Smart Agricultural Technology 10 (2025) 100710

Contents lists available at ScienceDirect

Smart Agricultural Technology

journal homepage: www.journals.elsevier.com/smart-agricultural-technology

Ethical, Legal and Social Aspects (ELSA) for AI: An assessment tool for Agri-food

Mireille van Hilten [a,*], Mark Ryan [a], Vincent Blok [b], Nina de Roo [a]

[a] Wageningen Economic Research, Wageningen University and Research, P.O. Box 29703, The Hague 2502 LS, the Netherlands
[b] Philosophy Department, Wageningen University and Research, P.O. Box 8130, Wageningen 6700 EW, the Netherlands

ARTICLE INFO

Keywords:
Ethical legal social aspects
ELSA
Artificial intelligence
AI
responsible AI
Agrifood
Agriculture
Assessment

ABSTRACT

As Artificial Intelligence (AI) continues to emerge in various sectors, ethical frameworks and guidelines aim to contribute to responsible AI development. While AI ethics has gained prominence in addressing broader societal concerns, existing regulations and guidelines often lack specificity for certain domain-specific applications (e.g. agri-food). AI is rapidly developed and deployed throughout the agri-food sector, but there is little practical guidance on how to do this responsibly. This study examines if the agri-food sector needs domain-specific guidance for the development and use of responsible AI and, if so, what it could look like. This research proposes it does and aims to fill this gap by introducing a novel approach for responsible AI in agri-food: the ethical, legal, and social aspects (ELSA) Scan. This assessment comprises 25 targeted questions aimed at identifying ELSA considerations. These questions were developed and based on 23 ELSA aspects of AI in agri-food literature and from testing in two case studies (arable and dairy farming). The ELSA Scan provides a clear and implementable approach for identifying ELSA in the development and use of AI in agri-food with AI developers and organisations.

1. Introduction

The increased use of artificial intelligence (AI) offers many opportunities and benefits, but risks and threats may also emerge. These are commonly referred to as ethical, legal, and social aspects (ELSA[1]) of AI technologies. As a result of emerging 'ELSA aspects' in AI design and the societal concerns they raise, much funding is being dedicated to research and addressing them [1,2,3]. Also, AI ethics associations have been set up to tackle the risks and challenges posed by AI [4], as well as various legal frameworks and policies that have been established (such as the United States Blueprint for an AI Bill of Rights [5], the EU AI Act [6], and China's Artificial Intelligence Law [7]). While these actions are undoubtedly positive steps towards ensuring AI is being developed and used responsibly, they are usually very high level and often focus on the unacceptable-risk forms of AI, such as biometric identification [8]. However, because of the horizontal nature of these laws, which apply to all sectors, they do not provide clear recommendations for specific sectors and industries in which AI is deployed, such as transportation, health, agri-food or energy.

In addition to AI legislation, AI ethics has emerged to respond to broader social and ethical challenges posed by AI. Various disciplines are engaged in AI ethics (e.g., philosophers, computer scientists, anthropologists, economists, and neuroscientists) to examine the ethical acceptability and societal desirability of AI. As a result of efforts within this field, over 200 types of ethics guidelines [9] and over 100 ethical frameworks and approaches [10] have been developed to assist decision-making on responsible AI. These guidelines and frameworks are important to guide AI development towards responsible AI applications in society. However, similarly to horizontal law, they often do not provide domain-specific considerations and are often not tailored to specific sectors and applications of AI, which makes it challenging to consider sector-specific or contextual issues for responsible AI. For example, AI risks in health are different from agri-food because they directly involve the health of citizens. In contrast, AI risks in agri-food may be related to animal welfare, the environment, and food security, which are less important in healthcare.

Therefore, this paper presents the development of an assessment tool for ELSA aspects of AI in a specific context: the agri-food domain. In this domain, ethical, legal, and social aspects of AI have received increased attention over the past several years [11–14]. The agri-food sector is

* Corresponding author.
E-mail address: mireille.vanhilten@wur.nl (M. van Hilten).

[1] These ethical, legal and social aspects (ELSA) are referred to in this paper as 'ELSA aspects'.

https://doi.org/10.1016/j.atech.2024.100710
Received 30 April 2024; Received in revised form 6 December 2024; Accepted 9 December 2024
Available online 13 December 2024

unique because of several specific challenges. Firstly, the natural origin and uniqueness of each product (fruit, vegetable, animal, etc.) makes the handling (sorting, packing, and processing) context-specific and dependent on human labour [15]. Secondly, it involves natural resources like soil, air and biodiversity and uncontrolled inputs like climate that make an agricultural operational environment highly variable [15]. The combination of these challenges leads to the issue that current AI legislation and guidelines cannot be applied in generic ways to the development of context-specific data-driven AI in agri-food. For example, autonomous vehicles that weed a field as opposed to scanning fruit in an orchard require different configurations (sensors, location, image classification, etc.), which also means that responsible development of AI requires knowledge of the agri-food context in which the AI technology is applied, which can be prone to specific risks to human, animals and nature. Additionally, topics that are considered important for AI in agri-food (e.g., sustainability, the environment, and animal welfare) are rarely included in AI ethics guidelines [14]. This is another reason why generic AI ethics guidelines are insufficient for addressing some of the challenges relevant to the application of AI in agri-food and why we need a domain-specific approach.

Therefore, the primary objective of this paper is to provide arguments for an ELSA assessment tool that can be used to evaluate ELSA aspects of AI in the context of the agri-food domain with AI developers and organisations. This assessment tool identifies ethical, legal and social challenges and opportunities in AI technologies in agri-food, considering the contextual and sectoral specificities. The paper claims that the ELSA Scan is a suitable approach to assess the ELSA aspects of AI-based systems in a way that considers contextual and sectoral settings. We provide a framework with 25 ELSA questions that enables AI developers and organisations to identify ELSA aspects in responsible AI design in agri-food.

Section 2 of the paper outlines the materials and methods used in this paper. Section 3 presents the results, starting with the results of the literature review (3.1). Section 3.2 considers how the EU's High-level Expert Group's AI requirements [16] can be applied to the agri-food sector. With the help of our literature review, we develop a list of ELSA questions to identify the 23 ELSA aspects of AI in the agri-food sector. Section 3.3 empirically explores these questions in two specific case studies: one with an AI recommendation system to identify and respond to mastitis in cows and the second with an AI crop robot. We evaluate how the ELSA Scan works in practice, and also based on the feedback of stakeholders and an expert discussion on the ELSA questions (3.4), this section concludes with the proposal of an ELSA Scan for AI developers and organisations in agri-food (3.5.). The ELSA Scan comprises 25 questions: a 15-question intake survey and a 10-question interview. Section 4 discusses the proposed ELSA Scan's importance for AI in agri-food. The conclusion provides how the ELSA Scan can be implemented in practice and essential topics for future research.

2. Materials and methods

This paper aims to develop and empirically explore an ELSA assessment for AI development and use in agri-food. To achieve this, we developed a multi-step research methodology (shown in Fig. 1. The main research question is: "Does the agri-food sector need domain-specific guidance for developing responsible AI, and what should this look like?".

To answer this question, our research method comprises five main steps, as illustrated in Fig. 1. This figure also highlights the structure of our research and the following sub-sections of our methodology

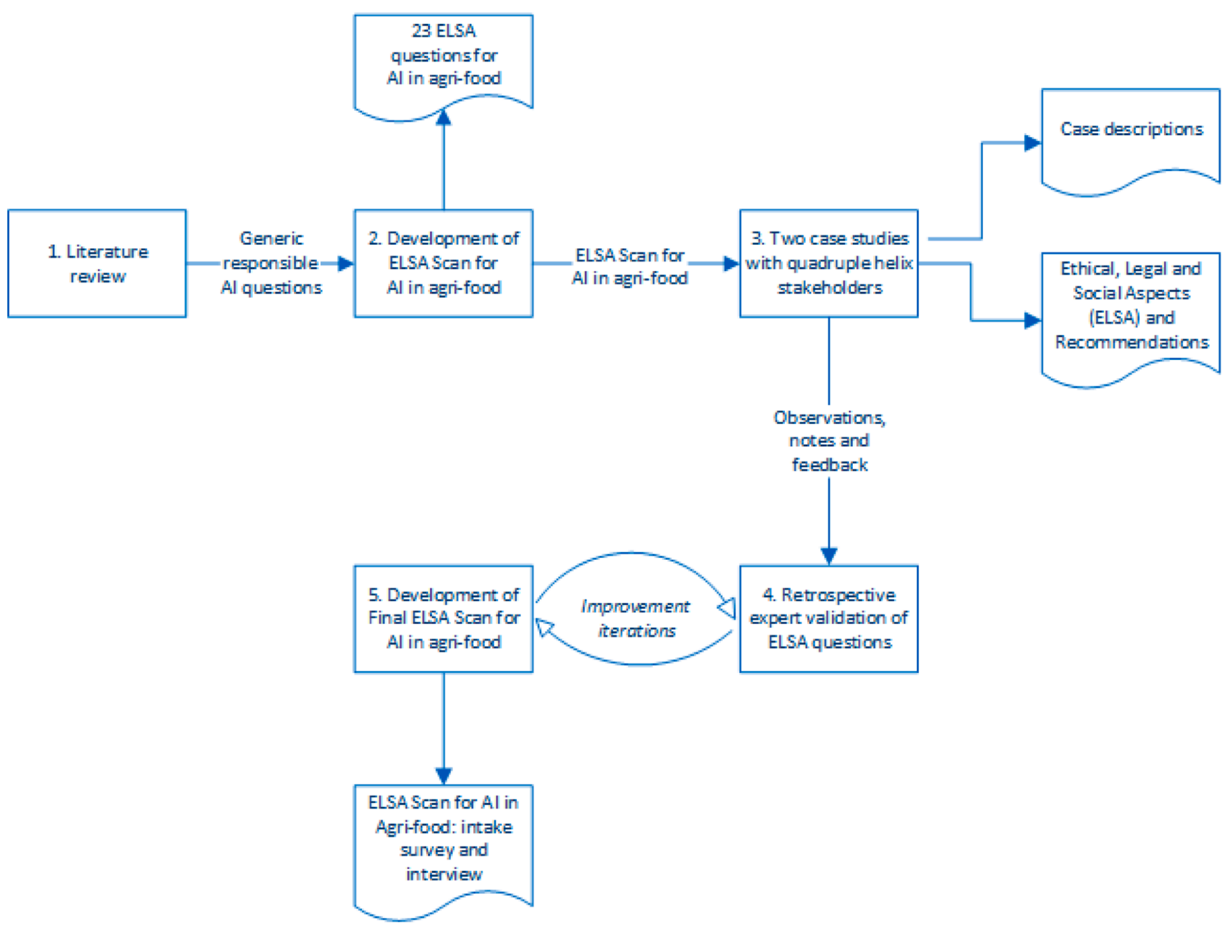

Fig. 1. The research method of five steps for developing the ELSA Scan for agri-food.

(Sections 2.1 - 2.5) and results (Sections 3.1 - 3.5).

2.1. Literature review

The first step in our methodology was conducting a review of literature that has been published about ELSA of AI in agri-food. We searched Scopus (see Appendix A for the query string) for articles about AI's ethical, legal, or social impacts in agri-food. Our search query limited this to subject areas relevant to this paper's focus (e.g., business, sociology, agri-food) while excluding subject areas less relevant (e.g., chemistry, physics, linguistics). We also limited our search to articles from European-affiliated countries because for the L aspect of ELSA, it was essential to concentrate on articles with a European legal focus (as other regions would follow different legal requirements). Our search criteria brought back 79 articles. We implemented a three-stage screening process to eliminate irrelevant articles ($N = 68$), using the following exclusion criteria based on an evaluation of the articles' abstracts:

- Articles that do not focus on the agri-food domain (37)
- Articles that do not focus on AI (22)
- Articles that do not focus on ELSA aspects (6)
- Articles that focus on case studies outside of Europe (3)

Many excluded papers did not focus on agri-food but were much more general papers on AI, data science, and computing. Some papers were focused on entirely different areas than agri-food (e.g., papers on healthcare, fire safety, cybersecurity, and telework). Several other articles were relevant to agri-food but did not focus on AI (e.g., papers on supply management in agri-food, economic issues of globalisation, and value-chain innovation). Six papers were excluded because they did not focus on topics relevant to ELSA (e.g., a simulation of nitrogen and carbon dynamics or using AI to determine the postharvest time of kiwifruit). Three more papers were excluded because they did not focus on Europe/European countries (e.g., the Philippines, Africa, and New Zealand). This process led to a final set of 11 articles for our research (see Table 1 below).

