially useful when values conflict, which is inherent in these paradoxes. However, instead of practicing *phronesis* consumers solve this tension by acting on their beliefs within the carnist bias. Because consumers are rarely challenged to question the carnist system, this bias is mostly implicit. There is a certain *unconscious intention* involved: the desire to consume meat and dairy and the underlying beliefs influence consumers' thoughts and actions without them being consciously aware of it. Because meat and dairy are a regular and acknowledged part of Western consumption behaviour, consumers do not engage in dissonance reduction every time they consume these. Moreover, when a behaviour becomes habitual there is little or no attention for conscious reflection (Bastian and Loughnan, 2016). Something that is unconscious cannot be critically deliberated and practiced, undermining *phronesis* and the pursuit of compassion. Therefore in order to motivate *phronesis* the carnist bias needs to be addressed.

Rees (2016) describes two strategies to mitigate the behavioural effects of implicit bias. First, education could be directed towards raising awareness on and challenging the underlying unconscious prejudices. In our view most beliefs within the carnist bias can be seen as prejudices when defined in accordance with Regan (2004, p.5): *"beliefs we accept uncritically, without giving due attention to the need to understand and justify it"*. The difference with the current definition of implicit bias as only entailing social prejudices, is that ours also includes prejudices that are not directly directed towards animals, but nevertheless result in negative consequences for them (Rees, 2016). The social prejudice would be that animals cannot suffer like humans do. An example of a more indirect prejudice would be Descartes' *"prejudice of common sense"* (or common practice) or *"what we all believe"* (or do): most people (believe that it is justifiable to) consume meat and dairy and therefore it must be the right thing to do, which is found in the

'normal' rationalisation (Regan, 2004 p.9). However, acting on implicit bias occurs even in individuals who are actively trying to resist prejudice. An additional strategy is motivating empathy by supporting consumers to figure out and imagine how the harms of meat and dairy production feel for the animals involved (Rees, 2016; Gruen, 2021). This requires reflection on and correction of the information given to us in order to perceive more accurately (Gruen, 2021). Critically considering prejudices and their consequences for animals motivates *phronesis* and ensures that consumption behaviour is conducted from a more ethical and compassionate perspective, which is essential in virtue ethics. However, these are indirect strategies to mitigate implicit bias. They are directed towards controlling vicious motivations in behaviour, instead of eliminating these motivations from automatically occurring in cognition (Rees, 2016). In this way practicing *phronesis* is made dependent on the efforts of others. In virtue ethics, even more important than conducting virtuous actions are actions coming from virtuous character. This means that you do not have to think about the action itself as being compassionate, the compassionate action naturally follows from being a compassionate person (Hursthouse, 2011). The less (implicit) bias present in character, the more compassionate the person is. Therefore, even though motivating *phronesis* through indirect mitigation strategies may gradually reduce the underlying implicit bias itself, from a virtue ethical perspective the direct strategy of developing this compassionate character is even better. In our view, this means two things. First, consumers need to be able to recognise and challenge their own prejudices and take these into account when practicing *phronesis* independent of the efforts of others. Second and maybe even more important, they need to be able to prevent new prejudices from arising within them in the first place. However, not knowing they are acting on a biased belief system which means that they have the choice of becoming more compassionate, prevents consumers to think about and apply certain competencies we believe necessary for independently practicing *phronesis* and for mitigating the risk of bias from occurring in the future.

We elaborate on two important competencies, and explain how these competencies could challenge prejudices within the carnist bias. The first one is the competency of personal accountability. In *phronesis* you acknowledge and employ your own responsibility for your actions independent of the actions of others or "the norm" and without shifting it, challenging the prejudice of common sense and making meat and dairy consumption a personal choice and responsibility. The second one is the competency of awareness. According to Aristotle (2019 p.37) a *'vicious person'* is voluntarily *'ignorant of the actions he must do or avoid, and this sort of error makes people unjust'*. It is culpable ignorance to believe animals have lived a good life or cannot suffer (Hursthouse, 2011). The information is available when you are open to it and can be included in practicing *phronesis*. More awareness can therefore challenge this social prejudice. Please note that these competencies are useful in tackling any other given bias, not just the carnist bias. We believe that *phronesis* and compassion can be motivated through an intervention inspired by the Socratic Method and Visual Thinking Strategies combining the direct and indirect strategies to mitigate the carnist bias. This intervention is aimed at developing competencies necessary for recognising (and preventing) bias by raising awareness on and challenging prejudices while at the same time motivating empathy by including the negative consequences of these prejudices for the animals involved.

Motivating phronesis

The Socratic Method (SM) and Visual Thinking Strategies (VTS) are similar-structured dialogues both guided by a neutral facilitator and designed to support critical, reflective and independent thinking (Yenawine, 2013; Robertson, 2024). Next to the fact that these skills are important for sharpening ethical reasoning and practicing *phronesis*, we believe both dialogues are complementary and can be seamlessly integrated. The SM is a philosophical dialogue in which participants collectively critically examine their moral principles, beliefs and underlying assumptions about a complex ethical and conceptual matter through a basic moral question (Bolten, 2001). In our intervention this conceptual matter would be the competency, let us say the competency of personal accountability. The moral question should be

an open question that stimulates participants to investigate and reflect on their personal accountability towards farmed animals in their everyday lives when it comes to their meat and dairy consumption. It should be formulated in such a way that it evokes and challenges participants' beliefs and underlying assumptions and arguments, such as *'What responsibilities do I as a consumer have towards farmed animals when it comes to my own meat and/ or dairy consumption?'* (Nicholson, 2022). In order to accurately investigate this moral question the concept of responsibility has to be made more concrete by using a specific real-life example (Bolten, 2001; Nicholson, 2022). Moreover, it is important that participants refer to the same experience in order to stay focused on the concept under scrutiny and not deviate (Bolten, 2001). Instead of deciding on this example together as a group, as is typically done in Socratic dialogues, in our intervention the facilitator provides this concrete experience by applying VTS. To investigate and develop the competency of personal accountability we would like participants to question prejudices related to this competency. However, because these are unconscious prejudices often connected to cognitive dissonance participants will probably not come up with an example of such an experience themselves.

In VTS images and three open-ended questions are used as an invitation to critically think about and reflect on the subject matter being depicted (Yenawine, 2013). For investigating the question of responsibility and challenging the related prejudice of common sense an image selection could be a picture of slaughterhouse workers looking into the camera while having inflicted suffering on animals. According to Nietzsche (2003), being able to identify with the 'perpetrator' by depicting this evil without judgment evokes an unpleasant feeling in the spectator and forces him/ her to think about the 'perpetrator' in him/herself. This would question the established norms and motivate to discard herd morality (Nietzsche, 2003). Using the VTS-questions participants are asked to interpret and make sense of what is depicted in the image:

1. What is going on in this image? This question opens the dialogue and asks for a first perspective on the information presented in the image in narrative form.
2. What do you see that makes you say that... (the facilitator reiterates (part) of the answer given to the first question)? This question asks to provide visual evidence as arguments for/clarification of this perspective. In order to not deviate from the subject matter under consideration participants are asked what they see as compared to 'why do you say that...?'.
3. What more can we find? This question opens up the dialogue for other perspectives.

