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Ethical aspects of AI robots for agri-food; a relational approach based on four case studies

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Abstract
These last years, the development of AI robots for agriculture, livestock farming and food processing industries is rapidly increasing. These robots are expected to help produce and deliver food more efficiently for a growing human population, but they also raise societal and ethical questions. As the type of questions raised by these AI robots in society have been rarely empirically explored, we engaged in four case studies focussing on four types of AI robots for agri-food 'in the making': manure collectors, weeding robots, harvesting robots and food processing robots which select and package fruits, vegetables and meats. Based on qualitative interviews with 33 experts engaged in the development or implementation of these four types of robots, this article provides a broad and varied exploration of the values that play a role in their evaluation and the ethical questions that they raise. Compared to the recently published literature reviews mapping the ethical questions related to AI robots in agri-food, we conclude that stakeholders in our case studies primarily adopt a relational perspective to the value of AI robots and to finding a solution to the ethical questions. Building on our findings we suggest it is best to seek a distribution of tasks between human beings and robots in agri-food, which helps to realize the most acceptable, good or just collaboration between them in food production or processing that contributes to realizing societal goals and help to respond to the 21 century challenges.

Keywords AI robots · Values · Ethics · Qualitative research · Experts

1 Introduction

In the past years, robots have evolved from single-task automatons that are located in a restricted environment, to increasingly independent functioning intelligent systems. These independent robots are sometimes referred to as a variant of Artificial Intelligence (AI). A combination of components such as sensors, actuators and intelligent data analytics allow it to perceive its environment and respond to it in a flexible manner, which resembles behaviour that is called 'intelligent', 'rational' and 'autonomous'. In comparison to non-AI automatons, AI robots adapt their actions to the environment, they are able to learn, solve problems, anticipate consequences of certain courses of action and reason about which one to choose.

AI software may be a system without embodiment, but can also be embodied in a physical machine such as a robot. There are many well-known examples of AI robots that have physical embodiment, such as the grass mower or vacuum cleaner in domestic environments; care robots that support and accompany elderly people or provide medication to patients, cars that increasingly have robotic elements that take over the wheel from human drivers to prevent accidents and production robots in industrial contexts which are introduced to take over a lot of the monotonous work from people. The flexibility and independence of these AI robots opens a whole range of new possibilities, as well as questions regarding the value of their employment for society (Wirtz et al. 2018).

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Autonomous robots are also developed for arable, horticulture, livestock farming and for input suppliers and food processing industries (Vasconez et al. 2019). Authoritative policy documents present AI robotics as one of the digital farming technologies that will help solve a whole range of societal problems (Lajoie-O'Malley et al. 2020). According to the EU's industrial policy approach (also called 'the Advances Technologies for Industry (ATI)'[1]), for example autonomous robots and other digital farming technology have an important role to play in producing and delivering food more efficiently to a growing population, while at the same time making the food production system more environmentally sustainable (van de Velde and Kretz 2020, 5).

Next to promises and expectations, the development of AI robots for the agri-food sector also raises a lot of questions about their value for the human (social) world, including ethical questions, which are only beginning to be explored and discussed. We engaged therefore in four case studies, focussing on four different types of robots intended for the agri-food sector: a manure collector, weeding robot, harvesting robot and a food processing robot which packs and selects food (fruits or meats). In these case studies we explored the values that play a role in the evaluations. Based on the uncertainties of our respondents about values, as well as the value conflicts that we perceived, we identified relevant ethical questions that demand further ethical reflection and study.

2 Background

The empirical research that we carried out starts from the supposition that moral life is thoroughly intertwined with social life and can therefore be studied empirically. This understanding of morality fits with communitarian and some feminist approaches (Taylor 1989; Walker 1999), which understand moral behaviour and evaluation to be something we learn when we grow up in a social environment. In 'normal' situations the moral norms and values with which people grow up provide suitable guidance for action and social interaction. But when they fail to do that, ethical reflection is required. This happens, for example, when people experience uncertainty about what value or norm applies or when they have rivalling views on what the good, right, dutiful or acceptable course of action is. In such situations ethics can provide systematic and structured methods that support reflection and dialogue about the values and norms that usually organise social life.

The introduction of new technologies (such as AI robots) in society may also lead to uncertainty about societal values and norms or value conflicts; or, in other words, they may call for ethical reflection. Until now, empirical research exploring the values and norms related to AI robots in agri-food has been scarce and the ethical questions to which they give rise have been rarely described. There is some empirical work on values related to previous (non-AI) generations of robotics for livestock (Driessen and Heutinck 2015; Bos and Munnichs 2016). On AI robotics there's (to our knowledge) only a paper by Legun and Burch describing a co-design approach to robotic apple orchards in New Zealand (Legun and Burch 2021) and a paper by Ryan (2019) which explores a broad variety of ethical issues, but which is based on only three interviews and a literature study on AI and Smart Information Systems more generally. In addition, there's one paper exploring issues in relation to AI robotics and labour (Marinoudi et al. 2019) and a few insightful reports which explore values and ethical questions related to employment and safety of workers collaborating with robots (Duckett et al. 2018; Pekkeriet and Splinter 2020).

There are, however, some recent theoretical studies of social and ethical questions related to AI robotics for agri-food. As there was no work on ethics of AI robotics in agri-food available, members of our own research team started to explore the broad and rich literature on ethics of AI robotics intended for other areas of application two years ago (e.g. health care, the military, traffic, education etc.) and listed the ethical questions that are also relevant for agri-food, as well as the extra questions relevant for applications in agri-food which are not yet discussed in this literature. The result is now published and can be consulted online (Ryan et al. 2021). This review, as well as another review focussing on ethical aspects of digital farming more generally, shaped the background of our empirical study (Van der Burg et al. 2019). A summary of the ethical themes and questions described in these two sources is provided in the following table (Table 1). This table summarizes the ethical questions listed in two tables on p.10 and p.11 in Ryan et al. (2021) and the table on p.2 in Van der Burg et al. (2019).