Our method of identifying ELSA aspects in agri-food followed a mixed-methods approach. Firstly, we built on the categorisation provided by Jobin et al. [17] (also, subsequently, expanded upon in Ryan & Stahl [18] and Ryan [14]). This deductive step helped to classify ELSA aspects when analysing the 11 AI in agri-food articles. Jobin et al. (2019) highlighted 11 key social and ethical themes of AI. Within this analysis, we noted that eight of these themes could be classified as 'ethical' aspects (transparency, justice and fairness, non-maleficence, responsibility, privacy, beneficence, freedom and autonomy, and trust), and three could be considered 'social' aspects (dignity, sustainability, and solidarity).

From Jobin et al.'s 2019 list [17], trust was also not included as an ELSA aspect. The HLEG [16] does not include trust as a key requirement but views it as an overarching value that underpins and frames all other aspects and principles. Following the example of the HLEG, trust was not explicitly used as an aspect in our analysis of the literature. Secondly, while bias and discrimination are discussed as sub-categories of justice and fairness in Jobin et al. 2019 [17], we agree with the HLEG about the importance of emphasising bias and discrimination (it is part of one of their seven requirements) as a crucial aspect of analysis in AI. Thus, bias and discrimination were included as a separate aspect. These steps left us with 11 ELSA aspects to evaluate the AI in agri-food literature (bias and discrimination replacing trust).

Through an inductive analysis of the 11 papers focusing on AI in agri-food (Table 1), seven more aspects emerged that were not included in those outlined in Jobin et al. [17]: industrialisation, animal welfare, the impact on the role of the farmer, the impact on gender, class, and race, the impact on societal views of food production, labour, and power asymmetries. Lastly, the aspects of dignity and solidarity (from Jobin et al.'s 2019 list) did not emerge in the agri-food literature we analysed. In addition, several distinct legal aspects were identified within the literature (data ownership and governance, human rights, standardisation and protocols, data and AI regulations, AI code of conduct

Table 2
23 Ethical, Legal and Social aspects from literature.

Ethical	Legal	Social
1. Transparency 2. Justice and fairness 3. Bias and discrimination 4. Beneficence 5. Non-maleficence 6. Freedom and autonomy 7. Privacy 8. Responsibility	9. Privacy law and data protection 10. Data ownership and data governance 11. Liability 12. Human rights 13. Standardisation and Protocols 14. Data and AI regulations 15. AI code of conduct and guidelines	16. Sustainability 17. Animal welfare 18. Industrialisation 19. Impact on gender, class, race 20. Impact on societal views of food production 21. Labour 22. Power asymmetries 23. Costs and other economic aspects

Table 1
The 11 Articles Found in the literature.

Authors and year of publication
P. Demircioglu, I. Bogrekci, M. N. Durakbasa, and J. Bauer, "Autonomation, Automation, AI, and Industry-Agriculture 5.0 in Sustainable Agro-Ecological Food Production," *Lecture Notes in Mechanical Engineering*, pp. 545–556, 2024, doi: 10.1007/978–3–031–53,991–6_42.
I. Härtel, "Agricultural Law 4.0: Digital Revolution in Agriculture," in *Handbook Industry 4.0: Law, Technology, Society*, Springer Berlin Heidelberg, 2022, pp. 331–350. doi: 10.1007/978–3–662–64,448–5_17.
K. Hoxhallari, W. Purcell, and T. Neubauer, "The potential of Explainable Artificial Intelligence in Precision Livestock Farming," in *Precision Livestock Farming 2022 - Papers Presented at the 10th European Conference on Precision Livestock Farming, ECPLF 2022*, Organising Committee of the 10th European Conference on Precision Livestock Farming (ECPLF), University of Veterinary Medicine Vienna, 2022, pp. 710–717.
I. A. Ibrahim and J. M. Truby, "FarmTech: Regulating the use of digital technologies in the agricultural sector," *Food Energy Secur*, vol. 12, no. 4, 2023, doi: 10.1002/fes3.483.
V. Marinoudi, C. G. Sørensen, S. Pearson, and D. Bochtis, "Robotics and labour in agriculture. A context consideration," *Biosyst Eng*, vol. 184, pp. 111–121, 2019, doi: 10.1016/j.biosystemseng.2019.06.013.
D. C. Rose and J. Chilvers, "Agriculture 4.0: Broadening Responsible Innovation in an Era of Smart Farming," *Front Sustain Food Syst*, vol. 2, 2018, doi: 10.3389/fsufs.2018.00087.
M. Ryan, "Agricultural Big Data Analytics and the Ethics of Power," *J Agric Environ Ethics*, vol. 33, no. 1, pp. 49–69, 2020, doi: 10.1007/s10806–019–09,812–0.
M. Ryan, "The social and ethical impacts of artificial intelligence in agriculture: mapping the agricultural AI literature," *AI Soc*, vol. 38, no. 6, pp. 2473–2485, 2022, doi: 10.1007/s00146–021–01,377–9.
S. Sapienza, "Smart Solutions in AgriTech: Research Trajectories in the Digital Transition," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, Springer Science and Business Media Deutschland GmbH, 2022, pp. 150–162. doi: 10.1007/978–3–031–12,673–4_11.
M. Uddin, A. Chowdhury, and M. A. Kabir, "Legal and ethical aspects of deploying artificial intelligence in climate-smart agriculture," *AI Soc*, vol. 39, no. 1, pp. 221–234, 2024, doi: 10.1007/s00146–022–01,421–2.
VE. Vocaturo, G. Rani, V. S. Dhaka, and E. Zumpano, "AI-Driven Agriculture: Opportunities and Challenges," in *Proceedings - 2023 IEEE International Conference on Big Data, BigData 2023*, Institute of Electrical and Electronics Engineers Inc., 2023, pp. 3530–3537. doi: 10.1109/BigData59044.2023.10386314.

Table 3
Two case studies of AI Innovations.

Case No.	Title	AI development	Agri-food sector	Development stage
1	An AI-powered robot that helps farmers transition to regenerative farming by reducing tillage, covering cropping, improving water retention, reducing soil erosion, and promoting soil health	Private Research & Development (R&D)	Arable farming	Deployed
2	AI in decision support systems for dairy farmers to detect mastitis and recommend a treatment for the veterinarian	Public R&D (university)	Dairy farming	Define / design

Table 4
Examples of quadruple helix stakeholders.

Government	Civil society	Academia	Industry
Local/ regional government bodies	The end user of the AI application (farmer, operator, etc.)	Researchers	AI developers/ AI designers
Policymakers	Consumers	Universities	Third-party developers
Members of ministries	Nature/ environmental organisations	Research & development bodies	Retail
Representatives of municipalities	Food system-related NGOs	Students	Potential clients or representatives
	Legal/ compliance officers	Data scientists	Procurement officers or specialists

and guidelines). Overall, this left us with 23 distinct ELSA aspects of AI in agri-food, which came from the literature (see Table 2)

2.2. Development of ELSA Scan for agri-food

The *Ethical Guidelines for Trustworthy AI* by the High-Level Expert Group (HLEG) [19] provide an approach to assess an AI technology and is routed in the protection of people's fundamental rights (as provided by EU law). While the HLEG guidelines are relevant and applicable for fostering responsible and sustainable AI innovation in Europe, they lack nuance and applicability for specific domains. This step of the methodology aims to identify how these generic HLEG guidelines could be used to identify ELSA aspects for AI agri-food.

Based on the 23 ELSA aspects in AI in agri-food found in the literature (Table 1), we compared these aspects to the HLEG requirements to understand to which extent the set of HLEG guidelines covers the ELSA aspects found in the literature (Table 9 in Appendix B). We identified that the 22 HLEG requirements corresponded to roughly 15 ELSA aspects that were identified based on the agri-food literature. Following this, we noted that the HLEG guidelines did not provide sufficient corresponding questions for 9 ELSA aspects found in the literature (see Table 10 in Appendix B).

We therefore created questions for each of the 23 ELSA aspects building on the Assessment List for Trustworthy Artificial Intelligence (ALTAI), which contains 47 closed self-assessment questions that aim to guide developers of AI systems in general. The ELSA Scan questions were created by rephrasing each ELSA aspect into a question to ask AI developers and organisations to obtain more agri-food-specific information than what is contained in the more generic ALTAI questions. For example, in the animal farming case, the broad ethical principle of non-maleficence was phrased to give relevance to the potential harm that could be caused to the animals by using AI: 'What positive and negative effects on animal life can the AI solution potentially bring about?'

The authors discussed the core meaning of the 23 ELSA aspects to determine how these could be asked as understandable and relevant questions for AI developers and organisations. For example, transparency was phrased as the following question: 'How do you ensure the understandability of your algorithms and how do you provide information to others on where these answers come from (e.g., end-users, policymakers, etc.)?'. This process was followed for all 23 ELSA aspects (see Table 11 in Appendix C).

Table 12
Table 13

2.3. Two case studies with quadruple helix stakeholders

The ELSA Scan was applied in two case studies to study the phenomenon of AI development in agri-food in its particular context [20,21,22]. We followed the case study method and the guidelines from Yin [22] and Runeson and Höst [23] and adapted our case study approach from these five process steps: case study design, preparation for data collection, execution with data collection on the studied case, analysis of collected data and reporting [23]. A single case would have represented a critical test of the existing theory that was found, but a 'two-case' case study was used because a multiple-case study may provide us with the possibility of direct replication [22]. This means that we expect the ELSA Scan can be replicated in several different agri-food sectors. Therefore, we carefully selected two cases to predict contrasting results for anticipatable reasons (a theoretical replication) [22]. The external validity [22] was increased by selecting two contrasting cases (i.e. one in arable agriculture and one in livestock farming); the approach of the ELSA Scan for agri-food will be reasonably generalisable and applicable to AI technologies from other sectors besides dairy and arable farming. Details about the two case studies can be seen in Table 3.

These cases were selected using the following criteria: 1) the cases address sustainability objectives by using AI in a distinct agri-food sector, and 2) involve farmers or other end users, and 3) are in different stages of development. These two case studies were meant to identify how our ELSA approach could work in practice. In this phase of our research, we chose to have an in-depth exploration with stakeholders, and for this purpose, two cases were seen as sufficient to prepare and update our approach. The final approach will be used on many cases throughout several projects, so the two case studies we tested it with were to gather feedback about the method rather than a cross-examination of the ELSA content. For this cross-examination, we will use a much larger number of case studies in our analysis, but for the purpose of this study. Furthermore, the two case studies were only one component of our stakeholder engagement and testing of our approach, which will become evident in the following sections.

Stakeholder engagement aims to ensure that the perspectives, values, and concerns of those affected by AI are considered in the innovation process. Including stakeholders in Quadruple Helix (QH) collaborations can greatly benefit ELSA research [24]. QH is a multi-stakeholder process in which representatives from industry, government, knowledge institutes, and civil society collaborate towards innovation goals [25, 26]. Stakeholders from the QH were involved in the two case studies to verify how the ELSA Scan for agri-food identifies significant ELSA aspects [20,21]. See Table 4 for a list of examples of QH stakeholders.

We used a triangulation approach by gathering documentation about the two cases in advance (from their website or contact person) and a qualitative method by organising a workshop to gather comprehensive insights. Each case was researched in advance through a desk study using grey literature, which resulted in a Case Description (see Appendix D). This case description was verified by the case-owner; for instance, we

Table 5
Actual participants of the QH workshops.