The facilitator will repeat questions 2 and 3 until no new perspectives or visual evidences are shared. These questions unravelling the shared experience are also found in the SM as probing questions. They encourage participants to critically think about and reflect on their own interpretations and interpretations of others. Through these interpretations participants share their beliefs, judgments, feelings, and personal associations in relation to the subject matter in the example (Yenawine, 2013). This exposes different narratives and opposing perspectives and contradictions in beliefs important for answering the moral question (Bolten, 2001). Moreover, VTS motivates empathy by exposing the suffering inflicted on these animals for meat and/ or dairy consumption and by supporting consumers in reflecting on and correcting biased information provided to them by the industry and maintained through their own voluntary ignorance (Rooijakkers *et al.*, 2024).

The original abstract question *'What responsibilities do I as a consumer have towards farmed animals when it comes to my own meat and/or dairy consumption?'* is clarified and replaced by the concrete VTS-session which enables the facilitator to pose a concrete sub-question that can be further investigated during the Socratic dialogue, such as *'Who is responsible for the suffering inflicted on animals for meat and dairy consumption when examining the different interpretations and arguments given during the VTS-session?'* to answer the basic moral question. Follow-up probing Socratic questions could be asked to refine (conflicting) viewpoints and reflect more profoundly on the accuracy and legitimacy of the arguments

and positions taken on the concept of personal accountability to reach a deeper, shared understanding and examine which view(s) could be correct in answering the basic moral question (Bolten, 2001; Nicholson, 2022). This intervention could be repeated for developing the different competencies and challenging all related prejudices, one competency and one prejudice related to this competency at a time.

Conclusion

In this paper we argued for an intervention inspired by the Socratic Method and Visual Thinking Strategies to mitigate the carnist bias in order to motivate *phronesis* and compassion towards farmed animals. This intervention combines the direct mitigation strategy (concerned with character building) of developing competencies necessary for recognising bias and the indirect mitigation strategies (concerned with behaviour control) of raising awareness on and challenging prejudices within the carnist bias while at the same time motivating empathy by including the negative consequences of these prejudices for the animals involved.

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Behavioural barriers and drivers for on-farm emergency killing of pigs in the Netherlands

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Abstract

The decision to end an animal's life involves ethical considerations, while the act itself entails practical and emotional challenges. To facilitate on-farm emergency killing in an ethically responsible manner, this study aimed to gain insight into barriers and drivers experienced by Dutch pig farmers during the decision-making and execution of emergency killing. Semi-structured interviews were conducted with 12 pig farmers. Data were analysed thematically using the COM-B model (Capability, Opportunity, Motivation – Behaviour) as a deductive framework. Results highlighted the multifaceted nature of on-farm emergency killing with barriers and drivers present across all domains of the COM-B model. Within the capability domain, identified barriers were gaps in farmers' knowledge about the stunning and dying process, legal frameworks, welfare implications, and a lack of practical skills and experience with approved methods. Barriers regarding physical opportunity concerned physical and legal constraints; legal methods were considered slow, costly, impractical or requiring a permit. Socially induced barriers included taboos surrounding the topic, and perceived social pressure. In the motivation domain, automatic motivations, such as emotional aversion, habits, and perceptions of prohibited methods as animal-friendly, acted as barriers. Reflected processes, particularly ethical, animal welfare and cost-benefit considerations, emerged as key drivers in decision-making. Findings illustrate that the choice of killing method is shaped by a complex interplay of cognitive, emotional, practical, and contextual factors. It underscores the need for multi-component interventions that combine education, practical training, persuasive communication by peers and role models, and social dialogue, structural facilitation, and clear regulations, while also rewarding those who adopt humane and lawful killing practices. Such interventions could support farmers in carrying out emergency killing in an ethically responsible manner.

Keywords: pig farmers, COM-B model, euthanasia, swine production, pig welfare

Introduction

The on-farm management of animal life and death remains one of the most profound ethical challenges in livestock production. On-farm emergency killing is defined as the killing of animals that are injured or have a disease associated with severe pain or suffering with no other practical possibility to alleviate this suffering. As such, it is considered a critical component of animal welfare management (Council Regulation (EC) No 1099/2009). While the act of emergency killing is grounded in the moral obligation to prevent suffering, the decision-making process is fraught with ethical, practical, and emotional complexities, often described as the "caring-killing paradox" (Arluke, 1994).

Despite its importance for animal welfare, emergency killing remains one of the most challenging areas in livestock production. Studies across different farming systems have revealed substantial variability in how farmers approach euthanasia decisions. For example, in dairy cattle production, research has shown high variability in euthanasia timelines, with some farmers selecting never to euthanize non-

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ambulatory animals despite severely compromised animal welfare (Wagner et al., 2020). Similarly, in pig farming, uncertainty about the chances of recovery and the lack of valid clinical signs for occurring diseases or injuries have been identified as major factors delaying timely euthanasia (Stoffregen et al., 2024a and 2024b). These delays represent significant animal welfare challenges that necessitate a better understanding of the factors influencing farmers' decision-making and practices.

The complexity of on-farm emergency killing stems from multiple interacting factors. Research in the context of dairy farming (Denis-Robichaud et al., 2023) shows that, on the one hand, farmers face knowledge gaps regarding the stunning and/or dying process, legal frameworks, and welfare implications of different methods. On the other hand, many dairy farmers lack practical experience with approved euthanasia techniques, and training availability varies considerably across farms. Physical and legal constraints further complicate the situation, as legally permissible methods are often perceived as slow, costly, or impractical (Denis-Robichaud et al., 2023).

Social and cultural factors add another layer of complexity. Taboos surrounding the topic and perceived social pressure can influence farmers' willingness to discuss and perform emergency killing (Denis-Robichaud et al., 2023; Mullins et al., 2017). Emergency killing carries a substantial emotional burden for farmers and farm workers. Studies have documented that caretakers experience distress, painful emotions, anxiety, failure, and guilt when performing euthanasia (Barten et al., 2025; Denis-Robichaud et al., 2023; Román-Muñiz et al., 2021). Despite these emotional impacts, many farms lack communication about on-farm emergency killing related stress and have limited awareness of available mental health resources (Román-Muñiz et al., 2021). The decision-making process is further complicated by conflicting priorities between animal welfare, economic considerations, and ethical obligations (Wagner et al., 2020).

Recent research has called for multi-component interventions to address these challenges. In Germany, research on pig euthanasia has emphasized the need to enhance clinical reasoning skills and develop a valid taxonomy of clinical signs to support timely decision-making (Stoffregen et al., 2024a). Similarly, studies in the Netherlands have highlighted the importance of targeted support for dairy farmers, combining education, practical training, and policy changes to facilitate sustainable and animal-friendly decisions (Barten et al., 2025).

Despite this growing body of literature on emergency killing in livestock farming, most studies have focused on dairy cattle. Comprehensive studies exploring the full range of barriers and drivers in pig farming systems remain limited. Moreover, few studies have employed systematic behavioural frameworks to understand the complex interplay of factors influencing on-farm emergency killing practices.

The COM-B model (Capability, Opportunity, Motivation – Behaviour) provides a comprehensive framework for understanding behaviour change by examining the psychological and physical capability, social and physical opportunity, and automatic and reflective motivation that interact to influence behaviour (Michie et al., 2011). While the COM-B framework has been used to analyse various behaviours in agricultural contexts (Clark et al., 2024; Farrell et al., 2023; Wolframm et al., 2026), its application to the sensitive topic of on-farm emergency killing remains limited. Applying this framework could help to identify specific barriers and drivers across different domains, thereby informing the development of targeted, multi-component interventions.