After mapping the themes and questions that we could derive from the literature, we formed our interview protocol for the case studies and we engaged in the empirical work (between December 2019 and in 2020), the results of which are presented in this article. While we were writing the article (in 2021), two more interesting review papers were published focussing on societal aspects of AI robotics for agri-food: one by Sparrow and Howard (2021) and one by Rose et al. (2021). While these papers do not focus specifically on ethics, they map societal themes and questions related to the ones we noted in Table 1. And while revising this case study article for publication, another ethics paper was published by Ryan (2022), underlining the ethical issues

[1] https://ati.ec.europa.eu/reports/sectoral-watch/technological-trends-agri-food-industry.

Table 1 Ethical themes and questions relevant for AI robotics in agri-food

Themes	Possible questions toraise
1. Agency	How autonomous are and should AI robots be? Should AI robots be capable of moral agency just like humans are? In what contexts in agri-food would the development and use of artificial moral agency (AMA) be valuable/required/acceptable? What ethical standards should guide the behaviour and choices of such a robot and should be built into it?
2. Moral status of robots	Are AI robots with a high level of intelligence worthy of dignity and moral consideration? What capacities do they need to have to be worthy of moral consideration? And what would this imply? Would the ascription of rights to them entail for their position in the social world, for example with respect to their role in the workforce?
3. Responsibility and liability	Can agri-food robots be considered as 'responsible' agents? What (individual; social) approach to responsibility is most appropriate when considering AI robots in agriculture? Can robots be considered responsible, or are (only) the robot-developers or users' appropriate responsible agents? What should responsibility distribution/sharing look like when using agricultural AI robots? And (how) does the concept of liability (for damage/accidents) apply to robots and/or to (collaborations) of people?
3. Quality of relationships	What is the value of robot-human relationships in agri-food? What kind of robot-human relationships would we like to come about in various agri-food contexts? What impacts do robots have on the well-being of other sentient beings (animals, humans)? What impacts should it have? What about the safety of robots?
5. Employment and labour	What is the value of the effects of AI robots on various labour contexts in the agri-food sector? What is the value of its effects on the job market? How ought these effects to be evaluated with respect to justice and fairness ideals?
6. Accessibility and Benefit Distribution	What are benefits of AI robots? Where do AI robots offer benefits and to whom? What kind of farms will it benefit, and which will not? What is the just distribution of the benefits?
7. Good farming	What does 'good farming' mean? (How) can AI robots contribute to it? What are effects of the use of robots on the farm and how is/should this be evaluated? (for example, with respect to the level and quality of production, (flexibility of) choice of crops, physical burden of work, leisure, social relationships of the farmer on and around the farm)
8. Animal Welfare	What is the meaning of animal welfare? (How) can AI robots contribute to animal welfare (livestock and wild animals)? How should we weigh the interests of animals in relation to the interests of human beings?
9. Environmental sustainability	What is sustainable farming? (How) can AI robots contribute to realising it? How should environmental concerns be evaluated in relation to other (economic) concerns of the farmer? Do AI robots also produce environmental harms? What kind of environmental harms, resulting from these robots, is deemed acceptable, and why?
10. Data sharing	What are preconditions for trust in data sharing? What data should be open or shared with whom? In what ways do farmers and other stakeholders in the value-chain become vulnerable because of data sharing? What constitutes data misuse? Who is the owner of data or datasets? What privacy issues does sharing of farm data raise?
11. Distribution of power	What effects will AI robotics have on the distribution of power in society, especially among actors in agri-food? What is the value of these effects, with respect to (a) public goals, (b) market competition, (c) dependencies between market actors? What constitutes misuse of power and how can it be prevented or its effects mitigated? What is a fair/just distribution of power?

we identified, based on very different sources: a comparison between publications and conference papers on AI in agri-food and 11 overarching ethical principles for AI that Jobin et al. (2019) summarized, based on ethical guidelines and principles developed for AI worldwide. In these guidelines and principles, Ryan notes, specific issues that AI raises in agri-food are ignored, such as for example about animal welfare and care for the environment.

All of these review papers draw attention to a lack of attention for social, ethical and political impacts of AI robots that are specifically developed for the agri-food domain and they call to fill this gap in new research. This is needed, according to Rose et al. (2021), because '[u]ltimately the success or failure of autonomous robots in agriculture will not rest on the limits of our technical enterprise, but on our ability to involve society, learn from it and respond appropriately'(p.309). Sparrow and Howard (2021) add that failure to address societal aspects of robots may '(..) undermine the further development and deployment of agricultural robots, having a flow of effects on the economy, environment and society' (p.829).

Given the little available understanding of moral values and ethical questions related to AI robots 'in the making' intended for agri-food contexts, we engaged in our case studies.

3 Methods

The case studies consisted of interviews with various types of experts who have different roles with respect to the developing robots: (a) as engineers, scientists or R&D developers in companies involved in making robots for agri-food, (b) as advisors, R&D directors of large food production/processing companies and (anticipated) end-users who have a role in interacting with robots or bringing robots to user contexts, and (c) actors who have a broader overarching influence, such as policy makers at the national level, in branch organisations, labour safety officers and insurance companies. We primarily chose experts based on what Mauksch et al. call 'social acclamation': they were nominated as experts by peers in the field (Mauksch et al. 2020, 6). As our work was part of a larger multidisciplinary project, which contains both robotic and agri-sector experts, we began our search for respondents first with the experts that our project team recommended and afterwards broadened our search using a snowballing method to include additional experts that our interviewees recommended (see Table 2).

An interview guide was developed for semi-structured interviews, based on our reading of the background literature, most notably presented in Ryan et al. (2021) and Van der Burg et al. (2019). Prior to the interview, its anonymous and confidential nature was explained to participants, as well as the purpose for which it was going to be used and consent was asked from the interviewee to record the conversation. During the period in which the interviews were carried out, the Corona pandemic started which prevented doing interviews face-to-face. Two interviews on the manure collecting robot were done 'live' in 2019, the others were done in 2020 using Microsoft Teams.

