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PROJECT SUMMARY

The internet of things (IoT) has a revolutionary potential. A smart web of sensors, actuators, cameras, robots, drones and other connected devices allows for an unprecedented level of control and automated decision-making. The project Internet of Food & Farm 2020 (IoF2020) explores the potential of IoT-technologies for the European food and farming industry.

The goal is ambitious: to make precision farming a reality and to take a vital step towards a more sustainable food value chain. With the help of IoT technologies higher yields and better-quality produce are within reach. Pesticide and fertilizer use will drop and overall efficiency is optimized. IoT technologies also enable better traceability of food, leading to increased food safety.

Nineteen use-cases organised around five trials (arable, dairy, fruits, meat and vegetables) develop, test and demonstrate IoT technologies in an operational farm environment all over Europe, with the first results expected in the first quarter of 2018.

IoF2020 uses a lean multi-actor approach focusing on user acceptability, stakeholder engagement and the development of sustainable business models. IoF2020 aims to increase the economic viability and market share of developed technologies, while bringing end-users' and farmers' adoption of these technological solutions to the next stage. The aim of IoF2020 is to build a lasting innovation ecosystem that fosters the uptake of IoT technologies. Therefore, key stakeholders along the food value chain are involved in IoF2020, together with technology service providers, software companies and academic research institutions.

Led by the Wageningen University and Research (WUR), the 70+ members consortium includes partners from agriculture and ICT sectors, and uses open source technology provided by other initiatives (e.g. FIWARE). IoF2020 is part of Horizon2020 Industrial Leadership and is supported by the European Commission with a budget of €30 million.

EXECUTIVE SUMMARY

Sensors, drones, weather satellites and robots are examples of technologies that make farming ‘smart’. In this article we present the results of our review of the literature that concerns the ethical challenges that smart farming raises. Our reading suggests that current ethical discussion about smart farming circles around three themes: (1) data ownership and access, (2) distribution of power and (3) impacts on human life and society. Discussions that fall under these themes have however not yet reached a satisfying conclusion, as there seem to be different ideas at work in the background regarding the purpose and function of digital farms in society. The pros and cons of these rivalling ideas are rarely foregrounded in the discussion. We suggest that future research should focus first on the content of these goals, especially on the content of societal and commercial goals and whether and how they can be combined in differing contexts. This will offer a lead to think about what data ought to be shared with whom, to set preconditions for trust between stakeholders and –eventually- develop appropriate guidelines and codes of conduct for future farming digitalization trajectories.

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Ethics of smart farming: Current questions and directions for responsible innovation towards the future

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ABSTRACT

Sensors, drones, weather satellites and robots are examples of technologies that make farming 'smart'. In this article we present the results of our review of the literature that concerns the ethical challenges that smart farming raises. Our reading suggests that current ethical discussion about smart farming circles around three themes: (1) data ownership and access, (2) distribution of power and (3) impacts on human life and society. Discussions that fall under these themes have however not yet reached a satisfying conclusion, as there seem to be different ideas at work in the background regarding the purpose and function of digital farms in society. The pros and cons of these rivalling ideas are rarely foregrounded in the discussion. We suggest that future research should focus first on the content of these goals, especially on the content of societal and commercial goals and whether and how they can be combined in differing contexts. This will offer a lead to think about what data ought to be shared with whom, to set preconditions for trust between stakeholders and –eventually- develop appropriate guidelines and codes of conduct for future farming digitalization trajectories.

1. Introduction

The digitalization of farms is increasingly presented as a promising technological 'fix' for a wide range of societal problems, such as the provision of food for the growing world population, diminishing the environmental impact of farming and fostering the safety and societal acceptability of food products by means of increased traceability and transparency (Wolfert et al., 2017). Sensors, drones, weather satellites, intelligent software algorithms and robots are examples of technologies that together make farming 'smart'. Robots and drones make time-consuming tasks more effective, such as irrigation, monitoring the health and location of the herd or driving it in a direction, sowing of crops or milking of cows; weather satellites and sensors offer information that is helpful to tailor irrigation, fertilizer or pesticides to plant's needs or to define the right moment for seeding. In addition, all of these technologies together generate data, which can be combined and interpreted across farms in the region in order to provide even better information to farmers (based on more data) and promise to help reduce their ecological footprint. Farms that use a combination of these technologies are sometimes called 'smart farms'. Smart farming is not such an established term yet as precision agriculture, but it where precision agriculture is mainly taking in-field variability into account, smart farming goes beyond that by basing management tasks not only on location but also on data, enhanced by context- and situation awareness, triggered by real-time events (Wolfert et al., 2017).

This promising frontier in farm technology however also raises ethical challenges. Ethical challenges arise when new technologies confront human actors with questions about what would be the good, right, just, required or acceptable action to do, or what societal goals are worth striving for. These questions arise regularly, but they become problems when the moral norms and values that are available in society to think about them provide unsatisfying answers, or no answers at all. To make an inventory of the ethical questions raised by the development and (anticipated) use of digital technologies on farms, and the ways in which they are approached with current moral values and norms, we have explored available scholarly literature, policy (advice) reports and articles in popular media and blogs. Based on this inventory, we aim to analyse the problems that are difficult to solve with available moral concepts in society and therewith identify the questions that demand further research in the future. More awareness of the questions that need to be answered about smart farming will contribute to a more responsible innovation, as an innovation trajectory is considered 'responsible' if it tries to take societal values and norms into account at an early stage of development of the technology, which helps to realize products that are broadly accepted and widely used (Von Schomberg, 2011; Owen et al., 2013).

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2. Method

The research questions to which we sought an answer are:

- What types of ethical questions are raised in the literature on smart farming?
- What are the problems that demand future ethical research?

To answer these questions we reviewed the literature. But it was a challenge to select the right literature, as 'ethics of smart farming' is not yet an established field of study. Ethical questions and reflections may play an important role in articles about the digitalization of farms or that consider 'smart' or 'precision' farming. Yet, articles may be published in journals that belong to a variety of disciplines, including law, social sciences, political sciences or information technology. In these journals, articles that discuss ethical questions do not always contain the term 'ethics' in the title, the abstract or in the key words, which makes them hard to find. While we consider it a strength that we succeeded to bring together literature from various sources and create an overview over ethical questions that allows for a more systematic ethical study and discussion in the future, we realize that our selection may be debated or that we did not succeed to find some relevant articles. What this article resents is therefore no more than the result of an exploration of the literature; we do not pretend to offer a systematic review.

Three databases were searched in March and April 2018: Web of Science, LexisNexis and Google Scholar. Search terms were chosen to limit the review to articles mentioning 'smart', 'digital' or 'precision' and 'farming' (or 'agriculture') in combination with 'ethics'; and we used 'big data' in combination with 'farming' (or agriculture) and 'ethics'. We used 'big data' because most (but not all) technologies that are part of smart farming deal with data. Ethical questions raised about big data in farming will therefore likely be relevant to smart farming. We did not search for more specific related concepts such as 'privacy' and 'farming' as most of the discussion on this theme turns out to be juridical, rather than ethical, and because we wanted to explore the variety of ethical questions related to smart farming. An overview of the search by database can be found in Table 1.

