

Smart Farming in Ireland: Anticipating positive and negative impacts through a qualitative study of risk and benefit perceptions amongst expert actors in the Irish agri-food sector

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Abstract: *Smart Farming technologies have the potential to overhaul and transform the way farms are managed and operated, particularly in countries such as Ireland with a high proportion of small, family farms. Whilst smart farming offers solutions to issues such as productivity and sustainability for the sector, it also introduces potential challenges and risks. Governance approaches such as Responsible Research and Innovation (RRI) have been developed to reconcile our current global need for techno-scientific progress with the moral, social and ethical expectations and requirements of society as a whole. The current study explores the growth of Smart Farming within Ireland from a social, ethical and behavioural perspective. It aims to anticipate the potential implications of research and innovation in this area by exploring the perceived distribution of risks and benefits across different actors in the Irish agricultural sector. One-to-one, in-depth, semi-structured interviews have been carried out with 20 expert key informants. Interviewees come from the farming sector, the natural and social sciences, the agri-tech industry, the investment and financial sector, the policy sector, and governmental agencies. Thematic analysis was employed to analyse the data. Three main themes emerged as hot topics of discussions around Smart Farming in our interviews: (1) Financial Winners and Losers; (2) Unintended Consequences and; (3) Data Ownership and Data Sharing. A final theme – (4) Anticipating Impacts and Embedding Responsivity – considers participants’ reflections on the process of anticipating positive and negative impacts of Smart Farming and their thoughts on whether and how responsiveness can be embedded into research and innovation in this area.*

Keywords: *Responsible Research and Innovation; Risk perception; Smart Farming*

Introduction

In recent decades, information and communication technologies (ICT) have had a disruptive impact on society and the economy; computers, internet, smartphones, social media, robotics, sensors and cloud-based processes have revolutionised how society organises itself and how individuals and groups make decisions and behave. The practice of farming and food production is not immune to this digital revolution and is expected to change dramatically in the coming years and decades {Bronson, 2016 #336;Teagasc, 2016 #359}. There is enormous potential for collecting huge amounts of data on the farm from digital and connected farm machinery (e.g. tractors, drones, robotics), sensors in fields and on animals, enterprise data from farm management systems collected from computers, tablets and smartphone apps, and from farmers' social media accounts {Wolfert, 2017 #321;Kamilaris, 2017 #326}. 'Smart Farming' in the form of smart machines, big data, Internet of Things, ICT, sensors, remote sensing, robotics and cloud computing, amongst other technologies and processes, is viewed by many as the future of agriculture {Poppe, 2015 #232;Carolan, 2016 #323}. New technologies have already been applied to great effect in agriculture over the last few decades; for example, Precision Agriculture (PA) practices have enabled farmers to use farm-level data on inter- and intra-field variability to inform more efficient decision-making {Kempenaar, 2016 #330}. Smart Farming further advances these practices by also enabling the aggregation of individual farm data with data from other farms and/or other sources (e.g. historical data, weather data, market data, benchmarking data); in many cases, this process occurs in real-time. This data can be analysed to inform decision-making at farm, industry, and policy levels and/or support the development of new products and services {Sykuta, 2016 #328;Wolfert, 2017 #302}.

The advent of Smart Farming is viewed to bring with it solutions to issues such as productivity, sustainability, food security and other sectoral and societal concerns. However, a critical consideration to the success of Smart Farming is the willingness of farmers to integrate and adopt these smart, connected technologies on to their farm {Zhang, 2017 #350}. Furthermore, there is a need to anticipate the potential implications of research and innovation in this area from a socio-economic, ethical and behavioural perspective, and to consider what the introduction of Smart Farming means for different actors across the value chain – in particular, the farmer – and society as a whole {Carolan, 2016 #323;Zhang, 2017 #350;Wolfert, 2017 #321;Eastwood, 2017 #347}. In the current paper, we explore the views of a diverse range of expert actors on the concept of Smart Farming and the perceived distribution of risks and benefits associated with these technologies. We also reflect on how research and innovation is addressing, or needs to address, potential concerns and challenges in this space.