	Government	Civil society	Academia	Industry	Moderator & note taker
Dairy case	2 (employees Ministry of Agriculture)	2 dairy farmers	4 (software engineers (2) ethicist (1), social scientist (1)	4 (employees of dairy high tech company)	2
Arable case	1 (employee Ministry of Agriculture)	None	3 (social scientist, ethicist)	2 (employees of arable tech company)	2

defined the AI's scope jointly with the case-owner. To increase the validity of the case study research, the outcomes of the ELSA workshops and the notes were presented back to the cases.

We selected nine questions from the 23 ELSA questions from Step 2 of the research methodology (2.2); three ethical, three legal and three social questions. After analysis of the cases using the triangulation method described in Section 2.3, the selection was based on four criteria: 1) the division of ethical, legal and social aspects is equal, 2) the total number of questions fits a 2.5-hour time frame to discuss with the QH stakeholders during a workshop, 3) All types of stakeholders need to be able to answer the question 4) the questions fit the AI case. We allowed for context-specificity by tailoring questions to each case. For example, in the dairy case, we asked specific questions about how AI influences human-animal relations because the case involves a recommendation system for the treatment of cow disease. However, this same question was less relevant for the weeding robot case. One general question was added at the beginning of the workshop as a discussion starter and to allow participants to add their own ELSA aspects.

In terms of participants, we aimed for a balanced representation of all QH stakeholders. In practice, it proved to be challenging to attract representatives of civil society to the workshops. The participants of the workshop are presented in Table 5.

The QH workshops followed an agenda and protocol. The moderation was done by the fourth author, an experienced facilitator, to ensure an inclusive and safe atmosphere for open exchange and enquiry within the time frame available (2.5 h per workshop) while making sure that the ELSA experts listened mostly and only provided expertise upon request to avoid steering. Both workshops were recorded and transcribed for posterity. Observations were also noted during the workshop to test how the ELSA questions work and whether the scan identified ELSA aspects for the two cases to test and validate the ELSA Scan questions. The stakeholders were also asked to provide their feedback at the end of the workshop about the ELSA Scan process, which allowed us to improve it in later stages (see Sections 3.3 for the feedback and 3.5 for the final version of the scan).

2.4. Retrospective expert validation of ELSA questions

With the feedback from the workshops with QH stakeholders, including AI developers, the ELSA Scan was revised. However, most of the participants of the two workshops were AI practitioners, governmental representatives, and experts in particular AI applications, which is why a round of reflection with domain-specific experts in agri-food AI was added as Step 4 of the methodology. The experts came from a Philosophy (ethics) and Law (legal) and a Socio-Economic Research Institute (social) at Wageningen University & Research (WUR). We brought together researchers from all three ELSA domains (ethical, legal and social) to discuss the scan's overall approach and question formulation in a joint interdisciplinary focus group to reduce bias by individual researchers. Each researcher's notes and preliminary results of the workshops were compared and aggregated during the retrospective sessions, and the questions were refined through several iterations based on these discussions. The feedback and input from these iterative discussions was used to determine the selection criteria and develop the final ELSA Scan for AI in agri-food.

2.5. Development of final ELSA Scan for AI in agri-food

The last step (Step 5) to finalise the ELSA Scan questions was iteratively executed based on several rounds of discussions among the co-authors based on the case studies (Section 2.3) and the retrospective expert validation sessions (Section 2.4). During these discussions, careful consideration was placed on the following three design steps: a) to which extent the questions from the scan had identified ELSA aspects, b) the effectiveness of the formulation of open questions and c) the selection of questions for the ELSA Scan.

The feedback and input from the two QH workshops and the retrospective expert validation sessions supported the experts to determine which questions addressed ELSA aspects (design step a) and the effectiveness of the formulation of the questions (design step b). The formulation of the open-ended interview questions followed these criteria:

- The formulation should help uncover both ELSA challenges and opportunities
- The formulation should be understandable for AI developers
- The formulation should be open enough to provide various responses
- The formulation should reflect the ELSA aspects outlined in the literature review (Section 3.1)

The following inclusion criteria were used to select questions for the intake survey or interview (design step c).

The inclusion criteria for the intake survey are:

- They set the scope for the AI technology and provide the ELSA expert interviewer with the required knowledge to conduct the interview
- They should be typically closed questions or easily answerable in an intake survey
- The answers do not require further clarification with follow-up questions
- The AI developer or organisation can provide the answer to the question without involvement from additional stakeholders

The inclusion criteria for the interview are as follows:

- They identify essential opportunities and challenges concerning ELSA of AI in agri-food (e.g., described in the AI Act [27])
- They should be open-ended questions requiring discussion with the AI-developing organisation during an interview.
- The AI developer or organisation can provide the answer to the question without involvement from additional stakeholders

A total of 25 ELSA Questions were selected for the survey (15) and the interview (10), leaving the remaining questions to be used for a future QH approach. An introductory interview question was added to ensure that the AI developer can bring in ELSA aspects before being asked the ELSA Scan questions without being influenced by the interviewer. The final ELSA Scan questions are described in the Results section under 3.5.

3. Results

The first result of the research is the description of ELSA aspects for agri-food from literature (3.1), followed by the initial version of the ELSA Scan questions (3.2). After validation of the ELSA Scan methodology with two cases from the agri-food sector (3.3), the questions for the ELSA Scan assessment were refined by experts (3.4) and built upon for the Final ELSA Scan (3.5).

3.1. Literature review

The following subsections highlight the main findings from the 23 ELSA aspects that we identified in the literature (see Table 2 in Section 2.1).

3.1.1. Transparency

The transparency of AI decision-making and how AI is used on farms is unclear [14]. Farmers are left with simply adopting the decisions provided by AI recommendation software without clear indications about how such decisions have been made [14]. For example, the challenges and limitations of AI in precision livestock farming are due to its complexity and non-transparency to which Explainable AI (XAI) can be operated to solve many of these problems [28]. Despite this, 'algorithmic explainability is a paramount requisite for AI systems meant to support public decision-making' [29]. Transparency is also seen as the root cause for many other issues, some very specifically related to transparency in data-driven systems, from the internal workings of the AI system, such as testing, to problems with reproducibility [30].

3.1.2. Justice and fairness

There is also a growing concern in the literature that AI will create 'digital divides' [31,32]. These are situations where certain groups do not have fair access and use of AI [33]. Fair access to AI for all farmers is mentioned as an issue [23], as there is the possibility that only larger, wealthier, monocultural farms may be able to deploy AI because of the high costs required to invest and maintain these systems and because AI works best on monocultural farms [14,32]. Also, farmers in remote locations may not have adequate internet access, face data transmission limitations and have difficulty getting their technologies repaired if anything goes wrong [32,33].

3.1.3. Bias and discrimination

The adoption of AI technologies is related to the trustworthiness of data sets and the availability of training data, which could cause unintentional bias leading to discrimination of certain groups in society to malicious attacks, for example, to manipulate decision-making [24].

3.1.4. Beneficence

Closely related to themes around justice and fair distribution of resources, a concern is that only larger, wealthy agribusinesses will benefit from the deployment and use of AI on farms [32]. While farmers will deploy AI on their farms, the data generated, and information used from this process will benefit AI tech companies, while the farmer does not get anything out of it [31] [14]. The deployment of AI may allow large agribusinesses to retrieve data from farms, upsell products to farmers, or use their data to buy farmland at low prices [14]. Potential end users should be provided with fair access to benefit from the potential of AI [14]

3.1.5. Non-maleficence

One of the main concerns surrounding AI use in agri-food is that it will harm the health and safety of those working on the farm [14,32,33]. There is a risk that AI-powered robots will emit fumes or chemicals incorrectly, leading to health impacts on farm workers [14]. Another highlighted concern is that if the farm becomes more digitalised (because of AI), it opens them up to greater risks of cyber-attacks, hacking, digital sabotage, and so forth, which would not have existed previously [14,33]. Furthermore, using AI that provides inaccurate recommendations may harm the farm, the farmer, and the farm animals [14,32]. Whilst these findings bring forward this 'non-maleficence' aspect to aim for the AI to follow the moral rule of doing no harm to end users, animals and nature, there is also the opportunity for AI to reduce many harms that currently occur on farms, such as giving more individualised treatment to animals (i.e., not all animals receive unnecessary medicine), reducing human error, bias, and automation of repetitive and tedious tasks [14].

3.1.6. Freedom and autonomy

The literature has expressed concern that deploying AI on the farm may infringe on farmers' autonomy and control of their farms [31,33]. In recent years, large businesses in agri-food have prohibited farmers from repairing their farm machinery for fear that they will tamper or damage the AI hardware installed within these pieces of machinery [14], constraining their freedom and control over their farms. In addition, there may also be pressure on farmers to accept the advice provided by AI recommendation systems despite their lack of understanding or agreement with it [31,33].

There is a call to provide farmers with greater power to resist AI deployment if it creates ethical, social, and environmental harm, regardless of the economic benefit it may bring. Therefore, farmers 'should be able to question and contest whether benefits to productivity should supersede social, ethical, or environmental concerns and be able to convince innovators and policy-makers to change the direction of innovations for sustainable agriculture' [34].

3.1.7. Privacy

Next to scalability, cost, and interoperability, other primary considerations for integrating AI that need to be addressed are privacy and security issues [29]. Despite farmers concerns about data ownership, privacy and the sharing of data, the power of agricultural technology providers causes farmers to consent to terms and conditions they may not be aware of [31], which could include the usage of data needed for AI technologies.

3.1.8. Responsibility

There are many issues related to responsibility in the development and use of AI in agri-food [33]. One of the biggest challenges in AI use in agri-food is identifying who or what was responsible for issues and harms caused by AI, as so many different actors were involved throughout its life cycle, deployment, and use [35]. With the increased level of autonomy within AI applications, it may become unclear who is responsible when harms occur due to the recommendations provided by AI or because of harm caused by AI-powered robots on the farm [32] [32]. Others claim that there is an unfair distribution of responsibility from the deployment and use of AI. For example, the deployment of AI may allow large agribusinesses to retrieve data from farms, upsell products to farmers, or use their data to buy farmland at low prices, while the farmer is the one responsible for ensuring that their farm fits the parameters for the AI to work effectively [14].

3.1.9. Privacy law and data protection

There are concerns about privacy, security, and data protection when data is retrieved and used in AI processes in agri-food [32]. However, there is often a lot of confusion and conflation of terminology in the literature. As Sapienza [35] points out: 'data privacy', 'data confidentiality', 'data protection', and similar expressions are used interchangeably' in the agri-food AI literature [35, p. 6]. However, they often refer to different things legally, making it challenging to identify what is at stake and how to address it. Regardless of this, they all commonly refer to issues of personal or sensitive data [35]. Much of farm data is non-personal but instead refers to 'data on temperature, humidity, nitrogen levels, geographical information, water use, vehicle data', although this data could still be sensitive (e.g., for market competitiveness or intellectual property reasons) [35, p. 6].

3.1.10. Data ownership and data governance

Another aspect considered in the literature is data ownership and who owns the data retrieved, used, and aggregated by AI devices and robots [14,32,35]. There is a concern that because data is not owned and controlled by farmers, agribusinesses, regulators, and competitors will use it illegitimately [14,32,33,35]. However, some have proposed that data ownership is a legally problematic terminology to enforce and that it is often better to speak about 'data governance' instead [35]: 'data governance expresses the procedures that govern the creation of data-related rules, the regulatory instruments adopted to create, modify and to amend these rules, and the objectives that they are meant to fulfil' [35, p. 7].