3.1 Qualitative analysis

The audio-recordings of the interviews were transcribed verbatim and analysed by two researchers and results were subsequently discussed with the entire group of co-authors until consensus was reached. The analysis was conducted using thematic analysis, which is a variant of the grounded theory approach (Glaser and Strauss 1967; Lingard et al. 2008; Tong et al. 2007). First, we performed a semantic analysis on the interview transcripts, meaning that we focused on the explicit content of the data: we highlighted parts of the text and attached codes that describe the content of the selected text passage as far as it was considered relevant to our research questions. Based on commonalities between the content of coded text passages, we grouped them together under themes and subthemes. Values came forward as part of these subthemes and were labelled and grouped under the theme; under 'labour', for example, we identified values such as 'fairness', 'efficiency', 'business sustainability', 'safety', 'labour enjoyment', which were either expressed literally by the interviewee or the content was described.

Based on our identification of values, the value-uncertainties that our respondents expressed and the value-conflicts we encountered, we identified the ethical questions. Interviewees not always considered their own thinking 'ethical'. They did, however, describe uncertainties about values and value conflicts, which we interpreted as 'ethical' on the basis of the themes and questions already described in the literature. Uncertainties sometimes stemmed from interaction with the robots, such as when respondents questioned what

Table 2 Overview of respondents

	Arable	Food processing	Horticulture	Livestock
Experts involved in or influencing the end-user context				
Grower or Farmer	3		2	1
R&D manager robot using company		2		
Advisor	1		2	4
Experts involved in developing and/or making AI robots				
R&D employee commercial robot or machine developing company	3	2	2	4
Researcher			1	
Business developer		1		
Experts who have a general policy and/or regulation-oriented perspective				
Branch organization	2			
Work safety officer	1			
Employee insurance company	1			
National policy maker	1			
Total number of respondents	*33*			

degree of autonomy is appropriate for AI robots, or whether robots, their developer or their users should be responsible for the damage that robots cause. Examples of value disagreements occurred, when respondents brought forward rivalling opinions regarding whether it is fair or not fair (or just) to replace (migrant) labourers by robots, or when respondents disagree as to what makes labour enjoyable or fulfilling and whether robots contribute to improving it. We noted all of these uncertainties and value conflicts, which was the basis for the list of ethical questions we identified and which we listed in the discussion of the paper.

4 Results

The interviews gave us a broad and varied overview over the values that play a role in the evaluation of AI robots for the agri-food sector. What was most striking, perhaps, is that our respondents predominantly talked about values of AI robots in the context of various relationships: the sociability of AI robots is considered in a social world, the relationship with society at large, labour relationships in businesses and more abstract cloud relationships between robots and with the tech companies that make and sometimes manage the robots and the data that they collect. Even values related to robotic interaction with other sentient beings such as animals, or with the natural or material environment, were considered from a human social perspective, rather than a separate class of relationships that may demand taking a different viewpoint. In the following we will explain our findings in relation to these relationships.

4.1 Autonomy and sociability of robots

4.1.1 Degree of autonomy and human dependence on robots

The degree of autonomy of robots was a frequently returning topic in our interviews. Some respondents thought robots should have a high level of autonomy and would not be satisfied if they would have to be continuously monitored by a person,

> "If that would be needed to check the performance of the robot, then it would be a bad robot. I wouldn't want to have it. It is not for nothing that it is called 'a robot'. It should be able to function independently." (Arable farmer)

A high level of autonomy can have the advantage that human actors can rely on robots to do jobs. But some respondents expressed concerns about developing similarities between robots and human beings, arguing that "from the moment onwards that we start to see a robot as an equivalent creature, that is the crossing line" (robot developer, food processing). It would be wrong, this robot developer argues, to compare robots with human labourers: "we should not level robots with (migrant) workers" (robot developer, food processing). He was however the only one comparing the capacities of AI robots to human beings. Others reflected on the effects an increased degree of autonomy would have for the people around it. Some reflected, for example, on risks (stress, injuries) an autonomous robot would imply for animals, people, crops, buildings or machinery. Some argued that increasingly independent robots should also be able to communicate risks with the people around it,

> "I think that if you want there to be autonomy for robots, then you have to get clear on the question: how should we understand each other? (..) With a flashing light a robot says: 'I am driving and move aside otherwise I crush you'. But when people think that is unacceptable, they will say: 'you don't belong in my society'. So, if you want them to be capable, then the robot should be more intelligent, or more understanding in a social way, then just turning on a flashing light." (Robot developer, food processing)

The capacity to communicate makes AI robots capable of safe social interaction. Others even suggested making robots 'polite' or giving them a 'kind' appearance, which would facilitate interaction. This suggests that making robots more autonomous, should make them also able to function in social environments: robots should become sociable.

4.1.2 Tolerance/acceptance of mistakes

Autonomous robots are sometimes expected to reduce risks, as they are considered more steady and trustworthy workers than human beings, thus reducing risks resulting from bad job performance. Compared to humans, robots are expected to improve reliability and predictability of cleanliness of barns and continuity of effective work in greenhouses and food processing industries. In these contexts, however, there are different degrees of tolerance for robotic mistakes. In relation to the weeding robot, respondents were not sure about whether or not risks for the yield would increase with the use of autonomous robots, as there are no measurements of the exact margin of error of human workers,

> "Look when I weed with humans and they try to pull out a weed, then they sometimes accidentally pull out an onion that stands next to it (..) So you will always tolerate some crop damage, and that will always be acceptable to some extent. You will always have to take into account that [the robot] will also take out some crops, yes." (Arable farmer)

In arable farming, where human performance and mistakes are usually not monitored, we encountered high tolerance for robotic mistakes. In the food processing sector, by contrast, human performance and errors are already assessed and there is consequently less tolerance towards a robot's mistakes. The consequences of mistakes also explains the level of tolerance: respondents find it hard to accept mistakes when robots cause actual damage to crops, especially when this leads to unsafe foods that may cause recall operations from consumers/shops. This may result in financial losses and/or loss of good reputation. For milking robots, for example, some mistakes are unacceptable, such as transferring milk from a cow treated with antibiotics to the bulk tank. Such milk is not acceptable for the milk processor and it means that the farmer gets a substantive fine. If the robot makes this mistake, and fails to inform about it, this will result in financial losses and a bad reputation for the farmer, which respondents consider unacceptable.