The title and abstract of articles we found was reviewed by the authors to determine relevance. Inclusion was based on whether or not the article concerned smart farming and contained a reflection on, or discussion of, ethical questions. We let our interpretation of what is 'ethical' emerge from descriptions of the authors, meaning that we highlighted parts of the text which discuss 'right' and 'wrong' or the conflict between values or norms and excluded juridical discussions (for example about copyrights or licensing), political, aesthetic or business connotations of these terms. Ethical approaches to 'right' and 'wrong' usually deal with perceptions of society that are worth striving for and the ways in which smart farming can (not) contribute to realizing that.

This approach to ethics fits with communitarianism and feminist approaches to ethics, which presuppose that any social world contains a broad variety of moral concepts that prescribe what to do, or refrain from doing, in order to realize a 'good life' for individuals or a 'good society' (Taylor, 1989; Walker, 1999). In 'normal' situations these concepts provide good guidance for action, but ethical questions arise when they fail to do that. In these situations people may experience uncertainty about what to do, or what goals to strive for, as there are rivalling views on what the good, right, dutiful or acceptable course of action is, or what the good society looks like that should be strived for. Such ethical questions call for reflection, which may involve a creative exploration of the meanings of available moral concepts or ways to apply them, or the justification of their use. This is what we looked for in the literature that we read.

Table 1
Overview of search strategy and yield.

Database	Search terms	Amount of articles found
Web of science	'smart farming' AND ethics: 0 'precision farming' AND ethics: 4 'big data' AND farming AND ethics: 2 'digital farming' AND ethics: 1 'smart agriculture' AND ethics: 1	8
Google scholar	Same search-term combinations as web of science	50[*]
LexisNexis	Same search-term combinations as web of science	116

* 10.400 hits were found, 50 reviewed.

In our exploration of the literature we were interested to find out what ethical questions authors identified and how they reflected on them or discussed them. Limitations were not placed on the quality of the reflection or discussion, for we were primarily interested in an identification of the question as well as whether or not authors provided an answer that was satisfying to them. We realize that some of the questions we encountered are not unique to farming data, but we chose to limit our exploration just to those.

It is because a lot of the ethical discussion about smart farming is not thematized as 'ethics', that we searched also beyond the selection that our search in databases yielded. Further sources were also located through backtracking of citations provided within reviewed articles, through acquaintances with colleagues who sent us articles or links to blogs, or through meetings and workshops about ethical aspects of big data and smart farming. The search was limited to articles published in English and we excluded articles that discussed 'right' and 'wrong' but that did not eventually engage in ethical reflection, but ended up taking a juridical, political or management perspective. A management perspective to an ethical problem would, for example, sketch a procedure to deal with it and make sure it never occurs again, while an ethical perspective would take time to ask what values and norms are involved in the various possible ways to deal with it and what that would entail for the life of individuals and for society. The literature we found consists of peer-reviewed articles as well as other types of publications such as policy reports, magazines and blogs. After our selection procedures, we based our analysis on the remaining 44 sources.

3. Analysis

The articles, reports and blogs were analysed and key passages were underlined which appeared to refer to ethical questions and/or contained a reflection on moral concepts and the way they help to provide answers. We let our interpretation of what is 'ethical' emerge from descriptions of the authors, meaning that we highlighted parts of the text which discuss 'right' and 'wrong' in relation to aspects of smart farming.

The text-passages that we highlighted because they referred to ethical questions or moral concepts were interpreted and coded by the first author and then grouped under themes in a scheme. This scheme included themes like 'data ownership', 'open access to data' or 'digital divide', a description of the challenge such as 'who owns the data?' and 'what rights belong to data owners?' and a selection of text passages from the original sources to show how the challenge is described in it. The second author added literature found via LexisNexis to the scheme. The scheme was discussed with all authors until consensus was reached about the content of the themes and the ordering of subthemes, which together cover the main ethical challenges raised in the literature.

4. Results

Three interrelated themes emerged from the literature: (i) data ownership, accessibility, sharing and control, (ii) distribution of power and (iii) impacts on human life and society. We chose to present the results of our analysis of the literature in a narrative fashion, as this

Table 2
Issues that come forwards in the present literature.

Theme	Issues	Type of sources on which we based this theme
Data ownership, accessibility, sharing and control	How are data understood by different people? What are advantages/disadvantages of different (for ex. individual or relational) perspectives to farm data?	13 peer reviewed articles (Carolan, 2015/2017; Carbonell, 2016; Sykuta, 2016; Kshetri, 2014; Rasmussen, 2016; Bronson and Knezevic, 2016; Walter et al., 2017; Kamilaris et al., 2017; Tzounis et al., 2017; Schoitsch, 2017; Lokers et al., 2016; Eastwood et al., 2017)
	Who owns the data? What starting points do current laws provide to think about data ownership? Should different ownership rights be ascribed to different partners in the network? Do ownership rights help to protect the interests of (all) partners in the network? What are advantages/disadvantages of speaking about ownership in relation to data?	5 blogs (Davies, 2018; Tennison, 2018; Schuster, 2017; Broadcast pro Middel East; Economist, 2014)
	What does 'open access' to data mean? What are advantages/disadvantages of open access to different stakeholders? What are advantages/disadvantages of open access to the realization of societal goals or private company goals related to smart farming? Does it make sense to speak about openness in terms of 'degrees'? What data should be open or shared with whom? What is the meaning of fairness/equity in relation to data sharing? In what ways do partners/stakeholders become vulnerable because of the sharing of data? Who has responsibility to care for these vulnerabilities? And how can they be protected?	4 reports (Maru et al., 2018; De Beer, 2016; Kritikos, 2017; Poppe et al., 2016)
Distribution of power	What shifts in the distribution of power are expected to take place as an effect of smart farming?	15 Peer reviewed articles (Leone, 2017; Long and Blok, 2017; Eastwood et al., 2017; Kshetri, 2014; Bronson and Knezevic, 2016; Bronson, 2018; Carolan 2015/2017; Fleming et al., 2018; Carbonell, 2016; Kamilaris et al., 2017; Sykuta, 2016; Wolfert et al., 2017; Rodriguez et al., 2017)
	What are advantages and disadvantages of different power-distributions in the network in relation to (a) the realization of the goals of smart farming, (b) the distribution of burdens of benefits amongst partners within the network, (c) the sustainability of farms, and (d) the autonomy of farmers and consumers (e) the meaning of values such as fairness, justice, just distribution, transparency and trust?	1 blog (Economist, 2014)
	Who should be involved in reflection about the goals of smart farming? How should disagreement about goals be dealt with?	5 reports (Ferris and Rahman, 2016; Chaves Posada, 2014; De Beer 2016; Mooney et al., 2007; Maru et al., 2018)
Impacts on human life and society	Smart farming is expected to foster societal goals such as to diminish the environmental impact of farming and to improve food security. How should these goals be understood and valued? Does smart farming actually succeed to bring the desirable goals about? What are private company goals served with smart farming? How should these goals be understood and valued? Does smart farming actually succeed to bring them about? How does smart farming change the daily work, routines (inter)action, experience, choices and deliberation of smart farmers? Are (all) these changes desirable? For whom/what are they desirable? (How) Can undesirable impacts be avoided? What are the gains and losses associated with smart farming? And how should their desirability be weighed?	6 peer reviewed articles (Driessen and Heutinck, 2015; Carolan, 2015; Carbonel, 2016; Blok and Long, 2016; Eastwood et al., 2017; Kshetri, 2014) 3 blogs (Economist, 2014; Dyck, 2017; Gulf times 2017) 4 reports (Bos and Munnichs, 2016; De Beer, 2016; Kritikos, 2017; Poppe et al., 2016)