Responsible Research and Innovation in Smart Farming

A recent Technology Foresight report carried out in Ireland views the Irish agri-food sector as being on the verge of a technology-driven revolution with significant changes forecasted for the coming decades {Teagasc, 2016 #359}. The introduction of technologies and new innovations into society over the last number of decades has not been without controversy, criticism and societal opposition – particularly in the food and agricultural sector in Europe {Asveld, 2015 #133}. We know that when it comes to technological development, society is more cautious in their acceptance with varying values coming into play. Over the last number of decades, high-level crises have served to remind us that society continues to demand better governance from those in positions of responsibility and power – the BSE crisis, the GM food debate in Europe, the Horsemeat adulteration scandal, and more recently the Cambridge Analytica data scandal. New technological and digital developments are increasingly being met with a more critical spirit {Bruce, 2002 #387}. The promise of progress should no longer be assumed as a shared value which legitimises all technological developments in the agri-food sector.

New policies have been introduced in Europe aimed at ensuring ‘good governance’ in research and innovation. As an overarching concept, good governance approaches aim to ensure the fair distribution of risks and benefits in society, build trust in the decision-making process and insofar as is possible; avoid unintended negative consequences {Devaney, 2017 #355}. One governance framework receiving significant attention at European level has been Responsible Research and Innovation (RRI). RRI emerged as a result of the need to reconcile our current global need for techno-scientific progress with the moral, social and ethical expectations and requirements of society as a whole {Stilgoe, 2014 #138; Von Schomberg, 2013 #128}. RRI has been described as particularly relevant for ‘societally intricate technological trajectories’ {Asveld, 2015 #133}. Smart Farming would fit this label given the envisioned radical transformation of the Irish agri-food sector {Teagasc, 2016 #359}, alongside the socio-economic issues which may arise in the development and deployment of these technologies {Carolan, 2016 #323}. RRI is intended to guide the development and introduction of new technologies in a manner which identifies, accommodates, responds to and addresses societal concerns. It particularly emphasises the need for interactive processes between all relevant actors in order to reflect on and respond to ethical, socio-economic and cultural issues which may arise during technology development {Asveld, 2015 #133}. The RRI approach is not one to be implemented separately or in parallel to research and innovation activities; instead, the principles which embody RRI are embedded *within* research and innovation. RRI does not seek to prevent or hamper technology development or innovation, instead, it aims to ensure that the trajectory which innovation takes is conscious of and responsive to the concerns, needs and expectations of society {Asveld, 2015 #133}. Like similar studies which have applied the RRI framework to the agricultural research and innovation setting {Eastwood, 2017 #347}, this paper views RRI as having four main dimensions or principles: anticipation, inclusion, reflexivity, and responsiveness. Such principles are envisioned to act as a common set of objectives to guide actors in their pursuit of advancing Smart Farming {Devaney, 2017 #355}. It is argued that taking action that embodies these principles will increase trustworthiness in the decision-making processes which underlie research and innovation {Asveld, 2015 #133}.

RRI encourages mutual responsiveness – that is, it encourages all actors to acknowledge and reflect on the different values and visions that other actors may bring to the discussion around new technologies and innovations. Smart Farming requires input from, and collaboration between, a diversity of actors: agribusiness, tech companies, venture capitalists, new start-ups, public institutions, universities, governmental organisations and of course – farmers {Kamilaris, 2017 #326; Wolfert, 2017 #302}. It is expected that at least in some instances, these actors will hold differing views on how to progress Smart Farming and the anticipated positive and negative impacts which these technologies may have for the agricultural sector and society more broadly.

Anticipating the Risks and Benefits of Smart Farming

Smart Farming has to date largely been studied from a technical and productivist lens {Carolan, 2016 #323}. However, in line with the previous discussion on RRI as smart farming technologies are developed and introduced, it is increasingly pertinent that consideration is given to the potential risks and benefits of these technologies, particularly considering the different viewpoints of different actors {Eastwood, 2017 #347}. Risks represent different meanings for different people. A significant volume of research carried out by psychologists and sociologists over the last few decades has evolved thinking around risk as a phenomenon which originates in the human mind and which is influenced by subjective beliefs, values and social and cultural settings {McComas, 2006 #345; Renn, 2005 #346}. It has been widely established that individuals will evaluate technological transitions and developments in the context of their own lives and cognitive and emotive reasoning will be used to form opinions accordingly {Munnichs, 2004 #388}. Studying anticipated negative and positive implications through a lens of risk perception allows us to acknowledge and accept at the outset that risk is a social, cultural and psychological phenomenon – thus what is a risk to one stakeholder may not be perceived as a risk to another stakeholder. The area of Smart