4.1.3 Safety and communicative skills

Potential physical risks that arise for people or animals interacting with robots are often discussed in the interviews; such as, examples of robots accidentally driving over people and hurting them,

> "(..) the most efficient manure robot would always go on. (...) If something stands in the way, just drive over it or against it. (...) From a safety perspective I would say; as soon as something moves in the surrounding, the robot should stand still. Then you will probably have the safest robot. I think such a robot won't be of much value for the horticulturist, or for the farmer, but it is very safe." (Representative of insurance company)

Many respondents suggest to give robots communicative skills in order to be able to warn people or animals in their environment and prevent accidents; such as speech, alarm signals or in the form of lights which turn on when the robot moves around, thus encouraging everyone around it to pay attention. Furthermore robots could be designed with scary looks in order to communicate to people to pay attention, or they could be taught to behave 'politely' (grower, horticulture). There are also respondents who reflect on possibilities to train people working in the environment of the robots: people around robots could pay attention to their own safety and monitor the performance of the robot, thus reducing the risk of accidents.

4.1.4 Responsibility and accountability for damage

Robots can hurt people or animals and can cause damage to crops, buildings and machinery. Many respondents therefore reflected on the question who has to take responsibility for damage caused by an autonomous robot. This concern is well summarized by the following quote from a representative from an insurance company,

> "If you think about responsibility and safety: on the one hand you have more means to build in safety, to program that. On the other hand, you lose the human consideration and responsibility. That shifts to the machine. (...) Obviously, it means less risk because you enter a programmed world in which you can ban risks from a technological perspective, so to say. But (..) there is an increase of [juridical] risk because you enter a grey area between responsibility and autonomy. We enter a period in which that is less clear." (Representative from insurance company)

Given the unclarity regarding who should be held responsible for damage caused by an autonomous robot, some suspect that robot developers will try to keep robots more dependent on human beings than they actually need to be,

> "Technically it is already possible to make robots more autonomous than they are now. But often developers choose not to. For what happens if there's an accident? If the robot hurts someone, or an animal, or if, if it breaks a barn or a greenhouse or something. To avoid trouble, they make the robot depend on a human being, a user. That way this user is responsible for whatever happens. Without the human it is, it would be quite unclear...unclear who should be blamed, and who should pay." (Researcher, horticulture)

Respondents suggested different possibilities for responsibility (and liability) ascription. Some ascribe responsibility to the human user, who should monitor the performance of the robot. Others mention that sometimes the robot developer could be held responsible, for example if the robot does not perform as the developer promised, or when it dysfunctions. Questions about responsibility can be solved in a different way when farmers do not buy the robot, but just hire a robotic service, as in that case the company providing the robotic services can be held responsible.

4.2 Relationships of robots to society at large

4.2.1 Public perception of robots in agri-food

Many respondents reflected on the public perspective to the use of autonomous robots in food production and food processing. Some anticipated that in some social contexts, such as the Japanese society, the public is pro-innovation and accepts robots producing their food,

> "In Japan people (..) like it when food is produced in a very clean environment, like a laboratory, and they don't mind it when robots do the harvesting. But here

in Europe some people think that a tomato should grow on soil and should be harvested by human hands, not by robot hands. Acceptance might be an issue here, yes, but not in Japan." (Innovation advisor, horticulture)

Most respondents expect the public in the Netherlands to be 'conservative' or ' nostalgic' about the production of their food. Some respondents observed that when there will be too many robots involved in food production, or when robots are introduced too fast, this may lead to a feeling of alienation for citizens, which can have detrimental effects on their acceptance of the introduction of robots in the production of their food;

"You can automate a lot, but where is the human scale, the naturalness and the contact with the animal? That sort of thing, that is of course very important to the consumer, because they almost start to compare it with their own pet." (Advisor, livestock)

To accept AI robots as contributors to food production, consumers are asked to gradually abandon their overly romantic expectations, which takes time and persuasion. Yet, some respondents observe that public acceptance can be fostered by showing positive effects of the use of robots on public values, such as a clean environment, as well as by an attractive and friendly appearance of robots. This is for example brought forward in relation to a relatively small weeding robot which reduces the need to spray pesticides with a large machine, or makes spraying obsolete:

"You see, especially when a farmer sprays for weeds, you have an enormous tractor and an enormous spray arm behind it with a width of sometimes even 32 meters. An enormous thing, you know, and all kinds of fluids come out. Well, for a citizen, it is poison what comes out of it. So, you see an enormous machine with poison, and you think, well something is going completely wrong here. So, I think, if you can make it small, lower to the ground and less scary (..) that will help tremendously." (Branch organisation)

The contribution of robot use to mitigate environmental effects of farming is thought to play an important role in bringing about more societal acceptance of AI robots in agri-food.

4.2.2 Public interest in environmental sustainability

Environmental sustainability is an important driver behind the development of some of the robots in our case studies. For policy makers, this is an important reason to invest in robot development, as the policy maker we interviewed expressed: "robots bring all kinds of possibilities to realize sustainability goals and circular agriculture goals."

Weeding robots are supposed to make more environmentally friendly, biological farming (which does not use chemicals) more (financially) attractive, as they "offer an alternative for chemical plant disease control" (Robot developer, weeding robot). Chemicals that are usually used to reduce weeds also pollute the surroundings like the soil and nearby ditches and have negative effect on biodiversity (insects in particular). Furthermore, as robots are in principle light weighted and small in comparison to tractors and machinery, they are expected to reduce the pressure per cm^2 soil, which is expected to reduce the level of soil compaction.

"I am actually hoping that in 10 or 15 years we can say that the evolvement of robots has been booming and that we will have more, but lighter and smaller machines driving across the field and that this will reduce soil compaction and improve the quality and health of the soil." (Cultivation consultant, arable)

The harvesting robot and the food processing robots are also thought to contribute to more environmental sustainability. The food processing robot is meant to replace human labourers who select food and strive towards less food waste, "which is the by far the biggest environmental issue" (R&D manager, slaughterhouse). The manure collecting robots clean floors in the barns, which improves the quality of the living environment for cattle. Moreover, this reduces the likelihood that urine and faeces come together on the floor and start to produce ammonia and greenhouse gasses that both can emit to the environment and either reduce biodiversity (ammonia) or contribute to global warming. Summarized:"(..) the higher goals behind it are, in fact, methane emission, ammonia emission and animal welfare." (Livestock advisor).