3.1.10.1. Liability. Uddin et al. [32] state that autonomous robots and AI-powered recommendation systems create a unique challenge for liability claims because 'Under criminal law, consisting of a crime requires two elements – actus reus (voluntary criminal act or omission from the act) and mens rea (a guilty mind intention to commit a crime)' [32, p. 226]. Regarding mens rea, 'if we consider that AI-run robots or other technologies used for climate-smart agriculture have 'sufficient awareness' like a human, the technologies can be 'liable as direct perpetrators of criminal offences' [32, p. 226]. This outcome creates all kinds of complexities for current European law [36]. The authors point to how current law states that if someone of sound mind instructs another to commit a crime, and the perpetrator is seen as an 'innocent' [36], then the developer/company may be liable as a 'perpetrator-by-another' [32]. In a second scenario, the authors talk about 'natural-probable-consequence', whereby 'if no conspiracy can be proven, an accomplice may still be held legally liable if the perpetrator's acts were a probable natural consequence of a scheme encouraged or aided by an accomplice' [32, p. 228]]. In Europe, liability for actions caused by AI is currently attributed to human agents such as 'the owner, the developer, the manufacturer, or operator of an AI' [32, p. 228]; see also European Parliament Research Service, [36, p. 26].

It has been shown that many large agribusinesses get farmers to sign licencing agreements that absolve them of liability if their AI-controlled machinery causes damage [37]. In another study by Asher et al. [30]., complex topics addressed by AI for SDG targets (e.g., climate models) may greatly impact recommendations for society, the economy, and other domains, possibly impacting many citizens. Liability needs to be solved at an international level as well [30].

3.1.11. Human rights

Fundamental rights may concern rights such as human dignity and non-discrimination, as well as rights concerning data protection and privacy. The HLEG ethic guidelines for trustworthy AI [19] advise performing a fundamental rights impact assessment (FRIA), for example, to assess the potential harmful discrimination of people based on specific grounds, before self-assessing an AI system with the ALTAI [16]. Human rights are also about the willingness of farmers to share data, which depends on the extent to which their rights and obligations are comprehensible, as well as stakeholders' roles as stated in contracts. Developing educational programmes may help customers understand their rights and responsibilities [38]. Unless the question of the ownership of farm data can be met with a definitive response, all legal frameworks and initiatives will not be as efficient because different principles or provisions require the establishment of rights and obligations related to, among many things, data ownership [38].

3.1.12. Standardisation and protocols

The global phenomena of battling climate change by deploying AI-based technology authorises steps that align with global and local practices, which is a complex task since there is no legal framework or internationally binding instrument to regulate climate-smart agricultural [31, p. 231,39, p. 106]. In addition to this complexity, the potential of AI in agriculture is impacted by the availability of data. Investments in connectivity infrastructure, data-sharing strategies that uphold privacy, and efforts to collect accurate local data are needed to address the lack of standardisation and protocols by promoting open standards and interoperability for sharing agricultural data [33, p. 5]. In addition, the lack of standardised protocols for the exchange of agricultural data creates a fragmented and complicated field, and it impedes data integration and access to data by stakeholders such as farmers, researchers, and industry operators [39, p. 5].

3.1.13. Data and AI regulations

The adoption of AI technology is seen as something to be dealt with in a transdisciplinary way, of which a prominent legal aspect is the legislation [29], such as the EU Data and AI Act. At a national and international level, regulations play a crucial role in AI development. Law is adequate in addressing conflicting interests (e.g., between data confidentiality, openness and re-use) and in European legislation, data flows can even be over-regulated. The application of the General Data Protection Regulation (GDPR), the Non-personal Data Regulation, the Data Act, the Data Governance Act, and the Artificial Intelligence Act (AI Act), which is forthcoming in the context of agri-food, together with sectoral food law legislation suggests that the EU has already provided a clear direction to solve data ownership and governance issues' [35, p. 8].

3.1.14. AI code of conduct and guidelines

Some propose that AI ethics codes of conduct, principles, and guidelines should guide the industry towards responsible AI in the agri-food sector [39]. In the context of agri-food, while there is no code of conduct or set of guidelines for AI, the EU Code of Conduct on Agricultural Data-Sharing by Contractual Agreement (2018) was a non-binding document to guide data-sharing in the sector. While the principles of the code are focused on data ownership, the owner of data is still often confusing in practice (i.e., is it the farmer, technology provider, or credit provider?) [38]. Since compiling this literature review, an additional article has come out criticising this code because of its limitation of self-regulation and voluntariness, which often opens these types of codes and guidelines to breaches, lack of compliance, and refusal to engage with them altogether [40].

3.1.15. Sustainability

Sustainability is one of the most discussed topics in the literature on AI in agri-food [14,37]. Sustainability is an essential consideration for the agricultural sector, so it is unsurprising that it also plays a significant role in applying AI. Farmers are often placed with the burden of increasing yields and reducing prices while ensuring that sustainability targets are met [14,35]. By reducing, for example, the need for pesticides and minimising crop losses, smart farming technologies, such as a cloud-based early detection system, promote sustainable agriculture [29]. While AI offers many promises and opportunities to reduce emissions, meet sustainability requirements, and optimise levels of farming, AI also poses many sustainability concerns and considerations. For example, using AI-powered robots, drones, and machinery on the farm may emit toxic chemicals, cause soil compaction, lead fluid or fumes and increase environmental harm to the farm and its environment [37,39].

3.1.16. Animal welfare

The topic of animal welfare is more important in the agri-food domain application of AI than in other fields where there is a less direct impact on animals [14]. The literature is concerned that the increased use of AI in agri-food will harm animals on the farm and biodiversity in the farm surroundings [14]. AI robots could allow for riskier agricultural practices because humans are distanced from the direct harm of these actions (e.g., heavily spraying fields with chemicals) [14]. Furthermore, there are concerns that AI could be used as just another way to objectify, control, and dehumanise animals in the agri-food sector [37].

3.1.17. Industrialisation

The proliferation of AI may pressure farmers to adapt and innovate towards AI or be threatened with being left behind [31]. If they do not, they are categorised as technological laggards [14]. This may require farmers to upskill and become technologically savvy or risk being left behind [37]. As a result, older, less educated, and poorer farmers may struggle to keep up with the innovations and increased skills required to succeed in the industry [37]. There is concern in the literature that AI may significantly impact the agricultural industry and 'agricultural societies' [34]. These authors state that there is the potential that AI will 're-script' what it means to be a farmer and what it means to farm as a whole. Therefore, they call for 'policy-makers, funders, technology companies, and researchers to consider the views of both farming communities and wider society' [34, p. 1]. 'In recent decades, the blurring of boundaries between the industrial and service sectors has been witnessed'[29]. A similar situation is seen in agri-food, specifically for the production of primary produce, in which industrialisation is undergoing [29]. Incorporating broader and more systematic theoretical and practical concepts and experiences into the education of engineers from across the global community is advised by including these concepts in engineering programs [29].

3.1.18. Impact on gender, class, race

In some papers, authors referred to AI's potential to dramatically impact certain classes and groups, for example, using AI and robots to replace seasonal migrant labour [14]. AI robots may be cheaper, more effective, and have less paperwork for farmers who would have typically employed migrant labourers. Some propose that there should be 'a broadening of notions of 'inclusion' in responsible innovation to account better for diverse and already existing spaces of participation in agri--tech' [34, p. 1].

3.1.19. Impact on societal views of food production

Too much dependence on technical solutions may come at the expense of conventional knowledge. For example, farmers who become too dependent on AI may lose touch with agricultural practices and knowledge used in traditional farming practices. 'Maintaining a balance between technology and traditional knowledge is crucial for sustainable agriculture' [39, p. 7]. In response to this, some claim that responsible innovation could support the anticipation of impacts at all levels: on-farm, farming landscapes, across food chains, and considering the 'effects on rural communities and publics as a whole' [34, p. 3].

3.1.20. Labour

The topic of employment is widely discussed in the AI agri-food literature. AI could replace many dirty, dull, and dangerous jobs on the farm and help respond to the declining number of farmers due to ageing farmer demographics, labour shortages, and increasing pressure to produce more with fewer resources [14]. On the other hand, there is a worry that AI will replace many traditional jobs, changing the entire landscape of agricultural work for the negative [33]. While robots are expected to replace numerous job roles in agri-food, some may be augmented. Robots will work collaboratively with humans in many cases, creating complex ethical, legislative and social impacts to which short and mid-term effects of robotised agri-food on jobs and employment need to be assessed [38].

3.1.21. Power asymmetries

With the influx of AI deployed on farms, Big Tech and large agribusinesses could gain increased power [31]. With the increased use of AI on farms, the industry has also seen more contracts and agreements for using these devices on farms. However, many legalistic and technical terminology is often used, confusing farmers not trained in these areas [31]. Many agribusinesses require farmers to be seeds or tractor customers before they can use the companies' AI. It is challenging to cut ties with these companies if one no longer wants their AI technologies (because they are fundamentally dependent on these other goods) [31]. 'If a few companies control key technologies and data in AI-driven agriculture, it can lead to monopolies and an unfair distribution of AI benefits in agriculture' [33, p. 6].

3.1.22. Costs and other economic aspects

AI-powered technologies, such as unmanned vehicles, potentially increase efficiency by reducing costs while contributing to sustainability in agri-food, and cost-effective and readily available devices (for example, simple webcams) can be integrated into agricultural practices with minimal effort [29]. However, economic aspects like cost, logistics and compatibility with existing practices are mentioned as issues for AI in agri-food and are considerations to be addressed concerning scalability and interoperability when integrating AI [27]. Standard AI frameworks can result in very powerful and complex AI technologies for straightforward tasks, for example, using a deep neural network instead of a basic decision support system rule, resulting in large amounts of (critical) systems that need testing at an extremely high price, with possible risk for attack [30]. Also, farmers may be faced with the loss of data analytics if they do not abide by the policies and requirements of the technology provider or are coerced to stay because of fear of legal and economic punishment [31]. Another crucial issue of initial costs is personnel training because it takes time and resources to reap the benefits of AI in agriculture [33, p. 3].

3.2. Development of ELSA Scan for agri-food

The comprehensive set of 23 questions of the first ELSA Scan design aims to cover the ethical, legal, and social aspects from literature (Table 11) in Appendix C. While the E, L and S categories were used for this initial list of ELSA questions this does not imply that an aspect belongs to only one category. Some ELSA aspects may have a degree of overlap, interchange, and co-dependency. For example, while privacy is an ethical issue, it is also significant in terms of data protection (e.g., GDPR in legislation). This is why two separate ELSA aspects are presented in the set of ELSA aspect, and therefore the questions. some aspects may be related to the ethical, legal or social perspective as well as another one. For example, privacy could be an ethical concern, but it is also an aspect that is covered by legislation by GPDR which is why it is also covered under the legal aspects.

3.3. Validation of ELSA Scan with two AI innovations

To empirically explore the ELSA Scan, one workshop for each of the two cases mentioned earlier was organised (see Table 3) and facilitated by a professional facilitator with previous knowledge of ELSA aspects.

3.3.1. Case 1: AI-powered robot supporting regenerative farming

This workshop was attended by eight stakeholders from the company developing the AI technology, the Ministry of Agriculture, and three researchers (see Table 5). Table 14 in Appendix E presents the main findings for each ELSA question we asked.

Based on the validation of the questions with this case, we gained insights on the applicability, order and formulations of the ELSA questions. The first question, 'what type of algorithms do you use in the application?' could have easily been posed beforehand, for example in a survey, because it did not lead to the identification of ELSA aspects and is mainly meant for the developer.

Two points of feedback were provided on the ELSA Scan and its questions. Firstly, while this workshop was not set-up as a judgmental assessment, nor a checklist, but was intended as a reflection tool, the outcomes of an ELSA Scan were not clear to stakeholders beforehand (e.g. is there a judgment attached to it or does it result in some kind of score? Or recommendations?). The second point was that the ELSA discussion should leave room for the idea of "'Man plus machine' to identify what the ethical capacities are of a man and a machine working together and how does that change the social structure".