allows to highlight and comment on the themes we encountered in the literature and the ethical challenges that belong to them. A summary of the most interesting ethical challenges we derived from the literature are presented in Table 2. In the discussion we will suggest directions for further development of the ethical discussions about smart farming.

Data ownership, accessibility, sharing and control

Privacy is a topic that often comes forwards in discussions about the use of personal data of millions of individuals by intermediaries with powerful analytic tools. In the area of smart farming, however, talking about privacy rights is scarce. Farm data are not usually considered 'personal': farm data –that is; data collected at farms- may register chemical components of the soil, the weather at a specific moment in time, it may keep track of the use of water and pesticides, the temperature in a glasshouse or stable, the fertility of a cow at a specific moment in time, health-related information (such as activity or temperature of an animal) or the amount of milk each cow produces, etc. Farm data such as these are not usually considered 'personal', although sometimes it is pointed out that farm data may have a personal meaning to farmers because the farm business and farm household were traditionally viewed as 'one-and-the-same economic unit' (p. 63, Sykuta, 2016). It is however more common to understand farm data as business- or trade data, which makes the question 'who owns the data?' more relevant (Bronson and Knezevic, 2016; Carbonell, 2016; Carolan, 2015; De Beer, 2016; Eastwood et al., 2017; the Economist, 2014; Kamilaris et al., 2017; Kshetri, 2014; Lokers et al., 2016; Poppe et al., 2016; Schoitsch, 2017; Schuster, 2017; Sykuta, 2016; Tzounis et al., 2017). In commercial environments commodities, technologies, innovations and information are usually 'owned' by somebody, who has specific rights to it. But smart farming makes ownership of farm data quite unclear: often, farmers presuppose that they own the 'primary data' as they collect them on their farms, yet intermediaries make the algorithms that allow to combine and interpret the data of many farms and use them to generate useful farming recommendations. These intermediaries are considered the owners of the 'computed data' (p.28, Poppe et al., 2016; p.20/21, Schuster, 2017; Kamilaris et al., 2017; Rasmussen, 2016). Furthermore, some authors remark that use of the term 'ownership' is odd and unusual in relation to data because physical things owned can be used by one person at the time, while data are not 'rivals' in this sense: use by one person or entity does not preclude others to use it too (p.3, De Beer, 2016; Tennison, 2018). At the time when this review is written, however, there are still limited articles available that discuss the appropriate content of the term 'ownership' in relation to data.[1]

In spite of the unclear meaning of the term 'ownership', authors nevertheless raise the question who owns the data, because they observe that data collected at farms have value that can be monetized by partners in the network. Clarity about ownership-rights is expected to help to settle who has the right to use the data and for what purposes (p.28, Poppe et al., 2016; Carbonell, 2016; Kamilaris et al., 2017; Kshetri, 2014; Rasmussen, 2016; Sykuta, 2016; Tzounis et al., 2017). The network contains farmers, agricultural technology providers (ATPs), intermediaries who facilitate the flow of data through the (open) data ecosystem and provide the algorithms to interpret them and consultants who offer recommendations to the farmers. These partners have to work together to make data available and useful, but farmers suspect that their data may be used by the other partners in the network for other purposes beside consulting them. For example, ATPs and intermediaries might use knowledge about the likely yield of a crop (such as wheat) in a certain year to make decisions on the stock market, or in commodity and real estate markets (p.29, Kamilaris et al., 2017; p.65 Sykuta, 2016; p.13 Kshetri, 2014; Rasmussen, 2016). Furthermore, recommendations offered to farmers on the basis of data-analyses can lead to price discrimination by input suppliers (such as seed providers). This is especially problematic in the case of large companies who provide (technological) farm supplies as well as services such as for example Monsanto who sells the technologies needed for smart farming, provides the algorithms to conduct the data-analyses, offers recommendations to farmers, and also sells inputs for these farms (such as seeds). It is also considered risky when the ATPs and service providers partner with input suppliers (p.63, Sykuta, 2016). Such concerns express distrust of ATPs and data platforms, as well as worries about the unfair competitive advantage that large companies may obtain as an effect of privileged insight into farmer's data in a particular country or region. Sometimes such uses of data are called 'misuse' (Broadcast Pro Middle East, 2016; Tzounis et al., 2017; Schoitsch, 2017).

In so far as the issues related to data are understood as 'ownership' problems, authors sometimes suggest to use technological protective measures such as data encryption, blocker tags, cryptographic algorithms, identity authentication mechanisms, data flow control policies, data filtering mechanisms, or secure data storing (p. 42/43, Tzounis et al., 2017). Most often, however, authors recommend to develop regulation regarding ownership (Bronson and Knezevic, 2016; Carbonell, 2016; Kamilaris et al., 2017; Rasmussen, 2016; Schuster, 2017; Walter et al., 2017). Sometimes they explore possibilities to solve issues based on new interpretations of current laws, such as Rasmussen and De Beer do in their respective publications. Rasmussen argues that patents, intellectual property rights and copyright laws do not offer a good starting point to identify what ownership rights of farmers mean and why they need protection. Patents only cover the creation or discovery of a process or machine, but 'data is not invented by the farmers and it is not a new process or machine' (p.208, Rasmussen, 2016). Farm data do not qualify as original works of authorship that could fall under copyright law. According to Rasmussen, it is however possible to look at farm data as trade secrets and use that to ascribe ownership to farmers (p.209, Rasmussen, 2016). Other authors also observe that farmers often regard their data – such as details concerning soil fertility and crop yield- as a trade secret that they would not want to see revealed to their competitors (p.33, Poppe et al., 2016; p.6 Carbonell, 2016; Kshetri, 2014; De Beer, 2016). De Beer, however, points out that intellectual property rights and patents do provide helpful tools to think about the ownership rights of other partners in the network who develop technology to collect the data or creative ways of storing and interpreting them (p.8–9, De Beer, 2016). According to him it is easier to protect the inventors of the technologies and data bases based on current laws, than it is to protect farmer's ownership rights. Local norms regarding what counts as a trade secret may matter a lot to farmer communities, but there are virtually no international laws that will bind other parties to respect them (p.14, De Beer, 2016). Trade secrets of small-scale farmers (for example, in the developing world) will therefore be hard to protect at a global scale. These farmers are therefore particularly vulnerable when they digitalize their farms (De Beer, 2016; Maru et al., 2018).