Not all respondents were, however, convinced that robots would contribute to mitigation of detrimental environmental effect of food production, as robots also need to be developed, produced and dismantled and they use energy. It is for this reason that some robot developers just strive to keep the impact of robots equal to the impact of human labourers: "(…) We need to make the footprint of that thing [a packaging robot] so small that it can compete with (..) people." (Developer robot, food processing).

4.2.3 Animal health and wellbeing

A positive contribution of the use of AI robots to animal health and welfare may also improve acceptance. Interviewees in the case study on the manure collecting robot reflected on avoidance of collisions between robots and animals, absence of hindrance to the cow's natural behaviour, diminishment of (hoof, claw and udder) diseases of cows, and a cleaner environment in the barn. These aspects give reasons to believe that this robot can contribute positively to animal health and wellbeing in comparison to conventional collectors, as robots can be made more flexible than conventional manure collectors and therefore there's less risk of collisions and less hindrance to animal behaviour. However, it is not clear how currently existing manure collectors contribute to animal health and welfare,

> "I suppose that in the development of the manure hoover, research has been done, but I am not aware of the results. How much percent this has improved the claw health, but well in my eyes this is settled: the cleaner the floor, the less claw disease you have, or the less chance there is that claw problems grow into a real problem. Yes, that is in my head, but I do not know the exact numbers." (Robot developer, livestock)

Currently, monitoring health and welfare is practically complicated, and therefore the exact contribution of a manure collecting robot to animal health and wellbeing is poorly quantified. Several interviewees mentioned that it would be an advantage if health and welfare monitoring could be automated, and manure robots could perhaps contribute to this,"(..) you need to be able to monitor animal welfare non-invasively. That is the biggest wish, for in that way you take out the human factor (..)" (Policy maker) Others mention robot should not alter animal behaviour in a way that becomes unnatural,

> "...you need to respect animal behaviour. That to me seems very important, so if... if you want to be coercive or if you disrespect the intrinsic value of the animal, or how you want to call it. Yes, then you are crossing a line. And you should look for (..) a way, and answer to 'how should I connect to normal animal behaviour?' (Advisor, livestock).

4.3 Labour relationships in businesses

4.3.1 Business sustainability

Envisioned users of AI robots are primarily agri-food entrepreneurs, which means they are concerned about the sustainability of their business. Businesses are sustainable when they continue to make (more) profit or become more competitive,

> "In the background (..) the economic sustainability of the business always plays a role: the business should be able to survive over time. That is why farmers are forced to think about what their business model actually is and why they earn money." (Robot developer, arable)

To realise more profit, farmers and growers have to bring down the costs of production and/or make their activities more efficient. Manure collecting robots take over part of the (heavy) work of the farmer and potentially reduce emissions as well as animal diseases, thus leading to more production and bringing down healthcare costs. The weeding robot aims to make the production process more efficient and less labour intensive and reduces the costs of pesticides. In food processing and harvesting in horticulture, robots are primarily intended to help realise a continuous labour force and reduce labour costs,

> "I am very interested in the harvesting robot, yes. (..) The large efflux of labourers is a burden to us. Until now we have been able to find new people, but you have to first teach them how to do the job and there are costs attached to that. And we see that people don't stay very long, so after a little while you have to do the same thing again. (..) So you would actually like to keep them longer, but then you have to give them a contract which is not very attractive financially speaking and therefore people are free to go and they don't show commitment, and therefore the constant availability of labourers is quite, well, unreliable." (Grower, horticulture)

In connection to the topic of business sustainability, many interviewees talked about the topic of labour. As in some sectors the costs of labour are considered high, a reduction would be welcomed.

4.3.2 Exploitation vs fair access to labour

Tasks that are taken over by robots are often low-skilled, monotonous and physically heavy jobs. As it is difficult to find people willing to do these jobs, in The Netherlands they are often carried out by migrant labourers from Eastern Europe. As it is heavy work and wages are low, some interviewees call it "modern slavery" and believe that robotization "(..) can only be a plus in that respect. In this way you can show that you are innovative and (..) working conditions, so to say, improve a bit" (Farmer, arable). According to the following advisor, substituting human labourers with robots is unproblematic,

> "Robots are taking over jobs that nobody wants to do. This will make everybody happy. [Interviewer: And what will the low-skilled labourer coming from Moldova think about that?] Nothing. He will happily stay at home and look for a different job." (R&D advisor, horticulture)

Related to migrant labourers, some respondents observed that robots would help to solve the problem of exploitation: labourers earn very little, are exposed to poor housing conditions and there is little consideration for their health and wellbeing (as became painfully clear during the corona pandemic). Therefore, they argue, it would be better to employ robots instead,

> "Yes, you will expel labour. But what kind of labour do you expel? Yes, and where did that labour come from? Was it a sustainable model? We of course see all results of Corona in slaughterhouses at the moment. In what kind of way people are housed and with what kind of salary they are sent home, that is not great. So, do you want to maintain that kind of labour in that way in the Netherlands?" (Business developer, food processing robot)

There were, however, also respondents who thought it problematic to replace human labourers by robots, as they recognise that these jobs do allow some people to earn a living,

> "At present, horticulture is very labour intensive. Are we going to tell all these hard-working people: 'well, from now on we don't need you anymore?' I happen to think this is problematic." (Branch organisation, horticulture)

Summarizing, most interviewees saw the advantages of ending what they call 'exploitation', but some considered it not respectful to replace these labourers by machines as they played such an important role in food production and processing in the past decades.