Besides the empirical exploration of the ELSA questions as shown in Table 14 and the feedback provided by the participants, observations provided three findings. Firstly, to assess ELSA aspects for a tangible application with a clear scope made a structured conversation easier for participants and facilitator. However, some questions led to generalization to AI and digitalisation regardless of the specific context of this case. This could make it difficult to assess ELSA aspects for a specific setting in agri-food. Secondly, following up questions with specific examples helped to contextualise the questions (without steering the answers). The third finding was that answering certain ELSA questions needs the involvement of policy makers and other stakeholders to ask critical follow-up questions for additional reflections in addition to the AI developer perspective and sometimes expertise, for example legal expertise supported the discussion about the AI Act.

3.3.2. Case 2: AI in decision support systems for advice on mastitis treatment

The workshop about the AI recommendation system for mastitis counted 16 participants (see Table 5) of which a dairy robotics company, a dairy farmer, researchers, policy-makers from the Ministry of Agriculture and researchers. The main findings for each of the ELSA questions we asked are in Table 15 in Appendix E.

The formulation of most questions was understood properly and they identified different ELSA aspects. One question provided a different ELSA aspect than expected; a question about potential trade-offs between profitability and animal welfare. The answer provided was about the ELSA aspect liability (legal), instead of the expected socio-economic aspect 'cost', because the distinction between public interests (i.e. animal and human welfare) and private interests (making money) was not formulated in the question clearly enough.

The feedback from the participants was that the insights from discussing ELSA aspects was needed to identify certain ELSA aspects and could not be possible answering questions on their own. An example is that the recommendation system could support decision-making 'when not to treat mastitis with antibiotics', which was taken as an improvement suggestion by the AI developer.

Table 6
Expert feedback on ELSA questions.

Philosophy (ethics)	Law (legal)	Socio-economic (social)
• Although comprehensive and usable for a 1.5-hour interview, some questions are too general they cannot be answered adequately in this timeframe. • Structural issues such as data-ownership and surveillance may not be uncovered using the ELSA Scan, maybe such aspects could be included in the form of dilemmas or scenarios. Including a question about disruption may address this. • The current definition of AI is too narrow. It leaves no room for AI as a system or ensemble that structurally changes human-technology relations. Questions about technical specifications of AI are underrepresented in the scan. The researcher needs to know more about the technology to identify the main ELSA issues. • The interview should allow for an additional question or discussion to delve into a topic or themes such as, what do you mean with 'human', or 'environment' in this case etc. • Sustainability: is it one of the principles, is it an overarching value, an extra category besides Ethical Legal and Social? • The questions seem structured in a random fashion, following the letters of the ELSA acronym, this is hindering a more systematic appraisal of the scan.	• The most interesting thing at this stage is to find out to what extent the so-called 'AI provider is aware of the developments in the regulations and whether this affects their processes in any way', asking for example, "To what extent are you aware of the proceedings in AI regulation (EU AI Act and AI liability Directive) and to what extent does this influence your development processes/ products?". • It is a very interesting question to ask in this stage of the regulatory procedure because the implications are (just like the regulation itself) not set in stone yet, but there is a clear direction in which the regulatory drafts point and it would be interesting to hear as to what extent practitioners are aware of this.	• Certain ELSA aspects do not need an ELSA Scan with only AI developers, because answering the question needs QH discussion about societal and systemic ELSA issues, for example the question for non-maleficence "How does the AI technology for agri-food challenge ethical values, social norms and longstanding rights and obligations of stakeholders?". • Most questions need a reformulation to address the ELSA aspect adequately, depending on if it's a survey or interview question, for example the question about animal welfare "How will you prevent unethical treatment recommendations by AI-informed decision-making, which may, for instance, maximise profits but jeopardise animal welfare?" is a leading question and could be rephrased to "How does your AI solution prioritise the welfare of animals, plants, and the environment alongside human interests and profits to promote sustainable agriculture? • To gather enough of information about the possible ELSA aspects from the AI developer during the interview, all questions should be open ended. • A 'pre-scan' survey could be an elaborate questionnaire, and the follow-up interview could identify additional ELSA aspects.

3.4. Retrospective expert validation of ELSA questions

Step 5 of the methodology (Section 2.5) was a round of reflection with domain-specific experts in agri-food AI to critically review the ELSA questions. The feedback received from these experts can be been in Table 6

The feedback from these three expert groups was compiled and used to identify ways to restructure the ELSA Scan, reformulate some questions, and add new ones. These changes led to the final ELSA Scan, described in the following section.

3.5. Development of final ELSA scan for AI in agri-food: intake survey and interview

Based on the validation from the explorative workshops with the two cases and the retrospective validation with experts, the ELSA Scan was developed into two parts: an intake survey and an interview (Fig. 2).

As was brought forward by the experts, it's crucial to understand the scope and development stage of the AI technology and previous efforts towards responsible AI by gathering information before carrying out the interview (this was a suggestion in the socio-economic expert group). This preliminary intake survey aims to find out background information about the AI case before the interview takes place, which addressed the concern felt in the ethics expert group that one needs to know more about the technology before the interview. Therefore, an 'Intake survey' takes place before the next step of the ELSA Scan: an interview with the AI developer. This two-tiered ELSA assessment is called a 'scan' to indicate that initial ELSA aspects of a particular AI technology can be identified in a relatively short time. This change responds to the issue of

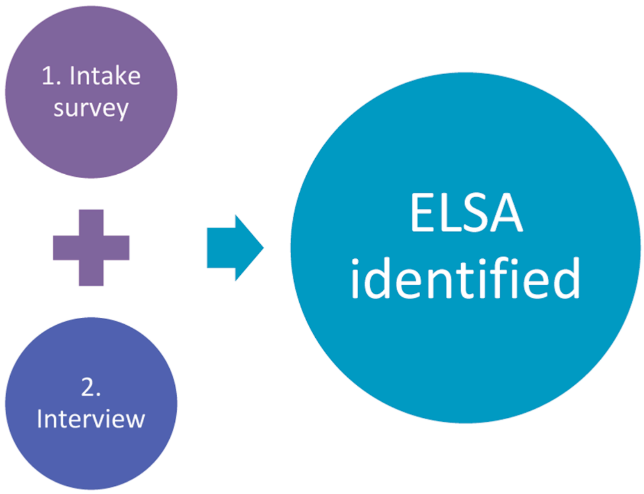

Fig. 2. The two-tiered ELSA Scan for AI in agri-food.

insufficient time to implement the Scan, which was raised in the ethics expert group. Lastly, we identified several questions that would be better addressed in a QH session with the AI developer or organisation, following the advice from the socio-economic expert group.[2]

The outcome of the ELSA Scan assessment is the initial identification of ELSA aspects in a particular agri-food case. It provides general recommendations that the organisation developing the AI technology can follow up on.

This final design of the ELSA Scan consists of 25 questions. The 25 questions comprise of: six ethical, seven legal, five social aspect questions, four general background information questions and three technical questions about the AI. The Intake survey has 15 questions (Table 7), which combines open-ended questions with closed questions.

The semi-structured interview is constructed with ten open-ended questions for an interview with the AI-developing organisation (taking advice from the socio-economic expert group to ensure more open-ended questions in the interview), see Table 8.

The ELSA Scan survey was developed as an online survey tool for AI developers that gathers information about the AI application in agri-food, including general and technical details. The results of this survey will be used as preparation for the interviewer, an ELSA expert. The interview is supported by a full protocol for internal use in which ELSA experts are instructed how to organise, gather consent and lead the semi-structured interview. The ELSA Scan outcomes can be provided to the AI developing organisation using a template that provides an overview of ELSA aspects in relation to the 10 questions, general references to, for example, legal acts and, separately, recommendations by the ELSA expert.

4. Discussion

Because large-scale adoption of AI technology may come with ELSA threats, stakeholders hold responsibility to ensure that AI is developed in a trustworthy and ethically responsible way [41]. This requires a combined approach in which safety, security and explainability are essential cross-cutting issues [41]. The ELSA Scan allows for cross-cutting assessments of potential issues and opportunities and primarily functions

[2] Discussing the ELSA aspects ‘Sustainability’ and ‘Privacy’ in a QH setting is expected to complement or contrast the AI developer perspective. Others are expected to not be fully addressed unless in a QH setting: ‘Bias and discrimination’, ‘Non-maleficence’, ‘Responsibility’, ‘Human Rights’, ‘Impact on gender, class, race’, ‘Impact on societal views of food production’, ‘Power asymmetries’ and ‘Costs and other economic aspects’.

Table 7
15 Questions for ELSA Intake survey.

Category	ELSA aspect	Question	Open / closed	Multiple Answer (MA) options
General	Sustainability	What is the AI technology? Please describe the context, functionality and customer group.	Open ended	Not applicable (N/A)
Social	Sustainability	Which goals will the AI technology serve to make the agri-food system more sustainable?	Open ended	N/A
Technical	Case data collection	What stage is the AI technology for agri-food in from a technical perspective?	Closed / MA	Define/design Prototype/ Proof of Concept Advanced User Testing Deployed Other
Technical	Case data collection	What type(s) of AI are you working on for this AI technology?	Closed / MA	Basic Data Science Machine Learning Neural Networks Deep learning Large Language Models (LLM) Other
Technical	Case data collection	What is the Technology Readiness Level (TRL) of the AI technology for agri-food?	Closed / MA	TRL 1- TRL 9
General	Eligibility for ELSA Scan	What other measures have been taken previously by the AI technology provider to identify ELSA ?	Open ended	N/A
Legal	Privacy law and data protection	What has the AI technology provider done for GDPR (General Data Protection Regulation) compliance and legal policy?	Open ended	N/A
Legal	Privacy law and data protection	Who (name, role) is in charge of storing the data?	Closed	Text
Legal	Data ownership and data	Who is the owner of the data collected (data owner) by the AI technology and which agri-food stakeholder is preferably supposed to be the owner (data rights holder)?	Closed	Text - short
Legal	Data and AI regulations	Did you provide appropriate legal training to those involved applicable to the AI solution for agri-food?	Closed	Yes / No / I don’t know / NA
Ethical	Privacy	Has the AI technology provider signed a data sharing agreement concerning the use	Closed	Yes / No / I don’t know / NA

(continued on next page)

Table 7 (*continued*)

Category	ELSA aspect	Question	Open / closed	Multiple Answer (MA) options
		of the external data (from other organisations) that are necessary for the AI technology?		
Legal	Liability	Who (name, role) is internally responsible for the AI technology from a legal perspective, in relation to the final user?	Closed	Text - short
Social	AI code of conduct	Are you aware of, and follow, any AI codes of conduct, possibly in the agri-food domain?	Closed	Yes / No / I don't know / NA
Ethical	AI code of conduct (ethics guidelines)	What efforts has the AI technology provider made toward consulting with an ethics board, ethics advisor, or policy officer, within or outside your organisation?	Open ended	N/A
General	Eligibility for ELSA Scan / Stakeholder engagement	Are the AI developers and preferably end users of the AI technology for agri-food part of the stakeholder group of the case and available during the ELSA Scan?	Closed / MA	Developers already engaged Developers and end users already engaged Developers available Developers and end users available None engaged or available Other

as a diagnostic tool to identify common ELSA aspects that require dedicated reflection and redesign.

Several ELSA aspects can be difficult to address when examining one particular application of AI in agri-food. While many ELSA aspects can be identified by evaluation of individual AI applications (e.g., privacy, transparency, and security), others are much broader and have structural-level impacts that are difficult to grasp when reflecting upon the technology itself. Furthermore, it is sometimes beyond the capacity of an AI developer or organisation to be able to respond to all ELSA aspects, especially when they are far beyond their capacity to implement. For example, ELSA aspects such as the industrialisation impact of AI on the culture and practice of farming or the impact on societal views of food production, or the possible power asymmetries that may arise [43] are sometimes challenging to understand and respond to.

Some of these are difficult to evaluate because of complexity, a lack of awareness, or developers' (often unknown and unintended) biases. For example, power asymmetries may be an unintentional effect caused using the AI. Similarly, gender, class, and race biases might emerge if there is a lack of diversity in the development team. Other ELSA aspects are challenging because they require political action and policy change at a much higher level than AI developers can respond to (e.g., industrialisation challenges caused by digitalisation and the proliferation of AI as a whole).