The present study aimed to gain insight into the barriers and drivers experienced by Dutch pig farmers during the decision-making and execution of emergency killing, using the COM-B model as a theoretical framework. By systematically examining capability, opportunity, and motivation factors, this research seeks to provide evidence-based recommendations for supporting farmers in carrying out emergency killing in an ethically responsible manner.

Materials & Methods

Research design

The study used a qualitative research design. Data were collected by means of semi-structured interviews with pig farmers in The Netherlands. Ethical approval was granted by the Research Ethics Committee of Van Hall University of Applied Sciences.

Participants

Dutch pig farmers (N= 12) were recruited as part of a larger project on the topic of on-farm emergency killing of pigs. Recruitment was aimed at obtaining a representative cross-section of pig farm types, sizes, and regional distribution in The Netherlands. Participants gave their written consent prior to the interviews. They were informed of the aims of the study as well as their anonymity and their right to withdraw. Considering the sensitive nature of the study topic, participants were informed of online mental health support for farmers.

Data collection and analysis

All interviews were conducted on-site and in Dutch. They took place April-May 2025. Each interview lasted 60-90 minutes. A semi-structured interview guide was used, consisting of introductory questions, two vignettes, and questions on decision-making, execution, and considerations regarding on-farm emergency killing. All interviews were audio-recorded. The anonymised recordings were transcribed offline in the aTrain tool, and subsequently manually checked for accuracy. The transcripts were imported in Atlas.ti 25.01.32924 and analysed using deductive thematic analysis (Braun & Clarke, 2006) with the COM-B model as the theoretical framework. Words or phrases with similar meanings were categorised into lower order themes. Each lower order theme was subsequently assigned to the relevant COM-B higher order theme, and classified as either facilitative (driver) or debilitative (barrier).

Results

Themes identified in the interviews were mapped onto the COM-B model as drivers and barriers (see Table 1). Selected illustrative quotes are presented to demonstrate how participants' accounts reflected these drivers and barriers.

Within the capability domain, responses suggested gaps in farmers' knowledge about the stunning and dying process (quote translated from Dutch by the authors):

> *"Yes, the unknown in fact, and then it dies. It doesn't feel anything anymore. However, I don't know about the process before that indeed." (Respondent H1)*

Respondents also reported gaps in the knowledge of applicable legislation:

> *"No, I cannot say. Yes, I know a captive bolt requires a permit, but other than that." (Respondent F1).*

Barriers in opportunity included physical constraints, such as the speed and practicality of legal methods:

> *"But I also heard that from farmers. It works [gas pit] but it is simply not practical and it takes long and yeah. It has to be easy and practical because yeah, you are working and it has to be done but yeah." (Respondent D1).*

Socially induced barriers included taboos surrounding the topic, and perceived social pressure:

> *"Yes, relatively rarely. Not that it is never discussed, but with a few farmers in the direct surroundings you sometimes talk about it briefly."" (Respondent G1)*

> *"The possibility that recordings are made in the pig facility. Or somebody walking in, yes that. It is a part of the choice [to kill the animal] to do that." (Respondent K1).*

In the motivation domain, automatic motivations, such as emotional aversion, acted as barriers:

> *"It is not a pleasant sight. And every farmer or pig farmer would like it to be different, nobody enjoys it." (Respondent H1).*

Reflected processes, particularly ethical, animal welfare and cost–benefit considerations, emerged as key drivers in decision-making:

> *"So in that sense, animal welfare is first and foremost of importance and the financial gains always work out well." (Respondent M1)*

Table 1. Drivers and barriers of on-farm emergency killing of pigs, mapped in the COM-B model.

Capability		**Opportunity**		**Motivation**	
Physical	*Psychological*	*Physical*	*Social*	*Automatic*	*Reflective*
Lack of experience and skill with humane killing methods **(barrier)**	Gaps in knowledge of legislation relating to killing methods **(barrier)**	Legal methods considered too slow (some illegal methods are faster) **(barrier)**	Taboos on discussing emergency killing in social environment **(barrier)**	Aversion to killing; preference for fast, easy to use method **(barrier)**	Animal welfare considerations **(driver)**
Safety concerns regarding humane killing methods **(barrier)**	Gaps in knowledge physiology of dying **(barrier)**	Cost of legal methods **(barrier)**	Concerns about public perception **(barrier)**	Aversion to blood and unpleasant aspects associated with legal methods **(barrier)**	Cost-benefit considerations of continued veterinary treatment of animals **(driver)**
	Not familiar with alternative (legal) killing methods **(barrier)**	Practicality of (legal) killing methods **(barrier)**	Lack of opportunities discussing emergency killing with veterinarian **(barrier)**	Illegal methods perceived as more humane **(barrier)**	Strict legal framework regarding animal fitness for transport **(driver)**
		Practical implications of strict legal framework regarding animal fitness for transport **(barrier)**	Social implications of strict legal framework regarding animal fitness for transport **(barrier)**	Illegal methods perceived as more hygienic **(barrier)**	

Discussion

This study mapped behavioural barriers and drivers for on-farm emergency killing of pigs based on interviews with Dutch pig farmers. Our findings show that decisions and considerations about when and how to carry out emergency killing are shaped by complex interactions of cognitive, emotional, practical, and contextual factors. The motivation to consider animal welfare is shown to be a key driver in decision making. Although economic factors and legislative frameworks play a pivotal role in emergency killing as well, all respondents expressed a strong desire to carry out emergency killings as humanely as possible.

At the same time, several barriers seemed to be rooted in animal welfare considerations as well. Some respondents expressed a preference for illegal killing methods, perceiving them to be more humane, as they appeared cleaner and more rapid. Some of the legal killing methods, on the other hand, looked unpleasant due to, for example, blood loss and peripheral muscle spasms. Respondents reported that they experienced the on-farm killing of animals as "*the worst part of being a farmer*", underlining their aversion to methods they considered cruel. This highlights the gaps in farmers' knowledge of the dying process: what appears to be animal-friendly and what is animal-friendly, are not necessarily the same.

Although it has been suggested that training programs for farmers and their staff might help to mitigate negative welfare outcomes for pigs (EFSA, 2020), addressing these challenges requires multi-component interventions that target all three domains of the COM-B model – capability, opportunity, and motivation. These interventions certainly include education and training but a more comprehensive approach is required; previous research as well as current findings indicate that farmers experience social pressure when it comes to having to perform on-farm emergency killings, and that the topic is surrounded by taboos (Denis-Robichaud et al., 2023; Mullins et al., 2017). In such cases, asking credible role models, e.g. peers, to demonstrate how to perform humane practices, can help normalise discussions of emergency killing, and reinforce both capability and motivation. This, in turn, may help to alleviate social pressures and taboos around the topic. The Behaviour Change Wheel (Michie et al., 2011) could guide the design of interventions that combine different functions such as education, structural facilitation, modelling, clear regulations, and incentives for those who adopt humane and lawful killing practices. This combined approach could further support farmers in carrying out emergency killing in an ethically responsible manner.