4.3.3 Craftsmanship, continuity and flexibility

The introduction of robots in labour contexts will bring shifts in the kind of jobs that humans have to fulfil. Some of the (potential) robot users that we interviewed are eager to start using robots, as they think they will be able to create more high-tech and interesting jobs for people, which will make their business a more attractive place to work for young ambitions people. Others are more hesitant, as they anticipate that they will have to change their own routines and the routines of other labourers on their farm and they do not want to learn entirely new skills, or are attached to their traditional craftsmanship and knowledge. Some respondents assume that robots and other digital technologies will fundamentally change farmers and growers into managers, rather than traditional craftsmen with skills to make plants grow, which they do not always like,

> "If you look at the developments in indoor farming, then you see that the role of the grower becomes less important. It is possible to automate the environment and then you see that the automation also takes the decisions about the climate in the greenhouse. So, the role of the grower will turn more and more into the role of a manager, it is no longer someone who deals with plants and executes daily decisions in a greenhouse. (..) the knowledge of growers is grasped in models and then the role of the grower will change too." (Advisor, horticulture)

The pro-innovation respondents are excited about the new possibilities that technologies offer to their business and are proud to be able to say, 'I have a robot in my factory' (robot developer, food processing robot). Other reasons to prefer robots over human labourers are the continued availability, continuity and reliability of the robot: robots do not need to take breaks, they are never ill and do not go on a vacation. While robots do need charging, maintenance and cleaning, they can immediately continue working after that. An anticipated disadvantage of the use of robots may be that in the agri-food sector they have to deal with fresh products or animals that are never exactly the same. People are flexible and are able to adapt to different products, but robots need to be trained to do that, and this is usually a challenge,

> "And right now, there is training for a specific cabbage so to say. That model is put in the machine and as long as the cabbage looks the same within margins than it is fine, but unfortunately agri-food products are not like that. One variety is slightly different than others and (…) all kinds of circumstances outside on the field make that the product is different each time (...). At this moment, these robots handle that insufficiently." (Business developer, food processing robot)

Given that adapting skills of robots to variability of products is difficult, some respondents suggest that products can also be adapted to the capacity of robots; so they could be made more uniform and easy to harvest for a robot. Creating the perfect match between crop and robot, would eventually make the company more efficient, but not more flexible,

> "It would be best if all tomatoes would grow more or less at the same height and if a robot could harvest them by gently ticking against the plant and catching the fruit in a little sack. You see, tomatoes are soft, so you don't want the robot to crush them, and therefore it is better if the robot does not pick them but catches them in a sack. But not all plants let go of the fruit when you tick the plant. (…) So, a tomato plant breeding company is now trying to breed a kind of plant that, well, fits perfectly with our robot and lets go of the fruit very easily. So, then you have a perfect fit. The only disadvantage is that once you have the perfect plant for your robot, it becomes very difficult to start growing something else. That's the disadvantage: you lose flexibility." (R&D advisor, horticulture)

Several respondents in horticulture and food processing expect that robots will make it possible to re-arrange the production process and make it more efficient. The optimal conditions for efficient and qualitative production and preservation of food may however not always coincide with the optimal labour conditions for people. While it is OK for robots to work in hot, cold or noisy environments, or in increasingly narrow alleys between plant beds in a greenhouse, this will be detrimental to the comfort of people and the ergonomic quality of their working conditions. Respondents expect that this development will strengthen the preference to work with robots instead of fragile and needy human beings.

4.4 Cloud relationships to robots

4.4.1 Accessibility of robots

Robots also engage in more abstract relationships, such as cloud relationships between people, organizations and machines via the internet. This gave rise to various considerations.

Some robot developers reflected on whether or not their robot should be connected to the Internet, as this will limit the selection of clients. Availability of the Internet and having sufficient broadband is not yet guaranteed everywhere in the world, particularly not in remote rural areas. Demanding Internet connection can therefore have direct impact on the accessibility of robotic innovation for a lot of rural users: they would be able to buy, use and profit from it only if it would be able to function offline too. This figured in the minds of robot developers anticipating the size of the market they are producing robots for, but also for societal reasons. Having connectivity or not was considered an important reason why some farmers are deprived of advantages that AI robots bring. The policy maker also spoke about the 'digital divide', referring to social inequality between the haves and the have-nots of digital technologies (including AI robots) and the benefits they bring.

4.4.2 Data security and trust in data sharing

When robots are connected to the Internet, it is important to think about the use and value of data. Data security and protection needs to be taken into account, since the robot's system, including the data it collects at a farm, becomes accessible for other people or organizations, whether that is intended or not.

> "Yes you're dealing with data security and you really have to take that into account. You need to have an agreement with that livestock farmer that in fact you are allowed to use those data." (Robot manufacturer, livestock)

There can be advantages to sharing data, for example, between the farmer, maintenance technician and manufacturer. Remote contact can make maintenance more efficient, for example by integrating a kind of 'black box' which can alert the company responsible for maintenance when services are needed. In addition, such a 'black box' can play a role after an accident, as it can help settle disputes about liability for damage, which is important for the farmer, the maintenance technician and the manufacturer. The data collected by such a black box may however also be of value to other organizations, which raises the question who is allowed to decide about the data and about who can use them.

Other advantages of data sharing that respondents anticipated concern the future possibility to make various digital devices connect and communicate together: a robot could then be connected to sensors that detect plant or animal needs or disease and with a farm management system, which allows to provide more accurate information that farmers can use to make their decisions.

> "I think that if you would have all that data, that you could do much better. That you would be able to steer what goes into that cow, or what goes into that group of cows. When you can understand the relationship between what goes in, the feed, and what comes out of the cow, the milk, then you would be able to steer better."(Robot developer, livestock)

Respondents, however, also mention that collecting and connecting data from different devices on their farm, may also make them vulnerable as third parties may access business data that they do not want to share: such as, data about the quality and quantity of the yield, the inputs and pesticides used and the trade secrets regarding the way it is produced. This is considered sensitive information, especially in the hands of clients or competitors. Data collected by a robot may also be interesting to controlling authorities of the government, or to insurance companies who determine the premium that farmers/growers or food processors have to pay based on data about the size of the field, the state of the machines, the buildings and the way these are maintained. Questions raised by the respondents about these possibilities, include who should have access to data and what data should be protected, under what preconditions, against whom. While recognizing the relevance of these questions, robot developers do not always know how to answer them: "Yes, then you start the debate about all that data, we haven't even got started about that. (..)" (Robot developer, horticulture).

5 Discussion

Our case studies offer a rich overview over values and ethical questions that play a role in our case studies, which we summarized in the left column of Table 3. Based on our analysis of the uncertainties about values we encountered in the reflection of our respondents, as well as the value conflicts, we identified ethical questions that we noted in the middle column of Table 3. We subsequently compared these questions with the themes that we had originally found in the literature and which we explained in a more elaborate way in Sect. 2 of this paper and in Table 1.