These types of ELSA aspects require reflection and input from a diverse group of stakeholders and decision-makers rather than only being seen as the responsibility of AI developers or small AI companies.

Table 8
10 Questions for ELSA Scan Interview.

Category	ELSA aspect(s)	Question
General	ELSA general self assessment	What ethical, legal and social aspects of AI in agri-food come to mind in relation to the AI technology?
Social	Sustainability, animal welfare	How does the AI technology prioritize the welfare of animals, plants, and the environment alongside human interests and profits to promote sustainable agriculture?
Ethical	Beneficence	How do agri-food stakeholders benefit from the AI technology?
Ethical	Justice and fairness	How does the AI technology ensure fairness for agri-food stakeholders?
Ethical	Transparency	How is the AI technology understandable and explainable to stakeholders in agri-food?
Ethical	Freedom and autonomy	To which extent is the AI technology working autonomously and how much control do agri-food stakeholders have?
Social	Labour	How does the AI technology affect the employment in the local agri-food community?
Legal	Liability	How is liability organised when considering actions taken by the AI technology for agri-food?
Legal	Data and AI regulations	To which extent does the organisation take AI regulation and policy into account for the agri-food domain?
Social	Industrialization	How can the AI technology potentially disrupt the entire agri-food sector?

While these issues are important and relevant for conducting ELSA AI diagnostics, they are somewhat beyond the bounds of AI development.

The advantage of the ELSA Scan is that it is built on literature specifically for AI in agri-food and that it has been empirically explored in two agri-food cases. Compared to, for example, the framework suggested by Jobin et al., the ELSA Scan has been developed to include the identification of legal aspects having to do with current AI and data legislation and is therefore up to date. The HLEG guidelines are also generic and to be used as a self-assessment using the ALTAI tool, while the ELSA Scan for agri-food involves an expert review of the specific ELSA aspects in the context of the AI for agri-food. Possible barriers to implement the ELSA Scan in a real-world setting may be data management and maintaining a high level of data collection and analysis by multiple ELSA researchers for multiple AI cases in agri-food, which can be mitigated by structured scientific research and project management. Stakeholders from the four helixes in agri-food may be impacted by the ELSA research, because findings will support challenges and opportunities found by the ELSA Scan. For example, actionable insights about AI innovations in certain sectors are expected to be of value to farmers and food value chain operators. Also, policy makers will be able to understand how to address ethical, legal and social issues in agri-food and which specific ELSA aspects are in need of further research funding.

Therefore, we state that the ELSA Scan be used as a first step to help AI developers and organisations in agri-food identify some of the predominant ELSA aspects related to their AI. However, addressing additional ELSA aspects with a broader community of stakeholders is also essential. QH stakeholders allow for a collective identification of ELSA aspects we identify in this paper and provide a place for collaborative discussions and actions to address these aspects.

5. Conclusion

This paper has established that the agri-food sector needs a domain-specific approach to develop responsible AI. The ELSA Scan for agri-food serves as an initial assessment to identify critical ELSA aspects and is expected to be used for AI in all agri-food sectors (arable, dairy, fruit, vegetable, meat, food production, retail, etc.). The ELSA Scan is relatively easy to implement at a low cost, also making it accessible for AI technology business of small sizes. In this research, we only involved QH stakeholders to explore the ELSA Scan methodology. The outcome of our research is that further research is needed on how to engage all QH stakeholders in the development of responsible AI in agri-food to uncover additional challenges and opportunities. Effort was put into having a farmer attend a workshop to represent the end user, as part of the helix of civil society, however the representation of this helix was missing for this case. Additional in-depth assessment such as an ELSA social laboratory setting with all four helixes, is needed to identify all ELSA aspects for example ‘Human rights’ and provide tailored recommendations to mitigate risks and take opportunities towards responsible AI development in agri-food. It is therefore recommended that future research tests the ELSA Scan in other countries, domains and use cases, potentially also outside of the EU. The ELSA Scan is already being deployed in various projects (in The Netherlands and EU[3]) from which evaluation data can be collected about the usability of the assessment, as well as research results as to the ELSA aspects in agri-food. Also, the ELSA Scan can be developed towards other data science-driven technologies, concerning the development of agricultural data spaces. The ELSA Scan was developed in the context of AI for agri-food, but the methodology could be used to develop other ELSA Scans for other sectors. In addition, future research should also provide a more robust examination of AI development in practice, focusing on the development of algorithms. This approach may include one or more quadruple helix workshops in an ELSA lab setting to provide such interventions to mainly uncover the actual bias at the programming level of AI software development.

CRediT authorship contribution statement

Mireille van Hilten: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Mark Ryan:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Investigation, Validation. **Vincent Blok:** Writing – review & editing, Conceptualization. **Nina de Roo:** Writing – review & editing, Writing – original draft, Validation, Formal analysis.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Mireille van Hilten, Mark Ryan, Nina de Roo reports financial support was provided by Ministry of Agriculture Nature and Food Quality. Vincent Blok reports financial support was provided by Netherlands Foundation of Scientific Research Institutes. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Can Atik, Olivia Azhari, Maria Jose Plano Casado, Janita Sanderse, Luuk Stellinga, Georgios Tsagdis, Idse Val, Roel Veraart, Hao Wang, Josephine van Zeben

Appendix A. Search Query String

(TITLE-ABS-KEY (ethic*) OR TITLE-ABS-KEY (legal*) OR TITLE-ABS-KEY (society*) AND (TITLE-ABS-KEY (agricult*) OR TITLE-ABS-KEY (agri-food)) AND (TITLE-ABS-KEY ("artificial intelligence"))) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ch") OR LIMIT-TO (DOCTYPE , "bk")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "ARTS") OR LIMIT-TO (SUBJAREA , "VETE") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ECON")) AND (LIMIT-TO (AFFILCOUNTRY , "Germany") OR LIMIT-TO (AFFILCOUNTRY , "United Kingdom") OR LIMIT-TO (AFFILCOUNTRY , "Italy") OR LIMIT-TO (AFFILCOUNTRY , "Spain") OR LIMIT-TO (AFFILCOUNTRY , "Netherlands") OR LIMIT-TO (AFFILCOUNTRY , "Austria") OR LIMIT-TO (AFFILCOUNTRY , "Portugal") OR LIMIT-TO (AFFILCOUNTRY , "Greece") OR LIMIT-TO (AFFILCOUNTRY , "Norway") OR LIMIT-TO (AFFILCOUNTRY , "Denmark") OR LIMIT-TO (AFFILCOUNTRY , "Switzerland") OR LIMIT-TO (AFFILCOUNTRY , "Poland") OR LIMIT-TO (AFFILCOUNTRY , "Ireland") OR LIMIT-TO (AFFILCOUNTRY , "Hungary") OR LIMIT-TO (AFFILCOUNTRY , "Romania") OR LIMIT-TO (AFFILCOUNTRY , "France") OR LIMIT-TO (AFFILCOUNTRY , "Finland") OR LIMIT-TO (AFFILCOUNTRY , "Sweden") OR LIMIT-TO (AFFILCOUNTRY , "Slovenia") OR LIMIT-TO (AFFILCOUNTRY , "Slovakia") OR LIMIT-TO (AFFILCOUNTRY , "North Macedonia") OR LIMIT-TO (AFFILCOUNTRY , "Czech Republic") OR LIMIT-TO (AFFILCOUNTRY , "Cyprus") OR LIMIT-TO (AFFILCOUNTRY , "Bulgaria"))

Appendix B. 23 ELSA aspects and the HLEG requirements

The AI guidelines, as defined by the HLEG [19] use seven requirements to guide the implementation and realisation of trustworthy AI based on a set of seven principles. With the guidelines comes the ‘Assessment List for Trustworthy Artificial Intelligence’ (ALTAI), a self-assessment tool for designers and developers of AI technology, data scientists, procurement officers, front-end staff, legal and compliance officers and management. The ALTAI includes available technical and non-technical methods for implementing the seven requirements throughout the life cycle of AI technologies. Without imposing a hierarchy, the seven requirements mirror the order of appearance of the principles and rights they relate to in the Charter of Fundamental Rights of the European Union (EU Charter) [42]. For example, the requirement ‘Human agency and oversight’ includes fundamental rights, human agency and human oversight, while ‘Technical robustness and safety’ is about resilience to attack and security, having a fallback plan and creating general safety, accuracy, reliability and reproducibility.

[3] In the Netherlands, the NextGenHighTech project [43] applies the ELSA Scan to cases in handsfree technologies in arable and horticulture farming. AgrifoodTEF is an EU network of Testing and Experimentation Facilities for AI to bridge the gap between innovation and go to market [44]. The implementation project of the Common European Agriculture Data Space (CEADS) commencing in 2025 will also apply the ELSA Scan [45].

Table 9
HLEG principles compared to 23 ELSA aspects.

Ethical	HLEG Requirements
1. Transparency	Traceability, Explainability, Communication
2. Justice and fairness	Avoidance of Unfair Bias
3. Bias and discrimination	Accessibility and Universal Design
4. Beneficence	-
5. Non-maleficence	General Safety
6. Freedom and autonomy	Human Agency and Autonomy, Human Oversight
7. Privacy	- (indirectly through Privacy and Data Governance)
8. Responsibility	Accountability (Auditability and Risk Management)
Legal	
9. Privacy law and data protection	Privacy and Data Governance
10. Data ownership and data governance	Privacy and Data Governance
11. Liability	Accountability (Auditability and Risk Management)
12. Human rights	- (indirectly through Human Oversight)
13. Standardisation and Protocols	Resilience to Attack and Security
14. Data and AI regulations	Risk Management
15. AI code of conduct and guidelines	-
Social	
16. Sustainability	- (only environmental, not animal health for example)
17. Animal welfare	-Avoidance of Unfair Bias
18. Industrialization	Impact on Society at large or Democracy, Human Oversight
19. Impact on gender, class, race	Impact on Work and Skills
20. Impact on societal views of food production	Impact on Society at large or Democracy-
21. Labour	-
22. Power asymmetries	-
23. Costs and other economical aspects	

Table 10
23 ELSA aspects compared to HLEG requirements.

HLEG requirements	ELSA
Human Agency and Oversight	
Human Agency and Autonomy	Freedom and autonomy
Human Oversight	Freedom and autonomy
Technical Robustness and Safety	
Resilience to Attack and Security	Privacy (ethical) - (Prerequisite)
General Safety	Non-maleficence (ethical)
Accuracy	Privacy (ethical) Privacy law and data protection (legal)
Reliability, Fall-back plans, and Reproducibility	- (Prerequisite)
Privacy and Data Governance	
Privacy	Privacy law and data protection (legal)
Data Governance	Privacy law and data protection (legal)
Transparency	
Traceability	Transparency (ethical)
Explainability	Transparency (ethical)
Communication	- (AI design)
Diversity, Non-discrimination, and Fairness	
Avoidance of Unfair Bias	Bias and discrimination (ethical)
Accessibility and Universal Design	Justice and fairness (ethical)
Stakeholder Participation	- (ELSA lab methodology)
Societal and Environmental Well-being	
Environmental Well-being	Sustainability (social)
Impact on Work and Skills	Labour (social)
Impact on Society at large or Democracy	Impact on societal views of food production Power asymmetries (social)
Accountability	
Auditability	Responsibility (ethical) Liability (legal)
Risk Management	Liability (legal)

Appendix C. Initial ELSA Scan questions

Table 11
23 Initial ELSA questions for agri-food.