The farmers interviewed in this study, represented a broad cross-section of pig farm types and sizes. Despite achieving data saturation, the sample size may have been insufficient to ensure representativeness of the broader population of pig farms. Future research could address this by conducting a survey to corroborate the barriers and drivers identified in this qualitative study. Moreover, given that farmers should coordinate with veterinarians in emergency killing, it may be important to incorporate veterinary perspectives into the development of effective interventions, and to develop interventions that specifically target veterinarians. Future research should therefore focus on the role and perspectives of veterinarians in on-farm emergency killing.

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Why do people choose to have or not to have pets? A comparative study of people living in Austria, Denmark and the UK

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Abstract

The level of pet ownership in the EU is high, with nearly half of households having pets, yet there is limited research on why some individuals choose not to own pets, including dogs or cats. This study explored why some people in Austria, Denmark, and the UK keep dogs and/or cats and why others do not (N=4,610). Further, we examined whether dog or cat ownership is associated with factors such as gender, living status, income, social support, and employment in the veterinary field. Findings showed that Austria had the highest level of pet ownership (52.0%), followed by the UK (45.1%) and Denmark (39.5%). Most pets were kept for companionship (76.4% of dogs and 73.3% of cats). Common reasons for not owning pets included time constraints (38.0%) and the belief it is unfair to keep a dog/cat in a flat (18.8%), with only 9.7% citing dislike of pets as a reason. Financial concerns were noted by 21.0% in the UK, compared to 14.2% in Austria and 11.3% in Denmark. Ownership was more prevalent among younger individuals, those in veterinary professions, and people living with others. While in Austria and Denmark women were more likely to own a dog/cat, in Denmark and the UK, higher income was positively correlated with pet ownership. This study concludes that practical barriers, rather than dislike, most commonly influence the decision not to own pets, and that financial issues may play a less significant role than previously thought.

Keywords: companion animal, ownership, non-ownership, dogs and cats, questionnaire-based study

Introduction

In recent years, the number of households in the EU keeping pets has steadily increased, reflecting a growing trend in animal companionship. Currently, nearly half (49%) of households own at least one pet (FEDIAF, 2025). Specifically, 25% of households have at least one dog, while 26% have at least one cat (FEDIAF, 2025). This rise in pet ownership underscores the significant role that animals play in the lives of many individuals and families across Europe. However, while many households embrace the companionship of dogs and cats, a significant number of individuals choose not to have pets. Demands of modern life can deter potential pet owners, as many feel unable to provide the necessary care and attention that pets require. For instance, a study among 1278 households including 24% of dog-owning households in a semi-rural part of the UK identified that primary reasons for not owning a dog often involve time constraints and lifestyle choices. For example, 26% of those without dogs stated 'being out all day' was a significant barrier, while 15% indicated a lack of time to adequately care for a pet (Westgarth *et al.*, 2007). Besides this, the existence of other forms of social support and the possible emotional distress in relation to pet ownership may play a role. For instance, a qualitative study from Australia involving elderly individuals revealed that some participants felt they did not need pets due to the strong social support they already received from family and friends, and the emotional burden associated with pet ownership including the grief of losing a pet was highlighted as a notable deterrent (Chur-Hansen *et al.*, 2008).

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Conversely, the decision to acquire a pet is often shaped by a variety of demographic and socioeconomic factors (Holland, 2019; Power, 2017; Downes *et al.*, 2009). A study conducted by Downes et al. (2009) explored pet ownership in Ireland, revealing that dog ownership is significantly influenced by residential location; households in urban areas are less likely to own dogs compared to those in rural settings. Additionally, housing type plays a crucial role, with fewer individuals living in apartments having dogs compared to those living in detached houses. Research from Australia underscores this connection, highlighting that individuals who live in rented accommodation often struggle to find suitable 'pet-friendly' properties (Power, 2017). Further, the obligation to care for a pet can disrupt daily routines, leading to challenges in balancing personal commitments with pet care responsibilities. Consequently, it can be assumed that pet ownership comes with certain stressors, including financial costs, responsibilities, and potential household conflicts.

While, as presented above, studies do exist on why people choose to own or not own a pet, these studies are often regionally limited and the data are not representative of the background population. It was the aim of the current study to address these gaps using a robust and representative dataset from Austria, Denmark, and the UK. The overall goal was to explore the motivations behind individuals' decisions on whether or not to keep dogs and/or cats. Further, we aimed to investigate the relationships between pet ownership and various demographic and socioeconomic factors, including gender, living status, income, social support, and employment in the veterinary field. Thus, the study aimed to answer the following research questions: i) What proportion of individuals owned, or did not own, a dog/cat? ii) How did factors such as gender, living status, income, social support, and veterinary employment affect pet ownership? iii) What reasons did individuals give for not owning a dog or cat? iv) What motivated people to acquire a dog and/or cat?

Material and methods

Study population, recruitment and study participants

Participants were recruited by NORSTAT, a European-based survey company, which was contracted to collect representative samples of UK, Danish and Austrian citizens (over 17 years of age), including pet owners. The aim was to gather samples with representative quotas on gender, age and geographical location. Details about sampling are described in Corr et al. (2024). Data were collected in March 2022. A total of 4,885 individuals clicked on the survey link, but 275 incomplete questionnaires were subsequently excluded. With a dropout rate of 5.6%, the study included 1,500 Austrians, 1,552 Danes and 1,558 UK citizens. The response rate was 30.34% for Austria, 27.5% for Denmark and 25.3% for the UK. The entire project was approved by the Research Ethics Committee of Science and Health (Ref: 504-010300/22-5000) at the University of Copenhagen.

Survey design and measurements

This study utilized a subset of data from a broader questionnaire study (cf. Corr *et al.*, 2024; Sandøe *et al.*, 2023) that explored socio-demographic factors and various aspects related to the development of small animal practice. The findings presented in this paper are based on two questions: respondents who indicated they do not own a dog or cat were asked to specify their reasons for this choice, selecting from nine provided options, including 'other reasons'. Additionally, respondents who indicated that they do own a dog and/or cat were asked to share their reasons for acquiring their pets. Dog owners were given ten potential reasons to choose from, while cat owners had eight options available; including 'Other' and 'I don't know'.

Data analysis

IBM® SPSS® Statistics version 30.0 was used for all analyses. Univariate descriptive statistics were presented in tables or text. Chi-square tests were conducted to determine whether ownership reasons for not having a dog/cat, and reasons for having a dog/cat, differed between the three countries. Bonferroni correction was applied for all multiple comparisons between the three countries. The significance level was 0.05. Logistic regression analysis was run separately for each country to examine whether socio-demographic factors, social support and employment in veterinary sector were associated with dog/cat ownership. The dependent variable was inserted on a dichotomous scale (1=owner of dog/cat; 0=no animal owner). The five categorical predictor variables were i) gender (1=male, 2=female), ii) living status (1=live alone, 2=live not alone), iii) total household income per year (0=I don't know/Prefer not to say; 1=low; 2=middle; 3=high), iv) social support (1=low, 2=moderate, 3=middle, 4=high), and v) work in the veterinary field (1=yes, 2=no). In addition, age (range: 18-100 years) was inserted as continuous variable.

Results

Table 1 shows that with 45.5%, almost half of respondents owned a dog and/or cat, while respondents in Austria reported the highest ownership of dogs and/or cats (52.0%), followed by those in the UK (45.1%) and Denmark (39.5%) ($p_{DK,UK}<0.001$).

What factors impact dog and/or cat ownership?