Authors who consider data ownership, usually seek to protect rights of individual actors, which may be persons or businesses. But there are also authors who abandon talking about data-ownership and instead argue that data are 'social' in nature, and therefore need to be shared openly. In her blog on the BBC website, Jeni Tennison (CEO of the Open Data Institute that fosters open (farm) data ecosystems around the world) argues that data always stem from multiple people and can be used by multiple people: owning data privately means, according to her, imposing obstacles for using them to tackle societal challenges such as climate change. Tennison considers it more appropriate to think about rights to data, rather than ownership, and she favours an open access approach (Tennison, 2018). Similarly, Tim Davies, founder of the Open Data Services Cooperative, argues on his blog that for data that do not contain personal information such as farm data, but which are *relational* in the sense that they are collected by many people and they serve a collective goal, it is more appropriate to say 'I have a stake in these data and therefore I should have access to it', rather than saying 'this is my data, I should have control over it' (Davies, 2018).

While there are some authors who worry about government's access to farm data, as it fosters surveillance (Sykuta, 2016), there are also authors who defend open access as a way for the government or members of the wider public (citizens or consumers) to monitor or control whether smart farming is actually helping to tackle societal problems, such as reducing the ecological footprint of farms, reducing waste or fostering food security and public acceptability of the production system (Carbonell, 2016; Carolan, 2017; Kritikos, 2017). According to Carbonell, for example, data must be open '(..) in order to respect the people's right to informational power' (p.8, Carbonell, 2016). He argues that collection of (anonymized) big datasets should be open sourced and in the public domain and the development of analytic tools should be funded by public money to make sure that they serve the common good (p.8, Carbonell, 2016). De Beer accentuates, in addition, that data access enhances entrepreneurship and new economic activity (p.5, De Beer, 2016). It is according to him important not to exclude farmers from that, such as farmers in the developing world. Fostering entrepreneurship everywhere is a global goal. Carolan (Carolan, 2017), however, suspects that a lot of people (citizens, farmers) may not be able to do very much with these data in an open

[1] There likely will be more interesting reflections in the future. Francois van Schalkwyk, Alexander Andrason & Gustavo Magalhaes are at present working on a paper which explores the labour theory of property to talk about ownership of data which allows for the sharing of data. Building on a paper by Ibarra et al. (2017) they make a distinction between thinking about data as capital and as labour, which leads to different perspectives on the rights that can be ascribed to the owners of data.

access system. Free access, according to him, is therefore not necessarily 'fair', as these data may be informative to the actions of some, while others will not know how to interpret them. (p.10, Carolan, 2017).[2] This would raise the question whether and to what extent open access actually supports the realization of societal goals, and who would use them.

Regarding these considerations to give access to data or not, it may be asked how open data should be. De Beer clarifies that open data can be understood in different ways. Most authors understand open access as: 'anyone can access, use or share data'. Closed data, by contrast, are 'not accessible to anyone outside of the organization that controls it' (p.3, De Beer, 2016). Between open and closed data, however, De Beer distinguishes various possibilities to share data amongst specific groups of people for specific purposes, but not with everyone. This opens up the question what data one wants to share with whom, or who has rights to access data and who does not. Building on these insights, Maru et al. distinguish between different streams of data, which places farmers in differing relationships with others: 'localized' data are generated on a farm and used there, 'imported' data are generated off the farm for use on the farm, 'exported' data are generated on the farm for use off the farm, and 'ancilliary' data are generated and collated on and off the farm, mainly for use off the farm. (p.11–13, Maru et al., 2018) All of these streams raise different opportunities, risks and challenges for farmers that need to be investigated in order to develop appropriate ways to protect them in relation to powerful international partners in the data sharing network.

Distribution of power

Reflections about power distribution, nationally or globally, are closely connected to the theme of data ownership and data access. A lot of authors describe and discuss power shifts taking place in the network of stakeholders around farms as an effect of the digitalization of farming, or entrenchment of power inequities. This raises concerns about (distributive) justice, equity, fairness and –again- trust (Bronson, 2018; Bronson and Knezevic, 2016; Kshetri, 2014; Kamilaris et al., 2017; Carbonell, 2016; Eastwood et al., 2017; Rodriguez et al., 2017; Pedro Sarmento, 2016; Fleming et al., 2018; Wolfert et al., 2017).

Global power-imbalances are expected to come about because of limited access of some farmers to digital technologies and or to the data that they generate (Kshetri, 2014; Rodriguez et al., 2017; De Beer, 2016; Maru et al., 2018; Ferris and Rahman, 2016). This is sometimes blamed on the so-called 'digital divide' between the developed and the developing world, which is caused by lacking means to buy the technologies required for digital farming (p.2, Kshetri, 2014; Maru et al., 2018; Ferris and Rahman, 2016), lacking scientific data skills of farmers, (p.6, Ferris and Rahman, 2016) or lacking alignment of the technology with the already available farming 'skills and capabilities, social and cultural attitudes towards a technology, the institutional environment, and social reorganization' (p.5, Kshetri, 2014; Maru et al., 2018; Chaves Posada, 2014). Furthermore, there may be other obstacles, such as the unavailability of translations of data or data-based recommendations in languages spoken by farmers in the developing world, lacking literacy amongst farmers or awareness of the existence of open data (p.6, Ferris and Rahman, 2016; Chaves Posada, 2014).

There is also concern that only large farms are able to pay for the costs of accessing the information based on data, while this is expensive for small-scale farms in developing countries (p.8, Ferris and Rahman, 2016; Chaves Posada, 2014) and that recommendations done on the basis of data are not always well-suited to the needs of small farms (Rodriguez et al., 2017; Kamilaris et al., 2017; Maru et al., 2018; Ferris and Rahman, 2016). It is also observed that open data may harm particularly vulnerable populations such as indigenous people or migrant farmers who lack basic land rights, as the collection of their data may betray their location, activities, and harm their control over resources (p.9, Ferris and Rahman, 2016). Maru et al. summarize all of these challenges regarding small farms in the developing world as concerning *affordability* of the access and use of data, the *applicability* of recommendations and *effectiveness* that concerns the capacity to find, interpret and use data. Maru et al. add also *appropriation* of data, which is needed to take ownership of data in a collective manner that supports the needs of a community (p.15, Maru et al., 2018).