Ethical aspects and questions			
1	Ethical	Transparency	How do you ensure the understandability of your algorithms and how do you provide information to others on where these answers come from (e.g., end-users, policymakers, etc.)?
2	Ethical	Justice and fairness	How do you ensure people will have access to the AI technology for agri-food that you are developing? How do you make sure that the AI is easy to use for all?
3	Ethical	Bias and discrimination	What ethical standards or values should guide the behaviour and choices of AI for agri-food and (how) should this be built into it?
4	Ethical	Beneficence	How do you ensure that your AI brings positive outcomes for society? How does your AI result in benefits for individuals and society?
5	Ethical	Non-maleficence	How does the AI technology for agri-food challenge ethical values, social norms and longstanding rights and obligations of stakeholders?
6	Ethical	Freedom and autonomy	Is there control or independence in working with the AI technology for agri-food?
7	Ethical	Privacy	How do you ensure your AI does not infringe on the privacy of individuals or groups?
8	Ethical	Responsibility	Can AI for agri-food be considered responsible, or are (only) the robot-developers or users' appropriate responsible agents?
Legal aspects and questions			
9	Legal	Privacy law and data protection	Have any data sharing agreements for the use of data necessary for the AI solution been signed?
10	Legal	Data ownership and data governance	How are you GDPR compliant?
11	Legal	Liability	Which liability issues could occur with respect to the AI technology for agri-food? And have you taken any steps to reduce the liability?
12	Legal	Human rights	How does the AI technology for agri-food challenge ethical values, social norms and longstanding rights and obligations of stakeholders?
13	Legal	Standardization and protocols	Did you provide appropriate legal training to those involved applicable to the AI technology for agri-food?
14	Legal	Data and AI regulations	How do you, and your organisation, implement AI policy? How have you responded to the forthcoming AI Act?
15	Legal	AI code of conduct and guidelines	Are you aware of, and follow, any AI codes of conduct?
Social aspects and questions			
16	Social	Sustainability	Are you aware of sustainability and/or societal cost involved? What are positive and negative effects on the environment that the AI technology for agri-food can potentially bring about?
17	Social & Ethical	Animal welfare	How will you prevent unethical treatment recommendations by AI-informed decision-making, which may, for instance, maximize profits but jeopardize animal welfare?
18	Social	Industrialization	How can the AI solution potentially disrupt the entire agri-food sector?
19	Social	Impact on gender, class, race	How do you ensure that your AI does not lead to harmful bias against gender, class, race, and so forth?
20	Social	Impact societal views of food production	How will you ensure that AI-based solutions for decision-making for agri-food are socially aware considering stakeholders': preferences, experiences, and domain knowledge?
21	Social	Labour	What are the effects of the AI technology for agri-food on labour context and the job market in the agri-food sector?
22	Social	Power asymmetries	What strategies are in place to prevent that people may suffer from the effects of the AI technology for agri-food, while others harvest the benefits?
23	Social	Cost and other economic aspects	How do ELSA compete with economic values?

Appendix D. Case descriptions

Table 12
Case Description Case 1.

Case Name	AI-powered robot supporting regenerative farming
Background	The AI-powered robot is an alternative approach to implementing digital technology and robotics in agriculture. In the optimal situation, all crops are in the right place to achieve maximum yield. This optimum can be calculated and predicted using computer models. After a model is put into operation, the crops can be planted, cared for, and harvested using robotic technology.
Case description	The AI technology is an advanced agricultural robot designed for smart farming. Equipped with 14 advanced depth sensing cameras and dual GPS antennas, it is ideal for large-scale and biodiverse environments and helps farmers transition to regenerative agriculture. This is achieved through practices such as cover crops, reduced tillage with our specialist tools, and smart crop rotation. This not only increases soil fertility, but also improves water retention, reduces erosion, and promotes biodiversity. In addition to improving soil health, regenerative agriculture can also lead to more resilient crops and higher yields. The operator of the robot can perform tasks (over multiple machines) according to a GPS pattern, with fixed driving paths reducing soil compaction. Each head of the robot has a certain tool (e.g. mowing) that allows weeds to be mowed between crops such as beans, for example, without spraying.
ELSA	Ethical, legal and social aspects have not been identified previously.
AI development stage *	Deployed

*- Concept/design.
- Prototype/Proof of Concept.
- Advanced: still in development, but advanced stage.
- Deployed: deployed in market, sold to customers.

Table 13
Case Description Case 2.

Case Name	AI in decision support systems for advice on mastitis treatment
Background	Despite the advances concerning diagnostic procedures, mastitis is still the most frequent and costly disease in dairy farms, with significant negative impacts on profitability and animal welfare. The search for suitable treatments demands the identification, classification, and prediction of their efficacy considering multiple variables and dimensions (i.e., animal welfare, operational costs, estimated profits, and environmental conditions). Artificial intelligence and machine learning, accompanied by user-friendly human-computer interaction and cognitively effective visualization techniques, have been providing the foundation for the creation of decision-support systems (DSSs) that enable the analysis of multiple variables at the same time. Whereas the development of data-driven DSSs has made great progress in controlled and experimental settings, their effective adoption in real-world applications is still challenging.
Case description	The AI technology aims to specify, implement, and validate an ELSA-compliant data-driven farmer-in-the-loop decision-support system (DSS) to support effective and responsible decision making. The DSS will be designed and implemented in generic terms, but its validation will rely on a case study concerning the recommendation of suitable treatment procedures for mastitis disease in dairy cattle. The farmer will provide the actual treatment. Knowledge graphs will be used to identify Ethical, Legal and Social aspects from data sources. The outcome is an ELSA-compliant data-driven farmer-in-the-loop decision-support system (DSS) for treatment recommendation is operational and validated in the field with stakeholders.
ELSA	Initial ELSA reflections: Ethical: AI-informed decision-making may involve unethical treatment recommendations, which may, for instance, maximize profits but jeopardize animal welfare. Legal: Legal challenges include handling data ownership and data sharing issues involving different stakeholders (farmers, and dairy companies), responsibility and accountability in case of errors of the AI system, as well as public enforcement issues. Social: The practical adoption of AI-based technologies for decision-making depends on making them explainable and understandable. AI-based decision-making needs to be socially aware, considering stakeholders' preferences, experiences, and domain knowledge.
AI development stage	Define / Design

*- Define/design.
- Prototype/Proof of Concept.
- Advanced: still in development, but advanced stage.
- Deployed: deployed in market, sold to customers.

Appendix E. Workshop findings

Table 14
Findings about ELSA questions from the workshop with Case 1.

ELSA aspect	Question asked	Key messages from the discussion	Reflections on questions
Transparency (ethical)	What kind of algorithms are used in the application?	The AI technology does not use deep learning. They aim to keep the machine 'as stupid as possible'; and train it to do very basic tasks only. They don't want the machine to think for itself.	- This question could be moved to a survey. - The discussion that followed from this question tended to remain generic and not about this specific AI technology.
Non-maleficence (ethical)	How is ensured the AI solution does not cause physical or emotional harm to humans and animals?	Upon request, for instance from national policies, the AI company can build in layers about what the robot should do if faced with a live animal (e.g. a dog), or a bird nest, or a fence. This applies to already known risks (i.e. objects that can be described in code).	This question was asked to the developing company and easily understood by all participants.
Sustainability (social)	What could be unintended or unexpected negative effects (social, environmental, or other) of using this application at a wide scale?	- All AI code is developed only by the AI company. When the robot will be used at wider scale, it may become possible for others to develop code as well. This increases the risk that someone may develop an undesirable code, for instance to do harm to humans or the environment. - Impact on working conditions and acceptance by farmer is unclear one multiple farm robots need to be managed. - If used at a large scale, the robot weeding, we may also lose genetic diversity, potentially contributing to the standardisation of genetic pool	It was difficult for the participants to think about unknown unknowns. After probing with prepared follow-up questions, this question helped the participants to think ahead in terms of time and scale about the potential risks of the wider use of the AI technology.
Sustainability (social)	What would you tell your family and friends at a birthday party, if they ask you in what ways this AI application contributes to a better world?	- Controlling weeds and diseases is mostly done with chemicals, potentially damaging nature and human health. Avoid pesticides needs manual weeding. The robot addresses the problem of the unavailability of labour in an effective way.	- Question was easily understood. - This question would have been a nice starter question, to make the participants feel comfortable (and also generate insights about how the participants see the contribution of their application to sustainability and which aspects of sustainability they come up with).
Liability (legal)	Which liability issues could occur with respect to the AI solution SFS?	- The training of the robot and the person responsible for operating the robot is crucial in terms of liability and responsibility of the company in case of harm. - Due to the novelty of the robot technology, risk cannot be addressed by the company because they not mandated to provide education about robots, although it is obligatory to take an on-boarding course, in which a drone licence is advised and to get liability insurance. - The obligation to furnish the robot with a stop button has been taken care of (legal requirement) and the company even has a button to switch all robots off and reset them.	This question needed further discussion before the participants gained new insights about legal liability. At this moment no formal training certificate exists for operating the robot. What comes close is a drone licence. The risks if this technology will be used by many different users (also abroad for instance), was not yet on the radar before the workshop.

(*continued on next page*)

Table 14 (*continued*)

ELSA aspect	Question asked	Key messages from the discussion	Reflections on questions
Data and AI regulations (legal)	In what ways do the new AI act and other regulations have implications for your application?	- The AI company does not have a dedicated employee responsible for policy or legal issues. - The AI act is only applicable for AI technologies that will be identified as high risk (by the government). If the robot will be categorised as high risk, a standard needs to be implemented to log and store activities in a safe place. This will require a tremendous amount of storage capacity (and energy). In case of an issue, the data should then be shared with the court.	- The AI company was not aware of the AI Act and very eager to learn more about it. During this part of the discussion, the legal expert explained a number of features of the AI Act. - As a result of this workshop, the participant of the Ministry of Agriculture decided it would be important to organise a knowledge exchange session with AI companies about the AI Act. Especially with smaller companies, like this AI agri-food business.
Data ownership and data governance (legal)	What kind of challenges could occur in terms of privacy when this application will be used by many people?	- The AI company established an independent cooperative and the farmer share their data with this association, not with the AI company. Farmers decide collectively how to manage this data. It is possible for the government to step in and insert specific rules or oversight activities. - Theoretically, the robot could also be used for unintended purposes, to collect other type of information that may be useful for Ministry of Agriculture or the police.	- Question was easily understood. - The AI company had thought about this issue in quite some detail already (establishment of the cooperative).

Table 15
Findings about ELSA questions from the workshop with Case 2.

ELSA aspect	Question asked	Key messages from the discussion	Reflections on questions
Sustainability (social)	What do you tell your family and friends at a birthday party, if they ask you in what ways this AI application will contribute to a better world?	- The AI technology improves decision making when a cow is ill by detecting a disease earlier than other tools, or by assisting a veterinarian in the decision what treatment to advice. Overall, it will contribute to more effective use of antibiotics. - The AI technology is more objective than a farmer, because of the human subjective mind in relation to the cow, possibly affecting the treatment.	This low key and positive question was good to start with because it is easy to answer for everyone and at the same time it provides room for sustainability aspects that come to mind first (for instance, improving human health was not mentioned in the answers while that could also have been a valid answer to this question).
Animal welfare vs profit (social)	What could be potential trade-offs between profitability and animal welfare in the AI application that is being developed, and how do you foresee to balance these?	Most farmers will only contact the vet once the mastitis can't be handled themselves. The AI technology is only assisting decision making and not taking action. Currently, the vet has the legal responsibility to decide when to use antibiotics. This recommendation AI technology will not change that, unless the law is changed. The veterinarian tasks won't necessarily be replaced.	The question provided views on liability (legal), not on animal welfare in relation to economical aspects. Nevertheless the participants mentioned relevant other points, namely who is finally responsible for deciding on the treatment. The AI developers did not know this and it is relevant for the further design.
Opportunity costs (social)	How do you know that this AI solution is indeed the best solution for the problem, or could it be solved in other ways?	- It's impossible to know this in advance. Currently, a vet almost always proposes some kind of treatment (i.e. antibiotics). If the solution can help to decide when not to treat, because 60 % of the cows with symptoms of mastitis are able to heal without treatment. If the diagnosis improves, this may increase to 80 % or 90 %. - Knowing which bacteria is causing the symptoms is crucial for selecting the right treatment, which will not be solved by the AI technology, because it makes use of existing data and currently we are not able to test this unless we take a tissue sample from the cow.	At first, the question seemed difficult to answer. But after a moment of silence and follow-up questions, it generated a lot of discussion and new insights, both for the dairy tech company and the software engineers.
Non-maleficence (ethical)	What positive and negative effects on animal life can the AI solution potentially bring about?	- Some potential negative effects identified were shorter lifetime of the cows and in increase of the total use of antibiotics (affecting the health of animals and humans). - Incorporating new technologies that distance ourselves from interactions with cows, may eventually harm cow welfare, for example if the data doesn't indicate illness but the cow actually needs treatment.	It was observed that the negative effects were focused on mostly.
Liability (legal)	What are potential liability issues and how do you plan to include such issues in the current stage of development of the AI technology?	It does not become clear from our discussion whether the AI Act also applies to animals (instead of humans). From the discussion we conclude that it is important that the AI technology remains at the level of suggesting certain options, rather than recommending very specific decisions and certainly not becoming responsible for taking the decision. This responsibility should remain with the vet and the farmer.	This question was easily understood.