Logistic regression analysis indicates that various factors resulted in significant differences in dog/cat-ownership in Austria ($\chi^2(10)=80.367$, $p<0.001$), Denmark ($\chi^2(10)=90.361$, $p<0.001$) and the UK ($\chi^2(10)=169.796$, $p<0.001$). Across all three countries, ownership was more common among individuals as age decreased ($p_{AT}<0.001$, $p_{DK}=0.002$, $p_{UK}=0.010$), those employed in the veterinary field ($p_{AT}=0.039$, $p_{DK}=0.009$, $p_{UK}<0.001$), and individuals living with others ($p_{AT,DK,UK}<0.001$). In Austria and Denmark, women were more likely to own a dog/cat compared to men ($p_{AT}=0.004$, $p_{DK}<0.001$). In Denmark and the UK, those in the higher income group were more likely to own a dog/cat compared to low/middle income groups (low/middle: $p_{DK}<0.001$, low: $p_{UK}=0.006$, middle: $p_{UK}=0.012$). UK respondents with moderate social support were more likely to have a dog/cat in comparison to respondents indicated a very high social support ($p=0.012$).

Table 1: Pet ownership in Austria, Denmark and the UK

	All	Austria	Denmark	UK	Chi-square test*
No animal owners	2271 (49.8)	616 (42.8)	864 (56.4)	791 (50.0)	$\chi^2(2)=63.347$, $p<0.001$
Dog and/or cat owners	2117 (45.5)	800 (52.0)	626 (39.5)	691 (45.1)	AT vs DK: $p<0.001$ AT vs. UK: $p<0.001$ DK vs. UK: $p=0.011$
Owners of other animals	222 (4.7)	84 (5.2)	62 (4.0)	76 (4.9)	
Total	4610	1500 (100.0)	1552 (100.0)	1561 (100.0)	

Count (%), Number of respondents (N, n) were calculated with unweighted data; Proportions were calculated with weighted data; rounding errors lead to some differences between rounded-off numerical values and actual values. *Test of differences between countries regarding dog/cat ownership; the Chi-square value reported reflects the overall test result for all three countries, while the subsequent three values represent post-hoc comparisons between individual countries that were carried out if the overall test was statistically significant

Why do owners not have a dog and/or a cat?

The main reason given for not having a dog or cat is concern about the time needed to care for it (38.0%), followed by feeling that keeping a dog/cat in a flat is unfair (18.8%), not being able to afford to care for it or pets not being allowed in the accommodation (15.4%) (Table 2). Significantly more

Table 2: Reasons for not having a dog/cat

		All (N=2271)	Austria (N=616)	Denmark (n=864)	UK (n=791)	Chi-square test*
1	I do not have time to care for a dog and/ or cat.	873 (38.0)	269 (41.4)	368 (43.0)	236 (29.5)	χ2 (2)=38.160, p**<0.001**[a] AT vs DK: p=0.680 AT vs. UK: p<0.001 DK vs. UK: p<0.001
2	I live in a flat and I do not think it is fair to keep a dog or a cat in that setting.	427 (18.8)	197 (31.4)	138 (16.4)	92 (11.2)	χ2 (2)=101.250, p**<0.001**[a] AT vs DK: p<0.001 AT vs. UK: p<0.001 DK vs. UK: p=0.011
3	I cannot afford to care for a dog and/or cat.	344 (15.4)	85 (14.2)	95 (11.3)	164 (21.0)	χ2 (2)=31.662, p**<0.001**[a] AT vs DK: p=0.104 AT vs. UK: p<0.001 DK vs. UK: p<0.001
4	I am not allowed to keep dogs and/or cats in my accommodation.	311 (13.4)	43 (7.2)	183 (21.0)	85 (10.1)	χ2 (2)=70.280, p**<0.001**[a] AT vs DK: p<0.001 AT vs. UK: p=0.015 DK vs. UK: <0.001
5	I do not like dogs and/or cats.	229 (9.7)	54 (8.5)	63 (7.2)	112 (13.6)	χ2 (2)=23.099, p**<0.001**[a] AT vs DK: p=0.300 AT vs. UK: p=0.002 DK vs. UK: p<0.001
6	I/someone in my household have/has allergies that would be affected.	211 (9.3)	64 (10.2)	84 (9.6)	63 (8.3)	χ2 (2)=2.724, p=0.256
7	Someone I live with does not like dogs and/or cats.	111 (4.5)	38 (5.4)	22 (2.6)	51 (6.0)	χ2 (2)=16.504, p**<0.001**[a] AT vs DK: p<0.001 AT vs. UK: p=0.831 DK vs. UK: p<0.001
8	I believe that people should not keep pets at all because it violates animals' rights.	46 (2.1)	19 (3.3)	16 (1.9)	11 (1.5)	χ2 (2)=5.218, p=0.074
9	Other reasons	476 (21.1)	92 (16.2)	205 (23.0)	179 (22.9)	χ2 (2)=18.821, p**<0.001**[a] AT vs DK: p<0.001 AT vs. UK: p<0.001 DK vs. UK: p=0.597

Count (%), Number of respondents (N, n) were calculated with unweighted data; Proportions were calculated with weighted data; rounding errors lead to some differences between rounded-off numerical values and actual values. [a]Bonferroni correction was applied for significant results of global tests; as there are nine tests being made one for each reason for not having a dog and/or cat, p-values were taken 9 times. Significant p-values are highlighted in bold. *Test of differences between countries regarding reasons for not having dog/cat; the Chi-square value reported reflects the overall test result for all three countries, while the subsequent three values represent post-hoc comparisons between individual countries that were carried out if the overall test was statistically significant

UK respondents (21.0%) indicate that they cannot afford pet ownership compared to Austrian and Danish respondents. Significantly more Austrians (31.4%) state that they do not think it is fair to keep a dog or cat in a flat compared to Danish and UK respondents. Only 9.3% indicated dislike of dogs or cats as a reason for not owning one.

Why do owners have a dog and/or a cat?

As shown in Tables 3 and 4, the majority of dog (76.4%) and cat (73.3%) owners acquired their pets primarily for companionship. Further, 33.8% of dog owners indicated that they got their dogs to exercise with them. Additionally, 13.8% of cat owners reported that the animal simply appeared at their homes and decided to stay.

Discussion

The results of this study provide valuable insights into the motivations behind pet ownership, revealing why some choose to own dogs and/or cats while others do not. It is no surprise that dogs and cats are primarily kept as companions; this finding underscores the close emotional bond that most owners have with their pets (Sandøe *et al.*, 2023) and highlights that companionship is a fundamental reason for pet acquisition. In addition, in all three countries studied, one in three dog owners reported that