Considering the developed world, similar concerns are expressed about digital tools being primarily developed for farms which are already big players in the market (Bronson, 2018; Fleming et al., 2018). They are thought to not benefit smaller and medium-sized labour-intensive farms sufficiently. Big data therewith risk to introduce unfair competition between these farms. It can make the benefits of 'smart farming' inaccessible to farms which do not have the right shape and size to begin with. Fleming et al. consider equity and access important issues in this respect (Fleming et al., 2018). Yet, Bronson and Knezevic look at these development in a more critical way, as they remark that the problem is not so much that some farms are not included in the digitalization, but that the developments in digital farming are 'supporting particular agricultural systems of production, and thus farmer livelihoods, at the expense of others.' (p.4, Bronson and Knezevic, 2016) Building on research that pointed out that technology's interactions with a social environment is responsible for its eventual environmental, social and human consequences, they call for more critical attention of scholars to the types of relationships between corporations and farmers that digital technologies are reproducing and enforcing. They suspect that digitalization will enforce a 'productivist model' of farming, even though food studies scholars have revealed productivism as a model of overproduction of inexpensive low-nutrient food that has brought great commercial gain to a handful of agri-food conglomerates, while for the rest of the world it has resulted in serious ecological, economic, health, and sociocultural consequences, without notably alleviating hunger and malnutricion in the long run. (p.3, Bronson and Knezevic, 2016).

Next to the 'digital divide', Bronson and Knezevic call for critical reflection on digitalization as a development that supports and enforces the view that farms are, or ought to be, technology-maximizing, profit oriented businesses. This reflection concerns what is sometimes called the 'big data divide', which refers to the divide between companies who decide what data they collect and possess the technologies and expertise to interpret them and those who don't have access to the data or who lack a role in deciding what data are collected and how they are interpreted (Bronson and Knezevic, 2016; Carolan, 2015/2017). The need to collect, combine and interpret data re-shuffles the power-distribution in the entire stakeholder network around farms. (p.3, Carbonell, 2016). Some authors expect that a few large corporations (such as, Monsanto, John Deere etc.) will get more power and will even be able to develop a monopoly, as they work together with many farmers and have access to an enormous amount of data, which makes it more difficult for smaller competitors to enter the market, as they will not have access to the same breath of data (p.64, Sykuta, 2016). Other authors anticipate more diverse developments in the actor-network around farms that digitalize: they observe that new entrants (start-ups) enter the network who bring smart technologies and/or expertise to analyse them, such as for example FarmLogs, FarmLink, FarmBot or Climate Corporation (which are sometimes supported by large venture capital firms) (p.45/46, Wolfert et al., 2017). Besides commercial players, it is sometimes expected that public institutions (such as universities, FAO, USDA, the American Farm Bureau Federation or

[2] Using the capability approach by Amartya Sen, he argues that we need to look at the capabilities of different stakeholders that are fostered by data access, as this may be very unequal and unfair. Such a capability approach takes interdependency of people within a group into account. As ICT technology in farming links stakeholders together, it is important to look at whose capabilities are fostered by data access and on what/whose capabilities it imposes limitations. (p.11, Carolan, 2017).

GODAN) also influence the power network around farms as they advocate for the adoption of smart farming technologies or for open data networks, or bring forwards specific ways to organize cooperation around the sharing of data. (p.46, Wolfert et al., 2017)

Depending on the anticipated developments in the power-network, authors raise different ethical concerns and questions. In one approach farmers come to depend on large companies, which raises concerns about the equity and just distribution of benefits and the privacy and autonomy of farmers. The large companies are expected to gain unique insights into what farmers are doing around the clock, which enables them to use these insights to classify behaviour of farmers (farm profiling) and offer tailored services to them (p. 10, Ferris and Rahman, 2016), or to influence decisions of farmers in ways that may benefit the large companies more than the farmers themselves, or that benefit some types of farmers (the large scale production oriented ones) more than others. (Bronson and Knezevic, 2016; Eastwood et al., 2017; Kamilaris et al., 2017; Fleming et al., 2018; the Economist, 2014; Sykuta, 2016).[3] This means also that the benefits of smart farming with respect to the increase of production but also its environmental sustainability, will be more accessible to some farmers than others: they will be more difficult to realize for mid-scale or smallholder farmers to be sustainable towards the future (Mooney et al., 2007). Kamilaris et al. (Kamilaris et al., 2017) and also Carbonell (Carbonell, 2016), think that power can be rebalanced '(..) through open-sourced farming data, and publicly funded data analytic tools' which rival large companies and are used in the public domain (p.2, Carbonell, 2016). They are confident that open source technology allows farmers to regain autonomy.

In the other approach, data are not thought to benefit large companies, but the community of farmers. Collaboration to realize common goals is also an important theme related to power-distribution that comes forward in the literature (Fleming et al., 2018; De Beer, 2016; Carolan, 2015; Chaves Posada, 2014). It is however not always clear how large or how small that community should be. The common goals are sometimes understood as global challenges, inviting the efforts of a community of humanity as a whole (De Beer, 2016); sometimes digitalization is understood as an opportunity to shape regional communities of collaboration who can share ideas about how food can be produced and consumed in the region (p.14, Carolan, 2015); and sometimes each company seems to focus on its own company-community and its interests (Bronson and Knezevic, 2016). Depending on the goals served and the size of the community that is taken as a starting point for reflection, people evaluate the possibilities of smart farming differently: mutual trust, transparency, equity, just distribution, acceptance, knowledge and responsibility may play a role in all reflections about the best power-distribution, but these values acquire different priority and content for each community. Ferris et al. therefore state that it is important to consider the context in which digitalisation is evaluated (p.14, Ferris and Rahman, 2016).

Power is also a topic of consideration in relation to the role of consumers. Kshetri and Leone, for example, think that consumers will have more power over farmers: they note in their respective articles that transparency about farm data enhances the autonomy of consumers, as better information about production processes inform consumer's choices and with those choices they can reward preferred businesses. Eventually, this is expected to change the ways in which farms work too, as: '[t]his practice puts business disregarding consumers preferences at a disadvantage' (p.10, Kshetri, 2014). Other authors imagine the digitalization of farms to provide opportunities to monitor the choices of consumers and exercise more power over their choices. Leone argues, for example, that the traceability and transparency of the production process in digitalized farms, not only allows to enhance and guarantee food safety' (p.246, Leone, 2017), it also enables to give 'personalized and context-sensitive dietary recommendations' (p. 427, Leone, 2017). This of course raises questions such as: what is a 'better' choice? How can misuse and dangerous forms of social control be prevented? (p.427, Leone, 2017) or 'is the profiling of consumer data a breach of privacy'? (Ferris and Rahman, 2016). The answers to these ethical questions will, according to some authors, impact on the ways in which the food-production system is organized in society, as well as on the design of the technology that supports smart farming, as it will influence what data are valued, how they need to be presented, linked and interpreted. (p. 427, Leone, 2017). Leone, just like other authors such as Long and Blok, and Eastwood et al., therefore pleads for an ethics-by-design approach, meaning that societal values should be taken into consideration when the technologies are made for smart farming. (p. 429, Leone, 2017; Long and Blok, 2017; Eastwood et al., 2017; Ferris and Rahman, 2016). Given the ways in which these technologies are able to influence society, including the ways in which farmers and consumers interact and the choices of consumers, they consider the digitalization process an innovation with societal relevance that demands to invite a broad variety of stakeholders to reflect and decide about the future of smart farming, including citizens.