This overview offers an innovative contribution to the literature, as empirical studies on the topic are scarce. Our empirical study underlines the practical relevance of a lot of the themes that are also described in the literature, as the themes and questions that we found coincide to a large extent with the themes and questions identified in the reviews of the ethical, social and policy issues related to AI robotics that we cited in the background part of this paper (Ryan et al. 2021; Rose et al. 2021; Sparrow et al. 2021). There are however also significant differences between the themes noted in the literature and the ones that occupy the minds of stakeholders in our empirical case studies. The most important difference is perhaps that the ethical literature has a strong focus on themes such as autonomy and the moral status of AI robots, while this plays a much less prominent role in the reflections of our stakeholders. Autonomy is important in ethics, as intelligence and free will which are its components, are also considered constitutive of moral agency. There is therefore a lot of discussion in ethics about whether or not robots can have intelligence and free will and whether that also means that robots can (or should) develop into artificial moral agents, which have ethical theories or principles designed into their algorithm (this is sometimes called 'machine ethics'; important authors are: Allen et al. 2006; Wallach and Allen 2008; Torrance 2008; Tonkens 2009; Arkin et al. 2012; Andersen et al. 2015). Ethicists furthermore question whether AI robots who have intelligence and free will, just like humans have, deserve our moral consideration, or even should get rights (Darling 2012/2016; Danaher 2020). Intelligence and agency of robots therefore play a very important role in ethical theory formation about what makes robots ethically significant.

When respondents in our case studies reflect about the value of AI robots in agri-food, however, they do not give such a prominent role to the intelligence and free will of these robots. While autonomy and the moral status of robots also plays a role in their reflections, they much more frequently took a relational perspective to their value. The risks that AI robots imply and their sociability in collaborations with humans on the workfloor was considered important, their capacities were evaluated as part of the workforce in effective and sustainable food production and processing businesses, in relation to the broader societal goals that consumers or citizens find important such as environmental sustainability, animal welfare and food safety and security, or as part of evolving cloud relationships between machines and (tech) businesses. This relational perspective to the value and ethical significance of AI robots is perhaps the most innovative contribution that our case studies offer to the ethical literature.

Adopting a relational perspective to the ethical significance of AI robots, means that the qualities of robots should not be considered in isolation from the social context in which they are to land. In ethics, intelligent robots are also often considered in the context of relationships, but these evaluations often compare the qualities of the robots to the qualities of human labourers. This is considered in different contexts such as in the military, in traffic, in surgery, as companion robots, sex robots, educational robots or care robots for children or frail elderly people. If a robot takes the place of a soldier, for example, there are ethical concerns that warfare will become like a computer game, losing sight of the responsibility for making choices that cause human drama. In care relationships, it is imagined that compared to human care givers, AI robots will not be able to show genuine respect for dignity of a patient, empathy with human suffering and will lack the ability to understand and communicate emotion. A comparison between characteristics of AI robots and humans is the focal point of such ethical evaluations; the human capacity to reflect, deliberate, choose and feel emotion are important ingredients in reflections about the wins and losses of replacements of humans with robots, which sometimes leads to recommendations regarding the sectors where it would be better to employ robots and the sectors where they should not be employed (Van Wynsberghe et al 2022; Sharkey et al. 2012).

In our case studies, by contrast, our respondents rarely compared the intelligent capacities of robots with those of humans. Perhaps intelligence did not strike them as a relevant topic to consider in relation to robots that collect manure, weed, pick bell peppers or select and package apples in boxes. Instead, our findings suggest that respondents find it more important to reflect on the value of the evolving robot-human collaboration. When considering the sociability of robots, for example, they reflected on values such as tolerance for mistakes (and effects of the introduction of robots on the tolerance of mistakes of humans), politeness in the interaction with human co-workers, a kind appearance of robots, a capacity to avoid or communicate danger, a capacity to alleviate strenuous or heavy work. All of these aspects (tolerance, politeness, kindness, communication, taking over heavy jobs) are interactive; they do not focus on what would make the robot an acceptable substitute for humans, but on

Table 3 Values and ethical questions raised by agri-food robots in the four case studies

Values	Ethical questions	Related to theme in the literature
Autonomy and sociability of robots		
Autonomy	What is the degree of autonomy a particular robot should be allowed to have? Should the technical possibility to make robots independent be used?	Agency
Equality	Should a robot acquire the same abilities and qualities as human workers? Does a particular robot deserve to be treated in the same way as human beings?	Moral status of robots
Human rights	Should a robot have rights?	Moral status of robots
Safety	To what extent are risks introduced by a robot on the workfloor acceptable?	Employment & labour
Sociability	How sociable should a robot be? What characteristics should it minimally have (in terms of communication, politeness, looks) in order to function in social interactions with people in agri-food environments?	Quality of relationships
Tolerance	What level of tolerance is due to robots vs humans with respect to the mistakes they make?	Quality of relationships
Responsibility	Who is responsible (and liable) for accidents and damage resulting from robots? How should responsibility be distributed among robots, robot developers and users?	Responsibility & liability
Relationships of robots to society at large		
Nostalgia/conservatism	What is the value of traditional craftsmanship vs robotic craftsmanship? In what way should food be produced? What is the added value of humans producing food as opposed to robots?	Good farming/food production
Societal acceptance/trust	(How) should societal trust in food production be preserved/fostered?	Quality of relationships
Sustainable environment	Should we require robots to make food production and processing more sustainable?	Environment
Animal health and wellbeing	What contribution should robots make to animal health and wellbeing? Should robots preserve it, improve it? And what approach to animal welfare do we choose?	Animal Welfare
Labour relationships in businesses		
Business sustainability	What is a desirable/acceptable direction into which robots should help agri-food businesses to develop?	Good farming
Value of labour: craftsmanship, continuity and flexibility	What is the value of labour? (How) should robots contribute to it? Should businesses become dependent on of the performance of robots? To what extent should flexibility of food production be preserved/fostered?	Employment and labour
Fairness	What does a fair labour market require (in the Netherlands/worldwide) with respect to the availability/accessibility of labour?	Employment and labour
Health, wellbeing, safety	What does the health and safety of labourers require? What requirements does this impose on the performance of robots?	Employment and labour
Efficiency	Is there a limit to the efficiency of food production that we should try to realize with robots? What is the right balance between efficiency and other values (such as, enjoyment of labour, flexibility, fairness)?	Good farming (or food production)