Table 3: Reasons for acquiring a dog

		All (N=1245)	Austria (n=409)	Denmark (n=385)	UK (n=451)	Chi-square test
1	To provide companionship (for humans)	957 (76.4)	311 (76.3)	314 (81.3)	332 (72.4)	χ^2 (2)=7.607, p=0.220[a]
2	To exercise with (walks)	421 (33.8)	125 (31.6)	133 (34.4)	163 (35.1)	χ^2 (2)=3.116, p=0.211
3	To protect home and/or property	182 (14.7)	77 (19.9)	51 (13.3)	54 (11.4)	χ^2 (2)=8.911, p=0.120[a]
4	As company for other pet(s)	168 (13.6)	69 (16.5)	24 (6.2)	75 (17.0)	χ^2 (2)=25.178, p<0.001[a] AT vs DK: p<0.001 AT vs. UK: p=0.925 DK vs. UK: p<0.001
5	For dog sports (training, agility, etc.)	69 (5.7)	27 (6.6)	20 (5.2)	22 (5.4)	χ^2 (2)=1.345, p=0.510
6	As a hunting dog	54 (4.5)	16 (3.9)	22 (5.7)	16 (4.1)	χ^2 (2)=2.615, p=0.270
7	To breed from	53 (4.4)	15 (3.4)	7 (2.0)	31 (7.3)	χ^2 (2)=13.543, p<0.010[a] AT vs DK: p=0.113 AT vs. UK: p=0.037 DK vs. UK: p<0.001
8	To show in competitions / exhibitions	43 (3.7)	11 (2.9)	8 (2.0)	24 (5.9)	χ^2 (2)=101.250, p=0.220[a]
9	Other	100 (7.9)	39 (9.3)	31 (8.2)	30 (6.5)	χ^2 (2)=2.415, p=0.299
10	I don't know	16 (1.1)	5 (1.1)	3 (0.8)	8 (1.6)	χ^2 (2)=1.638, p=0.441

Count (%), Number of respondents (N, n) were calculated with unweighted data; Proportions were calculated with weighted data; rounding errors lead to some differences between rounded-off numerical values and actual values. [a]Bonferroni correction was applied for significant results of global tests; as there are ten tests being made one for each reason for having a dog, p-values were taken 10 times. Significant p-values are highlighted in bold. *Test of differences between countries regarding reasons for having a dog; the Chi-square value reported reflects the overall test result for all three countries, while the subsequent three values represent post-hoc comparisons between individual countries that were carried out if the overall test was statistically significant

Table 4. Reasons for acquiring a cat

		All (n=1273)	Austria (n=575)	Denmark (n=318)	UK (n=380)	Chi-square test
1	To provide companionship (for humans)	943 (73.3)	426 (72.4)	244 (76.8)	273 (71.8)	$\chi 2$ (2)=2.154, p<0.341
2	As company for other pet(s)	193 (15.3)	108 (18.9)	32 (9.3)	53 (14.9)	$\chi 2$ (2)=2.415, p=0.016[a] AT vs DK: p<0.001 AT vs. UK: p=0.051 DK vs. UK: p=0.118
3	It/they just appeared at my home and stayed	172 (13.8)	100 (18.4)	33 (9.9)	39 (10.2)	$\chi 2$ (2)=13.511, p<0.080[a]
4	To keep rodents away from the home	110 (8.6)	28 (5.1)	51 (15.5)	31 (8.0)	$\chi 2$ (2)=32.511, p<0.001[a] AT vs DK: p<0.001 AT vs. UK: p=0.039 DK vs. UK: p=0.001
5	To breed from	42 (3.6)	16 (2.9)	5 (1.8)	21 (6.2)	$\chi 2$ (2)=9.361, p<0.072
6	To show in competitions / exhibitions	24 (2.2)	10 (1.8)	1 (0.3)	13 (4.4)	$\chi 2$ (2)=9.154, p<0.080
7	Other	110 (8.6)	44 (7.5)	27 (9.1)	39 (9.6)	$\chi 2$ (2)=1.988, p=0.370
8	I don't know	19 (1.6)	6 (1.2)	2 (0.5)	11 (2.9)	$\chi 2$ (2)=7.483, p=0.192[a]

Count (%), Number of respondents (N, n) were calculated with unweighted data; Proportions were calculated with weighted data; rounding errors lead to some differences between rounded-off numerical values and actual values. [a]Bonferroni correction was applied for significant results of global tests; as there are eight tests being made one for each reason for having a dog, p-values were taken 8 times. Significant p-values are highlighted in bold. *Test of differences between countries regarding reasons for having a cat; the Chi-square value reported reflects the overall test result for all three countries, while the subsequent three values represent post-hoc comparisons between individual countries that were carried out if the overall test was statistically significant

they keep dogs primarily to exercise and stay active. This desire to stay active aligns with findings from Müllersdorf et al. (2009), who noted that individuals who are physically active tend to own pets more frequently. Another noteworthy result is that in Austria, 18% of cat owners indicated that they became owners because the cat simply appeared and decided to stay. This 'spontaneous' adoption highlights an interesting distinction between cats and dogs, as despite attempts to 'tie' cats to their original owners through microchipping and 'lost and found' websites, some cats do effectively manage to rehome themselves, suggesting a level of autonomy.

Turning to the group of non-pet owners, our study aligns with existing data showing that approximately 50% of people in Europe do not own cats or dogs. Notably, only a small percentage indicated that dislike is a reason for their lack of pet ownership. This finding is consistent with the research of Westgarth et al. (2007), which reported that only 10% cited a dislike for animals as a reason for not having pets. Recent studies have revealed that pet owners often reside in houses and/or their own homes, whereas non-pet owners typically live in apartments and/or as renters (Westgarth *et al.*, 2007; Downes, 2010; Müllersdorf *et al.*, 2010). In this context, it is interesting to note that only 13% of non-pet owners in our study indicated they do not own a pet because they are not allowed to keep one in their accommodation. A possible explanation for this relatively low percentage could be the growing awareness among landlords – especially in urban areas – that allowing pets has become an expectation for tenants, a shift compared to a decade ago. Another noteworthy finding is that many non-pet owners believe it is unfair to keep animals in apartments. Over 30% of Austrian respondents expressed this perspective, a significantly higher rate compared to 16% in Denmark and 11% in the UK. This may reflect cultural attitudes toward pet ownership, as well as the stricter (legal) regulations governing animal care in Austria (e.g. dog handler's license).

While one might assume that the rising costs of pet care, including veterinary expenses, contribute to the decision not to own pets, the results of this study indicate that financial considerations account for only about 15% of decisions not to own a pet. Notably, there are variations among the three countries: in the UK, nearly 21% of respondents cite costs as a reason for not owning a pet, which is significantly higher than in Austria and Denmark. In light of the ongoing cost-of-living crisis and increasing expenses across various sectors, data from the UK reveal that veterinary care has also been heavily impacted by these financial pressures (PDSA, 2023). Our findings from the UK further support the observation that individuals in higher income groups are more likely to own dogs or cats compared to those in lower or middle-income brackets. While income plays a significant role in pet ownership, our analysis highlights that other factors – such as age, living status, and employment in the veterinary field – are also strongly associated with pet ownership. These findings align with existing research. For instance, a cross-sectional study of pet-owning households across the UK indicated that the likelihood of dog ownership increases as the number of individuals in a household grows (Murray *et al.*, 2019). Additionally, studies conducted in the UK (Westgarth *et al.*, 2007) and Ireland (Downes *et al.*, 2009) have shown that households with children are more likely to own dogs.

This study concludes that practical considerations, rather than personal dislike, primarily influence the decision not to own pets. The findings reveal that financial issues may be less significant than previously assumed, and instead factors such as living arrangements, housing regulations, and cultural attitudes play a more crucial role in this decision-making process.