Impacts on human life and society

In discussions about if and with whom data ought to be shared, or the desirability of different power (re) distributions, a lot is presupposed about the desirability of different impacts of smart farming on society. Some of the literature focuses on an evaluation of these impacts. These impacts will be analysed as 'hard' and 'soft' impacts here (Van der Burg and Swierstra, 2013).

Hard impacts can be measured in quantitative ways. Hard impacts are important for smart farming, as the data it generates are typically 'big', therewith indicating that their value depends on the amount of data. It therefore seems appropriate to measure the impacts on society also in quantitative terms. Many authors do that. For example, impacts on the economic activity in a region can be measured by counting the amount of transactions or counting the number of farms and new startups (De Beer, 2016), impacts on the amount of jobs in a specific rural area (and parallel: demographic changes) (Kritikos, 2017; Poppe et al., 2016), the increase or decrease of production and profit in a farm or region, or the relative contribution of different countries to the increase of food-production for the world's population (Kshetri, 2014; De Beer, 2016; Özdemor and Kolker, 2016), increase of the safety of foods can be measured by looking at the amount of incidents with unsafe food or speed of detection of unsafe foods in case of an accident (Baki, 2010; Carbonell, 2016; Knaus, 2017; Kritikos, 2017; Kshetri, 2014; Özdemor and Kolker, 2016; Poppe et al., 2016) and effects on the use of water, fertilizer or pesticides in a farm, reduction of CO2 emissions (all authors), or effects on biodiversity in a region (Baki, 2010; Kritikos, 2017). The introduction of ICT, furthermore, demands investments in technology and training of staff that can be measured in quantitative monetary terms. (p.14, Eastwood et al., 2017).

The accumulation of data-based knowledge that smart farming makes possible, is also expected to realize soft impacts. Soft impacts refer to more subtle changes in the ways in which human beings are motivated to act, interact, behave, experience, decide, perceive or understand. Soft impacts can only be described in qualitative terms and often invite a lot of disagreement. There is, for example, a lot of disagreement about the sustainability goals of smart farming, which are usually understood in qualitative terms. Kritikos suspects, however, that the accumulation of digital agricultural data will help to 'improve the picture on the pressures of industrial agriculture upon the environment' and eventually contribute to a shared understanding of sustainable farm policy (p.21–22, Kritikos, 2017). Similarly, Carolan

[3] Another example: Providers of big data tools (such as John Deere who makes agricultural machinery) filed a copyright claim along with General Motors to prevent farmers from accessing, modifying, or repairing software on their tractors. Similarly Climate Corp. stipulates farmers cannot "modify, edit, adapt, disassemble, scrape …. decompile, reverse engineer or create derivative works from any Climate Corp Products."(cited in Carbonell, 2016)

notes that insight into data enables farmers to point to their extensive historical crop level data as evidence for the existence of climate change (p.9, Carolan, 2015). Precision agriculture is therefore ascribed potential to improve environmental stewardship, as data can help to convince policy makers, producers and also citizens of the urge to do something about climate change (p.12, Poppe et al., 2016). Quantitative data could therewith have soft impacts, as they can influence people's interpretation of sustainability, their sense of urgency regarding climate change, and their motivations to act.

Soft impacts are also discussed in terms of what is being lost when farms become digitalized. Loss of (traditional) farming skills and culture of the community of farmers, as well as changed ideas about what 'good farming' means (Baki, 2010; Blok and Gremmen, 2016; Blok and Long, 2016; Bos and Munnichs, 2016; Carolan, 2017; De Beer, 2016; Driessen and Heutinck, 2015; Dyck, 2017; Eastwood et al., 2017; The economist, 2014; Scholten et al., 2013). Smart farming technologies are expected to produce a focus on quantity, and to diminish farmer's attention for other aspects of their work. According to the 18 Iowa farmers that Carolan interviewed,[4] the ideal of smart farming boils down to the following quote: '(..) good farmers do not follow their gut, they follow data' (p.11, Carolan, 2015), therewith implying that digital technologies contribute to a more singular evaluation of the quality of farmers (solely in terms of yield), while before there was a larger variety of goods that attracted people to the profession of farmers, such as: taking care of biodiversity and shaping and maintaining trust in strong farm communities.

Similarly, in livestock farming several authors suspect that the focus will lie on data and production, and that other values will be (further) marginalized. Blok and Long, for example, suspect that '[a]s farmers become more concerned with data management rather than with animal husbandry, animal welfare issues could arise' (p. 552, Blok and Long, 2016). Bos et al. question whether smart/precision farming will foster current trends to increase scale and intensify livestock farming (p.12, Bos and Munnichs, 2016), and –as there will be less physical contact between farmer and animals, and between animals and citizens- they fear this might lead to alienation between farmers and their cattle which will be detrimental to the perception of animal welfare (p.12 and 33, Bos and Munnichs, 2016). Animal welfare is also studied in the extensive case-study by Driessen et al. (Driessen and Heutinck, 2015) who describe how the understanding of the content of values that constitute how farmers think about good livestock farming co-evolves with the development of Automatic Milking Systems (AMS). While farmers used to interact with cows on a daily basis during the milking and would notice shifts in behaviour of every cow as indications of their health, the health of animals is now monitored by the AMS, which lists information about the hygiene of the utters, the fertility of the cow, the amount of milk that an animal produces, body temperature etc. This alters the meaning of 'animal welfare' for farmers: while before farmers would look at cow behaviour, now they consult a list of information and determine on the basis of that whether action is required. Such changes shift how farmers think about animal welfare, as well as how they decide when they need to act. Their interaction with animals changes, and therefore their perception of welfare, their deliberation and the ways in which they act. Regarding all these changes, farmers appreciate the flexibility they obtain when they don't have to milk their cows, but they also have to learn new (and sometimes more managerial) skills to which they are not yet used: Driessen et al. report that the reorientation in their daily work is so radical that some farmers feel like an 'intern' at their own farm (Driessen and Heutinck, 2015).

Soft impacts on the daily work of farmers are often talked about in terms of losses. But soft impacts can also invite reflections about positive changes. While farmers observe that their communities are 'undermined' because the technologies serve individuals rather than communities of farmers, (p.12, Carolan, 2015) the 19 regional food system entrepreneurs that Carolan interviewed saw IoT technologies also as an opportunity to shape new communities which connect regional producers and consumers and allows them to exchange ideas about how food can be produced and consumed in the region (p.14, Carolan, 2015).