Table 3 (continued)

Values	Ethical questions	Related to theme in the literature
Cloud relationship to robots		
Accessibility of robots	Should the benefits of robotics be accessible to all? What does this mean for the way robots should be designed and how they should function? (e.g. should they be connected to the internet, which is not available everywhere? Should they be expensive or cheap? How much skills needed?)	Accessibility and Benefit Distribution
Control (connection to business sustainability)	Should robots be connected to larger digital systems and serve farm management? What goals should they help bring about? And who should be in charge of the farm?	Good farming (or food production)
Data security	Who should/should not have access to data collected by robots? What data should be accessible to whom? What data should be protected?	Data sharing
Trust in data sharing	With whom should data be shared? Who should have the right to benefit from data collected by a robot?	Data sharing

what would make the human–robot interaction acceptable or good.

In business relationships, rivalry between robots and humans did come forward as an important topic for consideration. But in this context, robots are not thought to compete with humans for their intelligence. Robots are valued over humans because they are continuously available and therefore reliable, they can continue to work day and night, have no need to rest and are able to do monotonous and heavy jobs without complaints, even in uncomfortable environments such as high temperatures or cold stores. Human labourers, by contrast, are valued over robots for their (traditional) craftsmanship, their capacity to understand and respond to dangerous situations, their creativity in solving problems and improving processes and also for their flexibility, which is needed to respond to changing market demands that may lead to a shift from producing (or processing) one product to the next (such as from apples to cucumbers). AI robots cannot easily handle such changes, but human labourers can. These comparisons between the qualities of robots and humans suggest that robots do not easily win the competition with humans. In fact, human beings and robots are valued for very different qualities, which are both needed in food production and processing, thus raising the question whether it is a good idea to try to make robots resemble humans more, or whether it would be more fruitful to think about how the qualities of both humans and robots can be fostered/perfected to shape valuable human–robot collaborations in agri-food that serve wider societal goals.

The relational perspective to AI robots that was dominant in our case studies supports adopting a line of thinking in ethics that moves beyond the tendency to compare the intelligence of AI robots with the intelligence of humans. This comparison perhaps makes sense in contexts where AI robots are developed as humanoids, but in agri-food this may not be the most fruitful way to proceed. We do not underestimate the challenges related to robot-human rivalry, as there is a real danger that robots will in fact steal the jobs of immigrant workers who are at present doing the low paid work in greenhouses, food processing industries and arable farms, but we think this will not easily be overcome by an identification of the difference between human and robotic intelligence or by settling the difference between human and robotic labour rights. It may be better to align with the approach chosen by our stakeholders and take a relational perspective to the qualities of both robots and humans and consider the distinctive role they can play in service of a larger societal goal, such as fostering the environmental sustainability of food production, the production of enough safe and good quality food, animal health and welfare, or the health, safety and welfare of labourers. We therewith plead to adopt and strengthen in agri-food the line of thinking of some authors in ethics who propose to consider the best division of tasks between robots and humans within sectors, thus aiming for an acceptable or desirable robot-human collaboration (Van Wynsberghe 2016; Van Koughnett et al 2009).

At the end of our literature review we remarked that environmental sustainability and animal health and welfare are largely overlooked in the ethics of AI robotics and therefore deserve more attention.[2] Based on our case studies, we add

[2] Until now, ethical work on AI robotics focussing on the effects of AI robots on the environment has been scarce (Van Wynsberghe, 2021), just like work on robotic contributions to animal health and wellbeing (Bendel, 2016). While there are definitions of animal welfare and corresponding assessment methods available which nowadays shape approaches to animal welfare in livestock farming (Brambell 1965), many questions continue to be asked in society regarding the acceptability of modern animal husbandry for food production (Thompson 2021) that go beyond this definition of animal welfare

to this that adoption of a relational perspective to ethics of AI robotics in agri-food may be more helpful to move toward answers. Our case studies also have limitations. Another important 'relational' theme in the literature which figured less prominently in our case studies, relates to developing power (im-)balances due to the introduction of AI robots (Van der Burg et al. 2019). While power imbalances, and the questions about fairness and justice this may raise, play a large role in the reviews that focus on social and ethical aspects of digital farming in general (Van der Burg et al. 2019; see also work on this topic by Kelly Bronson quoted in this review) and AI robotics for agri-food in particular (Rose et al. 2021; Sparrow et al. 2021), they played a minor role in the reflections of our respondents. Some respondents considered the question whether AI robots should be accessible to all (connectivity), and briefly mentioned the digital divide as a problem, but they did not explore at length the problematic aspects of developing power relationships between large tech businesses and farmers, or between large high-tech farms and small low-tech farms. This may be due to our method of inclusion of respondents, which focused on experts in the field who were already part of the innovation process and who were therefore perhaps less concerned about power structures as they were already on the 'power-side'. We see this as a limitation of our study.

6 Conclusion

In closing this article, we conclude that adopting a relational perspective to ethics of AI robotics in agri-food fits with the perspective adopted by most stakeholders in our study. While there's a significant overlap between the themes and ethical questions identified in our case studies (and noted in Table 3) and the ones noted in the recently published literature studies that identify societal, ethical and political aspects of AI robotics in agri-food, what is new is that our case studies suggest adopting a relational perspective to finding a suitable response. In such a relational perspective to ethics of AI robots, the 'intelligence' or 'free will' of the individual AI robot is not the focal point of ethical attention, but the quality of the relationships in which the robot is to engage. In such relationships, robots can also take over monotonous and heavy tasks, or may figure as reliable logical thinkers and perceptive agents with capacities that exceed the human ability to estimate food safety or quality. But humans also remain needed for their craftsmanship, flexibility and creativity. As robots and humans each have their qualities as well as their shortcomings, it is best to seek the most acceptable, good or just distribution of tasks that realizes a collaboration in food production or processing that contributes to realizing societal goals and help to respond to the 21 century challenges.

Footnote 2 (continued)

and which attend to the 'naturalness' and 'intrinsic value' of animals (Nuffield Council on Bioethics 2015).

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