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Between rules and realities: navigating harm-benefit analysis discrepancies with the compound model

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Abstract

The harm-benefit analysis (HBA) is a central element in evaluating project applications involving animals for scientific research. Its purpose is to justify animal harm by the projected benefits of the proposed work. Under EU Directive 2010/63/EU, reviewing bodies across EU Member States (MS) are required to conduct HBA for every research proposal. Yet, despite this regulatory mandate, structured guidance on how HBA should be operationalized is limited, leaving researchers and committees without a clear roadmap and compromising consistent, well-reasoned decision-making. Recent studies reveal substantial shortcomings in how HBA is applied among MS, underscoring the gap between regulatory expectations and the practical implementation. Several countries have issued their own national or regional guidance, but these documents diverge in key recommendations. When HBA is dissected into is constituent domains – harm, benefit, outcome, justification, and ethical considerations – it becomes clear that existing guidance is both inconsistent and incomplete across these domains. Although several HBA methods – described in more detail in the extended abstract – have been proposed, none has gained sufficient traction in actual review practice. The compound model (CM) was developed to bridge these gaps by combining systematic clarity with the realities of committee deliberation, drawing on existing guidance documents. As a result, the CM provides a more transparent and practicable pathway for the operationalization of HBA. It offers reviewing bodies a pragmatic, coherent tool to navigate the complexities of real-world project evaluations and move closer to consistent decisions. Here, we outline the background and core elements of the CM and attempt providing a response to persistent challenges with HBA implementation.

Keywords: harm-benefit analysis, animal research, decision-making, ethical review

Background: a regulatory mandate without a practical roadmap

Harm-benefit analysis (HBA) represents a core element in the ethical review of research involving animals. It aims to justify the harms animals are subjected to by the project's prospective benefits. As such, HBA has been integrated into regulatory frameworks and guidelines (Brønstad et al. 2016). Most notably, EU Member States (MS) are legally required to implement HBA in their project evaluation process under EU Directive 2010/63/EU (the Directive) (European Commission 2010). While HBA is mandated within EU MS, its relevance extends well beyond this context and can be regarded as internationally significant that is discussed across diverse regulatory frameworks (Hajosi and Grimm 2025a, Hajosi and Grimm 2025b, Kinter et al. 2021). While the Directive clearly establishes HBA as a necessary step, it remains vague on how it should be applied in practice. This lack of operational clarity has been a persistent issue – HBA has been scrutinized since its inclusion in the Directive more than a decade ago (Grimm 2015, Grimm et al. 2017, Grimm et al. 2019, Jörgensen 2021).

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Attempts to provide practical guidance are scarce and often raise as many questions as they answer. Existing guidance is typically fragmentary, nationally or regionally confined, and inconsistent. A closer examination and analysis reveal significant challenges: while some of the constituting HBA domains are well defined, others remain ambiguous; the process of assigning weight to domains – and weighing them against one another – remains largely theoretical and difficult to translate into practice. Moreover, how a project's benefit should outweigh harms done to animals is rarely addressed in a meaningful way (Hajosi and Grimm 2024). As a result, current guidance is incomplete, inconclusive, and often avoids confronting the core challenges of HBA and its practical implementation. This creates uncertainty for both project applicants and reviewing bodies, leading to a regulatory gap characterized by unclear expectation, inconsistent interpretation, and potentially conflicting advice. Given these challenges, this presentation will explore the lack of practical guidance and its implications.

The two most commonly discussed models for practically applying HBA – the discourse model (DM) and metric model (MM) – both have several positive as well as negative features (Grimm et al. 2019). While the DM allows for the required flexibility during reviewing committee discussions, the MM follows a relatively strict structure or algorithm. At the same time, the MM may provide clear structural guidance, whereas the DM risks that committees may drift into relatively loosely structured discussions without any clear objectives or navigation. As an alternative to the commonly accepted HBA models – and building on recently published work by Hajosi and Grimm (2024) – the compound model (CM) was developed. In this newly developed HBA method, an attempt is made to identify both strengths and shortcomings from existing guidance to propose a more transparent HBA model. It integrates well-reasoned elements from available frameworks while addressing critical gaps – resulting in a more structured and practicable approach to HBA (Hajosi and Grimm 2025c). In the forthcoming presentation, the CM and its practical application will be discussed in detail. Particular attention will be given to the practical and conceptual challenges inherent to conducting a meaningful HBA: the difficulties assessing and balancing harms, outcomes, and benefits, and including ethical considerations. The presentation will further explore how the CM seeks to address and mitigate some of these challenges by providing a structured and practice-oriented framework for ethical review and decision-making in animal research. Additionally, preliminary insights into its real-world applicability and potential limitations will be discussed where available.

Methodological strategy

The CM is grounded in previously analyzed guidance documents by Hajosi and Grimm (2024). It selectively incorporates elements that provide clarity and practical applicability across all HBA domains – harm, outcome, benefit, justification, and ethical considerations. At the same time, components that have been criticized in recent literature or deemed impractical were deliberately excluded. The CM therefore represents a selective synthesis: keeping functional elements, eliminating problematic ones, and introducing targeted modifications to support real-world application of HBA by both project applicants and reviewing bodies. As shown in Figure 1, the CM utilizes pieces from available guidance, combining them into a framework that ensures that all relevant HBA domains are adequately implemented and operationalized.

Ultimately, the CM aims to provide guidance to both project applicants and reviewers. It attempts to clarify which criteria are expected to be fulfilled by projet applicants by clearly delineating the components that render an HBA operational. At the same time, members of reviewing bodies can focus on the criteria that are relevant to the HBA. As a result, both sides are not left in the dark but instead gain clarity on what is required to perform an operational HBA, as well as on their respective expectations. This conceptual interplay between the expectations of project applicants and reviewing bodies remains crucial in the context of developing a meaningful HBA that consists of transparency and clear structural guidance.

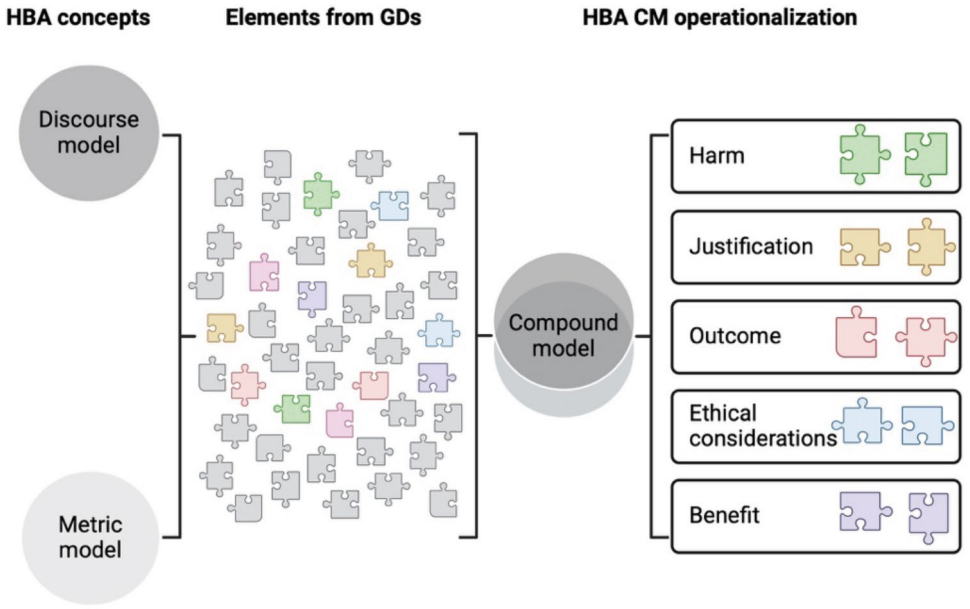


Figure 1. Hajosi and Grimm (2025c) illustrate the conceptualization of the CM [11]. (HBA = harm-benefit analysis; GDs = guidance documents; CM = compound model).