In all of these descriptions and anticipations of hard and soft impacts, values are at stake such as sustainability, entrepreneurship, equality, food security, animal welfare, strong communities, freedom, knowledge and care. While the authors work on the basis of intuitions regarding the acceptability or desirability of these values, in the publications they are primarily approached in a descriptive manner: expected changes are described and it is noted how these changes are evaluated by the people involved. Invitations to assess these changes are however rare. While some authors mention that such an assessment would be valuable (Driessen and Heutinck, 2015), authors usually remain normatively uncommittal and simply suggest possibilities for the further development of smart farming without offering arguments for it.

5. Discussion

From our narrative description of the literature about ethics of smart farming we infer that the ethical challenges identified in the area of smart farming can be ordered under three themes: (i) data ownership, accessibility, sharing and control, (ii) distribution of power and (iii) impacts on human life and society. Table 2 summarizes the challenges we encountered in the literature, related to these themes. These challenges, however, did not reach a satisfactory conclusion yet as they focus on consequences of smart farming innovation for (actors in) society, but do not look at possibilities to shape that future. We will explain this in the following, and do suggestions for future research which takes a more active role in contributing to shape the future. These are also summarized in Table 3 and contribute to responsible innovation, which is predicated on the idea that society can steer technological development into directions that it considers desirable.

To do this, it is first of all important to invest more time and energy into exploring views on the **purposes that smart farming should serve**. Smart farming technologies offer a variety of options for farming businesses to develop towards the future, but only limited possibilities have been explored until now in the literature. Enhancing imagination about these possibilities can empower stakeholders, such as farmers, to steer technological developments in directions that they consider desirable and seek ways to solve anticipated problems or solve them in a way that is satisfying to them. Furthermore, an exploration of future possibilities also enhances creativity in thinking about whether and how the goals of individual businesses can be combined with the realization of societal goals, such as sustainable farming, food security and safety. As smart technologies connects stakeholders together in a data sharing network which is to advance the goals of farming as well as societal (and environmental) goals, we think the goals of such a cooperation in a network deserve to be chosen carefully. Discussion about these goals need to be happening especially amongst stakeholders who have a role in smart farming, such as farmer's communities or cooperatives and amongst decision makers about smart farming in the government or industry, but they can be supported by academics who can take a role in offering input to broaden imagination about possibilities, facilitating reflection and (ethical) deliberation and analysing the pros and cons of the outcomes of discussions for the participating stakeholders.

Eventually, such a reflection is thought to contribute to responsible innovation too, as a reflection about goals of smart farming also provides input to the further development of technologies. Smart farming technologies may have to develop in a diversity of ways, depending on the types of collaborations that are already in place in particular contexts in which the technology is to land and the ways in which the

[4] As well as with 14 big data industry representatives and 19 regional food system entrepreneurs.

Table 3
Approaches for fruitful future research in ethics of smart farming.

Themes	Questions
Understandings of the goals of smart farming	- What goals does/should smart farming serve? - What are the pros and cons of these goals? - What possible societal roles do smart technologies allow farmers to develop? - What are the best ways to combine these roles? - What effects do the introduction of smart technologies have on responsibilities and dependencies of farmers and other stakeholders? - Are responsibilities and dependencies of different agents in the collaboration acceptable/desirable? What are the pros and cons of different possible collaborations? - What is the most acceptable/desirable way to use digital technology to develop the relationship between farms and society further?
Ethical implications of epistemological challenges in data-interpretation	- What/whose goals do/should the collection and analysis of data serve? - Are there differences of opinion regarding these goals, and the preferred way to collect and analyse data? - What is the best way to deal with these differences of opinion? - What are acceptable conditions regarding the selection of data and the choice of analytic method? - What justification is offered/should be offered for the choice of method of analysis (and to whom?)? - In what ways do present ethical approaches to smart farming facilitate/hinder having an open conversation about choices made about data interpretation?
Trust relationships and ownership/access rights to data	- What are reasons for stakeholders (farmers, ATPs, citizens, governments) to trust or distrust each other? - What are the commonalities/differences between preconditions for trust in data sharing? - What are the best ways to foster trust in smart farming?
Codes of conduct and guidelines	- What possibilities do current codes and guidelines offer to think about the ethical challenges that smart farming raises? - What are the limitations that these codes and guidelines impose on smart farming? - Do present codes and guidelines have to be revised, given the (diverse) understandings of 'good' farming with smart technologies, and insights into how public and commercial goals can be served best?

collaborators want to develop towards the future.[5] It is therefore important to do more extensive empirical research into the values and norms that already characterize collaborations and use that as input to reflect on the development of technologies too.

Scholarly work in ethics of smart farming can contribute to the enhancement of reflection of all stakeholders, including farmers and developers of technologies for smart farming, by means of a description and analysis of the values and norms related to the rivalling futures that can be served with smart farming. At this moment, we observe that imagination about the future of smart farming is rather limited, and we suggest to broaden that imagination. Two different background ideas regarding the purpose and function of farms in society seem to be at work in the scholarly discussions, but their comparative pros and cons are never foregrounded. On the one hand, farms appear as independent household-commercial units, to whom smart farming technologies offer an opportunity to increase production and profit and allow them to survive in the market competition. Yet, smart farming technologies also potentially threaten the survival of these farms as household-commercial units, as they may come to depend on (large) companies, which breaks the unit open and diminishes its autonomy. The presupposition that farms are, or should be, a household-commercial unit, figures in the background of a lot of concerns and explains why a significant part of the authors call for regulation, as they think farmers need protection of their interests, their profit, knowledge, skills, routines and autonomy.

On the other hand, authors ascribe to farms a role in realizing societal or global goals, such as to foster environmental sustainability, food security and public acceptability of the production system. Smart farming technologies appear in this light as aids, as they can help the community of farmers to diminish their impact on the environment, produce food more effectively using less resources and engage in an open communication with the wider public in order to come to a better alignment of norms and values that make the production of food socially acceptable. If the role of farms in contributing to public goals is highlighted, there can be good reasons to promote open access of data to allow all farms to use them, and to allow citizens and the government insight into whether and in how far farms are fulfilling their societal role well.

A lot of the ethical challenges surrounding the sharing of data, the distribution of power or the hard and soft impacts of smart farming, seem to hinge on different views of what farms are and what purposes they should serve. Our primary first proposal for future research is therefore to seek more clarity regarding the societal role of farms, broaden imagination of stakeholders about the possible other goals that smart farming could serve, and enhance their reflection about their relative value. This will enrich the reflection about smart farming and provides a starting point to think about its value, the questions it raises and points into directions to seek for answers. A broadened and enriched reflection about the rivalling value of the goals of smart farming, will inform the innovation process and contribute to an innovation that is 'responsible' in the sense that it takes into account the values of stakeholders which eventually increases the chance that it will be accepted and used.