(*continued on next page*)

Table 15 (*continued*)

ELSA aspect	Question asked	Key messages from the discussion	Reflections on questions
Data and AI regulations (legal)	To what extent are you aware of the proceedings in AI regulation (EU AI Act and AI liability Directive)?	The dairy tech company is quite experienced with digital solutions and has made arrangements for other digital solutions to draw from. The question is whether these arrangements can be easily used when shifting from non-AI to AI technologies. The farmer was mainly concerned about data ownership rights.	This question was easily understood. The dairy technology company is experienced with digital technologies and well aware about the upcoming regulations.

Data availability

Data will be made available on request.

References

[1] European Commission, "Artificial Intelligence (AI) in Science." Accessed: Jan. 16, 2024. [Online]. Available: https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/key-enabling-technologies/artificial-intelligence-ai-science_en.
[2] NHS Transformation Directorate, "Artificial Intelligence (AI) funding streams." Accessed: Jan. 16, 2024. [Online]. Available: https://transform.england.nhs.uk/ai-lab/explore-all-resources/understand-ai/artificial-intelligence-ai-funding-streams/.
[3] National Science Foundation, "NSF announces $16M to strengthen and diversify artificial intelligence research capacity." Accessed: Jan. 16, 2024. [Online]. Available: https://new.nsf.gov/news/nsf-announces-16m-strengthen-diversify-ai-research.
[4] "10 organizations leading the way in ethical AI." Accessed: Jan. 17, 2024. [Online]. Available: https://www.methodspace.com/blog/10-organizations-leading-the-way-in-ethical-ai.
[5] The White House, Blueprint for an AI Bill of Rights - MAKING AUTOMATED SYSTEMS WORK FOR THE AMERICAN PEOPLE, no. PG-1-73. 2022, pp. 1–73. Accessed: Apr. 09, 2024. [Online]. Available: https://www.whitehouse.gov/ostp/ai-bill-of-rights.
[6] European Commission, "Proposal for a regulation of the European Parliament and of the Council laying down harmonised rules on Artificial Intelligence (Artificial Intelligence act) and amending certain union legislative acts," 2021. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0206.
[7] Digichina, "Translation: measures for the Management of Generative Artificial Intelligence Services (Draft for Comment) – April 2023," 2023. Accessed: Apr. 09, 2024. [Online]. Available: https://digichina.stanford.edu/work/translation-measures-for-the-management-of-generative-artificial-intelligence-services-draft-for-comment-april-2023/.
[8] EU, "EU AI Act: First Regulation On Artificial Intelligence," EU News. Accessed: Apr. 28, 2024. [Online]. Available: https://www.europarl.europa.eu/news/en/headlines/society/20230601STO93804/eu-ai-act-first-regulation-on-artificial-intelligence.
[9] N.K. Corrêa, et al., Worldwide AI ethics: a review of 200 guidelines and recommendations for AI governance, Patterns 4 (10) (2023), https://doi.org/10.1016/j.patter.2023.100857.
[10] E. Prem, From ethical AI frameworks to tools: a review of approaches, AI. Ethics 3 (3) (2023) 699–716, https://doi.org/10.1007/s43681-023-00258-9.
[11] M. Gardezi, et al., Artificial intelligence in farming: challenges and opportunities for building trust, Agron. J. (2023), https://doi.org/10.1002/agj2.21353.
[12] R. Dara, S.M. Hazrati Fard, J. Kaur, Recommendations for ethical and responsible use of artificial intelligence in digital agriculture, Front. Artif. Intell. 5 (2022), https://doi.org/10.3389/frai.2022.884192.
[13] R. Sparrow, M. Howard, Robots in agriculture: prospects, impacts, ethics, and policy, Precis. Agric. 22 (3) (2021) 818–833, https://doi.org/10.1007/S11119-020-09757-9.
[14] M. Ryan, The social and ethical impacts of artificial intelligence in agriculture: mapping the agricultural AI literature, AI. Soc. 38 (6) (2023) 2473–2485, https://doi.org/10.1007/s00146-021-01377-9.
[15] V. Marinoudi, C.G. Sørensen, S. Pearson, D. Bochtis, Robotics and labour in agriculture. A context consideration, Biosyst. Eng. 184 (2019) 111–121, https://doi.org/10.1016/j.biosystemseng.2019.06.013.
[16] High-Level Expert Group on AI (AI HLEG), "Assessment List for Trustworthy Artificial Intelligence (ALTAI) for self-assessment," 2020. doi: 10.2759/791819.
[17] A. Jobin, M. Ienca, E. Vayena, The global landscape of AI ethics guidelines, Nat. Mach. Intell. 1 (9) (2019) 389–399, https://doi.org/10.1038/s42256-019-0088-2.
[18] M. Ryan, B.C. Stahl, Artificial intelligence ethics guidelines for developers and users: clarifying their content and normative implications, J. Info. Commun. Ethics Soc. 19 (1) (2020) 61–86, https://doi.org/10.1108/JICES-12-2019-0138.
[19] High-Level Expert Group on Artificial Intelligence, Ethics guidelines for trustworthy AI. High-Level expert group on artificial intelligence, Eur. Commission (2019) 1–39 [Online]. Available: https://ec.europa.eu/digital.
[20] I. Benbasat, D. Goldstein, M. Mead, The case research strategy in studies of information systems, MIS Quarterly 11 (September) (1987) 369–386, https://doi.org/10.2307/248684.
[21] K.M. Eisenhardt, Building theories from case study research, Acad. Manage. Rev. 14 (4) (1989) 532–550, https://doi.org/10.2307/258557.
[22] R. Yin, Case study research and applications - design and methods, Sixth edit. 2018.
[23] P. Runeson, M. Höst, Guidelines for conducting and reporting case study research in software engineering, Empir. Softw. Eng. 14 (2) (2009) 131–164, https://doi.org/10.1007/s10664-008-9102-8.
[24] M. Ryan, V. Blok, Stop re-inventing the wheel: or how ELSA and RRI can align, J. Responsible Innov. 10 (1) (2023), https://doi.org/10.1080/23299460.2023.2196151.
[25] E.O. Popa, V. Blok, R. Wesselink, A processual approach to friction in quadruple helix collaborations, Sci. Public Policy. 47 (6) (2021) 876–889, https://doi.org/10.1093/scipol/scaa054.
[26] E.G. Carayannis, D.F.J. Campbell, Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem, Int. J. Technol. Manage. 46 (3–4) (2009) 201–234, https://doi.org/10.1504/ijtm.2009.023374.
[27] "European Parliament P9_TA(2024)0138 Artificial Intelligence Act European Parliament legislative resolution of 13 March 2024 on the proposal for a regulation of the European Parliament and of the Council on laying down harmonised rules on Artificial Intelligence (Artificial Intelligence Act) and amending certain Union Legislative Acts (COM(2021)0206-C9-0146/2021-2021/0106(COD)) (Ordinary legislative procedure: first reading)," 2019.
[28] K. Hoxhallari, W. Purcell, T. Neubauer, The potential of Explainable Artificial Intelligence in Precision Livestock Farming, in: Precision Livestock Farming 2022 - Papers Presented at the 10th European Conference on Precision Livestock Farming, ECPLF 2022, Organising Committee of the 10th European Conference on Precision Livestock Farming (ECPLF), University of Veterinary Medicine Vienna, 2022, pp. 710–717.
[29] P. Demircioglu, I. Bogrekci, M.N. Durakbasa, and J. Bauer, "Autonomation, Automation, AI, and Industry-Agriculture 5.0 in Sustainable Agro-Ecological Food Production," Lecture Notes Mech. Eng., pp. 545–556, 2024, doi: 10.1007/978-3-031-53991-6_42.
[30] N. Asher, S. Paul, and C. Russell, "Digital transformation for Sustainable Development Goals (SDGs) - a security, safety and privacy perspective on AI," 2021, pp. 0–20. doi: 10.1007/978-3-030-84060-0.
[31] M. Ryan, Agricultural big data analytics and the ethics of power, J. Agric. Environ. Ethics 33 (1) (2020) 49–69, https://doi.org/10.1007/s10806-019-09812-0.
[32] M. Uddin, A. Chowdhury, M.A. Kabir, Legal and ethical aspects of deploying artificial intelligence in climate-smart agriculture, AI. Soc. 39 (1) (2024) 221–234, https://doi.org/10.1007/s00146-022-01421-2.
[33] E. Vocaturo, G. Rani, V.S. Dhaka, E. Zumpano, AI-Driven agriculture: opportunities and challenges, in: 2023 IEEE International Conference on Big Data (BigData), IEEE, 2023, pp. 3530–3537, https://doi.org/10.1109/BigData59044.2023.10386314.
[34] D.C. Rose and J. Chilvers, "Agriculture 4.0: broadening responsible innovation in an era of smart farming," Front. Sustain. Food Syst., vol. 2, 2018, doi: 10.3389/fsufs.2018.00087.
[35] S. Sapienza, Smart solutions in AgriTech: research trajectories in the digital transition, in: Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), Springer Science and Business Media Deutschland GmbH, 2022, pp. 150–162, https://doi.org/10.1007/978-3-031-12673-4_11.
[36] E. Bird, J. Fox-Skelly, N. Jenner, R. Larbey, E. Weitkamp, and A. Winfield, "The ethics of artificial intelligence issues and initiatives: study panel for the future of science and technology," 2020. doi: 10.2861/6644.

[37] M. Ryan, S. van der Burg, M.-J. Bogaardt, Identifying key ethical debates for autonomous robots in agri-food: a research agenda, AI. Ethics 2 (3) (2022) 493–507, https://doi.org/10.1007/s43681-021-00104-w.
[38] I.A. Ibrahim, J.M. Truby, FarmTech: regulating the use of digital technologies in the agricultural sector, Food Energy Secur. 12 (4) (2023), https://doi.org/10.1002/fes3.483.
[39] E. Vocaturo, G. Rani, V.S. Dhaka, E. Zumpano, AI-Driven agriculture: opportunities and challenges, in: Proceedings - 2023 IEEE International Conference on Big Data, BigData 2023, Institute of Electrical and Electronics Engineers Inc., 2023, pp. 3530–3537, https://doi.org/10.1109/BigData59044.2023.10386314.
[40] M. Ryan, C. Atik, K. Rijswijk, M.J. Bogaardt, E. Maes, E. Deroo, The future of agricultural data-sharing policy in Europe: stakeholder insights on the EU Code of Conduct, Humanities Soc. Sci. Commun. 11 (1) (2024) 1–15, https://doi.org/10.1057/s41599-024-03710-1, 2024 11:1.
[41] I. Härtel, Agricultural Law 4.0: digital Revolution in Agriculture. Handbook Industry 4.0: Law, Technology, Society, Springer, Berlin Heidelberg, 2022, pp. 331–350, https://doi.org/10.1007/978-3-662-64448-5_17.
[42] Council of the European Union, "The Charter of Fundamental Rights in the context of Artificial Intelligence and Digital Change," 2020.