Refining the HBA concept through reframing its domains

The following description of the CM is based on the published model by Hajosi and Grimm (2025c). The CM provides a clearly structured approach to addressing each individual HBA domain. While only briefly discussed here, details on the CM's operational steps will be described and discussed in detail at the forthcoming presentation of this paper.

Briefly, the first step of the CM is to address the outcome domain, which serves as the entry point for the assessment of all other HBA domains. Once the outcome domain has been adequately addressed, the expected harms of the project are evaluated, as outlined in more detail in the following paragraphs. The benefit domain is relegated to a secondary role and assumes a modulating function in relation to the outcome domain. This novel outcome-benefit relationship represents a significant change from current HBA approaches and will be discussed further in the oral presentation. Furthermore, the ethical considerations domain is entirely removed from the CM, representing another major shift; the underlying rationale is briefly outlined below. Finally, once all domains have been addressed, the justification component – or weighing element – is carried out by using a matrix that integrates the results of each domain evaluation, making the HBA speak in favor of or against a project application. Against this background, the changes to the individual HBA domain are outlined in more detail.

Among all HBA domains, the harm domain has historically been the most extensively defined, given its relative regulatory clarity. Within the CM, it remains integral – but is no longer the entry point. Instead, the outcome domain is positioned as the starting point and prerequisite. The outcome domain establishes that a project must first demonstrate that it will yield knowledge gain before an HBA can be meaningfully conducted and it forms the basis for any anticipated benefit. Consequently, outcome must be assessed prior to evaluating any other domain. Harms are assessed in alignment with the Directive,

particularly through severity categories. The CM further incorporates modulating factors (MFs), which can influence an animal's experience directly (primary MFs) or indirectly (secondary MFs). Additionally, an escalation model is introduced to capture the dynamic nature of harm, reflecting how severity may gradually increase over time in both duration and intensity, offering a more nuanced representation of the harm domain. The escalation model introduced by Hajosi and Grimm (2025c) is shown in Figure 2.

In contrast, the benefit domain is repositioned as a MF of the outcome domain. Given its inherently speculative and uncertain nature, benefit is not treated as an independent deciding factor. Instead, it refines the outcome by indicating the likelihood that anticipated knowledge will translate into real-world impact. The role of animal numbers is also redefined. Within the CM, only the total number of animals required to achieve the outcome is relevant. Animal numbers are not high or low – they are either *right* (sufficient) or *wrong* (insufficient) to generate reliable results.

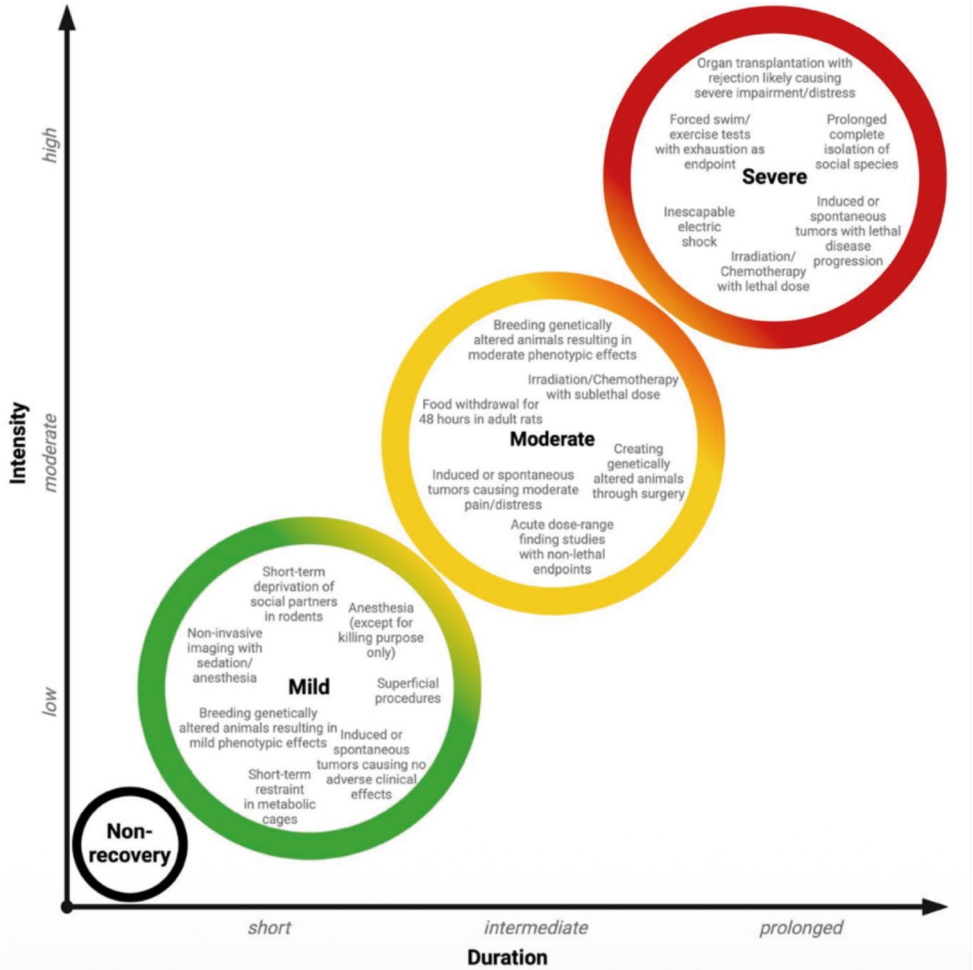


Figure 2. Escalation model as introduced by Hajosi and Grimm (2025c), which illustrates the gradual increase of severity and providing a more refined representation of harm. The example procedures within each severity (mild, moderate, severe) are derived from those described in Annex VIII of the Directive (European Commission 2010).

A particularly striking change is the removal of the ethical considerations domain. This is based on the premise that ethics are intrinsic to HBA and therefore do not require a separate domain. Having a distinct ethical considerations domain risks introducing subjective ethical frameworks that may not align with legal standards. By excluding this domain, the CM aims to strengthen objectivity, consistency, and adherence to the rule of law in decision-making during the project evaluation process.

Conclusion: new path forward – from dead end to direction

The CM, with its conceptual and structural changes, is likely to provoke discussion – and rightly so. Current approaches to HBA appear to have reached a conceptual impasse, where theoretical expectations and practical application diverge. The CM does not claim to be a universal solution. Rather, it offers a pragmatic attempt to address persistent challenges that hinder HBA's implementation in real-world evaluation settings. It acknowledges the practical realities faced by reviewing bodies, which often struggle to perform transparent and consistent HBA. A shift in the current framework appears necessary to render HBA more practicable, structured, and meaningful. Whether the CM fulfills this role remains to be determined. Its feasibility and performance have not been investigated thus far. However, a national pilot study that evaluates the CM's feasibility during the committee work is currently underway. The goal of this study is to evaluate whether the CM can be applied during reviewing committee's work as a practical tool to perform the HBA. While there are currently no empirical data available for this pilot study, preliminary findings from it may be available by the time of the conference. These data could provide a more comprehensive understanding of the real-world application of the CM, including both its current strengths and the challenges associated with its implementation.

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