Second, in the literature we reviewed, most discussants seem to 'black box' the interpretation of the data that ATPs and/or service providers carry out. We think the discussion would benefit from **ethical reflection about the epistemological choices** that are made in the selection of data, the ways in which meaningful connections are made between them and how they are interpreted. This offers a way for future users –such as farmers- to influence the shaping of the technology and make it more responsive to their needs and values. At this moment few authors call for a discussion about the selection of data. Bronson (Bronson, 2018) and Bronson and Knezevic (Bronson and Knezevic, 2016) are exceptions. They do realize that data are useless without interpretation and the interpretation chosen can serve diverse (commercial, political, cultural) ends about which members of society can

[5] In the Netherlands, for example, bell pepper growers try to make their company as large as possible as they compete with each other about price, and larger companies are able to keep their price low. But some strawberry growers collaborate more intensively and negotiate together about the price of their product. This is the reason why bell pepper growers regard information information about their yield as 'sensitive', for this is information that can be used against them in the price-negotiation. But the collaborating strawberry growers have no problem sharing information about yield with each other. Given these two contexts, it is likely that the sharing of data will demand much more discussion in the context of bell pepper growers, as it will demand a reorientation in the ways in which they are used to collaborate, than in the context of the already collaborating strawberry growers.

disagree. Apart from Bronson and Knezevic, however, most authors seem to presuppose that the power-imbalance between large companies and individual farms depends on data-interpretation that is somehow inaccessible and undisputable. The interpretation of data is however constitutive of a relationship with the people in the network who provide the data. The expected loss in farmer's autonomy, as well as vulnerability to possible secondary use of the data by the algorithm-experts for their own advantage, would however become a lot less frightening if the data-interpreters would be transparent about their choices and negotiate them with farmers. Current suggestions diminish the power-imbalances by making data accessible to everyone, seem a little naive as not everyone who has access will have the necessary expertise or technologies to understand how platforms interpret data and challenge that. If the black box of data interpretation is opened, however, choices underlying data interpretations can be shared and discussed with other stakeholders in the collaborative network such as farmers, the government or citizens. Asking justification may be complicated by the fact that the algorithms used to conduct the data interpretation are often considered intellectual property. We think, however, that the ethical debate should not (solely) focus on protecting rights, but should explore possibilities to shape a social ethics which contributes to the realization of shared goals. As farmers will contribute their data to the data interpretation platform, it makes sense to ascribe to them a right to ask for justification for what is being done with those data. How are they interpreted? And why are these algorithms used and not others? But it is equally sensible to ask how data, and the ways in which they are interpreted, can contribute to the realization of shared goals. And what are valuable ways to cooperate between partners in a data sharing network to realize those goals.

This line of thinking offers valuable input for critical ethical reflection on the concerns about (expected) power-imbalances resulting from smart farming that we encountered in the literature, as well as to think about ways to share data which are acceptable to participants in the data sharing network which eventually contributes to a more responsible innovation.

A third focus for future research are the preconditions for **trust between stakeholders who share data**. From the literature we infer that trust between stakeholders is not self-evident, and further research is needed to find out what the preconditions are to place trust for the diverse stakeholders who have a role in smart farming and who engage in a relationship together when they become members in a data sharing network.

Having trust is not self-evident, as the literature as well as the two previous themes in this discussion reveal that people disagree as to what the goals of smart farming are and who is a partner in the trust-relationship. Data ownership issues are often raised by authors who forefront a commercial perspective to smart farming, implying that stakeholders are primarily commercial organizations (ATPs, farms, service providers). In this cooperation between profit-oriented partners, questions may arise as to who owns the data, has a right to control them and make use of them to earn money. One of the questions is whether experts who develop algorithms to analyse the data may use knowledge based on data-analyses in their own interest, or whether the profits they make should be shared with the farms who originally provided them with the data.

However, given that smart farming is not only pursued for commercial purposes, but also for public goals, members of the wider public and governments may want to influence what data are being collected and how they are analysed and used. In the literature this led to questions about data access. In short, they want to have a say in the development of new technologies and the data sharing networks around it. An innovation process which is 'responsible' in the sense that it seeks to align technology with the values and norms of the envisioned end-users, would do effort to find out what they want. It would ask what goals smart farming should serve, how public and private goals should be combined, and then reflect on the type of data-analyses different stakeholders find valuable. In the conversation about these topics, end-users should also consider the preconditions they would want to set before placing their trust in a network of stakeholders containing citizens, the government, farms and tech-firms. It is impossible, however, to talk about these preconditions, if it is not clear what goals –societal, commercial, global, or a combination of these- smart farming should serve, as this defines the purpose of the cooperation. The themes noted in this discussion are therefore connected and should be dealt with together.

Fourth, **codes of conduct** shape an important topic for further research. It is understandable that authors call for regulation, as this would facilitate the interaction between commercial partners with rivalling interests, such as farmers, ATPs, intermediaries and service providers, and help them to realize innovation. It is however unclear at this moment how regulation could satisfactorily combine the private and societal goals that smart farming is intended to serve. Different codes of conduct have been developed in Europe, the US, Australia and Asia to facilitate the implementation and use of smart technologies in farming. However, these codes of conduct have not yet been informed by the previous discussed topics of existing and developing views on what 'good' smart farming means, what ethical requirements are concerning the epistemology of data interpretation platforms, or what stakeholders in a network need to trust each other so that they can exchange data and knowledge. It is therefore important to look at the possibilities that these codes of conduct and guidelines offer to contribute to the development of communities or collaborations around smart farming, but also at the ways in which they impose (probably unwanted) limitations on these collaborations. Further research can point out possibilities for the future development of farming with smart technologies which prove to be attractive, but which current codes and guidelines do not foster. It needs therefore to be investigated whether and how these codes and guidelines ought to be revised to serve the possibilities that smart technologies offer for the future development of farming.

6. Conclusion

At the end of this review we conclude that many interesting questions are raised in the literature about smart farming, which deserve to be answered. To conduct future ethical research, however, we suggest to move beyond the dominant focus either on protection of private interests – or on sharing everything with the public at large. As the proposals that we did in the discussion reveal, we would suggest that effort should be done to make smart farming innovation more responsible. Responsible innovation suggests that envisioned end-users in society –like farmers and other stakeholders- are not only passive recipients of new technologies, but can take a role in (co-)shaping the technological future. It would therefore be good not just to anticipate and evaluate the consequences that (are expected to) befall farmers and other stakeholders in the network and reflect on ways to protect them against possible harms, but to reflect on the preferred direction in which the further development of smart farming technology should unfold. In the literature we read, some authors adopted a responsible innovation approach (Blok and Long, 2016; Bronson, 2018; Eastwood et al., 2017). In agreement with these authors we suggest further research should support co-evolution of technology and society in desirable ways. To obtain insight in what is desirable and what not it is (1) necessary to see alternative possibilities to realize smart farming, (2) evaluate the pros and cons of these possibilities for different stakeholders and (3) make informed and deliberated choices. Such a reflective exchange engages stakeholders more in setting the goals that the innovation should serve, making choices about combining, interpreting and using data, identifying the preconditions for trust in data sharing, and in developing a clearer guideline for a fruitful collaboration towards the future.

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