Farming involves diverse actors: agribusiness, tech companies, venture capitalists, new start-ups, public institutions, universities, governmental organisations and of course – farmers {Kamilaris, 2017 #326; Wolfert, 2017 #302}. Understanding that risk is a social, cultural and psychological phenomenon reminds us that different actors will inevitably hold different views and expectations on the activities and processes involved in Smart Farming, and areas of contention and concern are likely to differ depending on the actor in question {Hoes, 2017 #341}. Being aware of and understanding and acknowledging these disparities is important for all actors in the network, but particularly those who are key governance actors; engaging in such reflexive thinking achieves in part the aims set out under RRI {Stilgoe, 2014 #138}. Recent evidence suggests that we have more work to do to integrate diverse stakeholder perspectives in the governance of smart technologies in agriculture {Eastwood, 2017 #347}.

The current study explores the extent to which principles embodied with RRI are currently embedded in expert actors' thinking around Smart Farming in Ireland and its future growth. In particular, given the early stage of Smart Farming development in Ireland, we focus on the dimension of anticipation; we employ a theoretical lens of risk perception – which considers how different actors view risks differently based on social, psychological and cultural factors – to explore how a diverse range of actors perceive the distribution of risks and benefits as a result of Smart Farming development in Ireland. This study also explores the processes and structures currently in place across the value chain – or that are considered as needing to be put in place – to address the concerns and needs that different actors within the agricultural sector may have with regard to the development of Smart Farming in Ireland.

Methodology

Design and Sample

The current study employed an exploratory qualitative research approach. One-to-one in-depth semi-structured interviews were carried out with key informants in the area of Smart Farming within Ireland. In the current study, we followed the framework for selecting expert key informants identified by {Devaney, 2018 #391@ @author-year}. Under this framework, potential participants are selected based on an expert continuum which distinguishes three types of groupings of individuals based on their 'closeness' to Smart Farming: subjective, mandated and objective. Subjective closeness is defined as those actors who have direct experience of smart farming, for example, industry actors; they will provide experiential knowledge of the topic. Mandated closeness reflects those actors who have a professional role responsibility related to smart farming, for example policy makers, regulators and support agencies; they are able to provide strategic insight. Objective closeness reflects those individuals who explore smart farming from an unbiased and rigour-driven perspective; for example, scientists. Adopting a framework such as this ensures that we interview a range of participants with different backgrounds and ensures a rounded and inclusive reflection of opinions on the topic of smart farming within Ireland. Based on this selection framework, potential participants were identified and invitations were issued to take part in the study. Twelve key informants were interviewed and included individuals in senior positions / advanced career levels from a variety of backgrounds; see Table 1. Our sample consisted of 2 females and 10 males and the interviewees were geographically dispersed across the Republic of Ireland. Interviews were conducted face-to-face with all participants in a location convenient to the interviewee, generally their place of work. The interviews took on average 60 minutes and were carried out during April - May 2018.

An interview schedule was used to structure and guide the interview. Participants were initially asked to describe their interpretation and understanding of the phrase *Smart Farming* before being presented with a definition and image (see Appendix A) which they were asked to discuss. These visual aids were used to further stimulate discussion around the characteristics which define Smart Farming from the participant's perspective. Participants were then asked questions about (1) the challenges and opportunities facing Smart Farming in Ireland; (2) the perceived risks and benefits which Smart Farming introduced and how

these were distributed across different actors; (3) the actions required to respond to challenges facing this sector.

Table 1. Categorisation of Interviewees

Category of Expert Actor	<i>n</i>
<i>Subjective</i>	
Agri-tech industry	1
Farming representatives	2
<i>Mandated</i>	
Government / policy	1
Research funder	1
<i>Objective</i>	
Social scientists	2
Computer / natural scientists	5
Total	12

Analysis

All interviews were transcribed and underwent qualitative analysis. An inductive Thematic Analysis was carried out following the 6-step guidelines outlined by {Braun, 2006 #306@ @author-year}. QSR NVivo 10 was used to organise the data and aid the analysis process.

Preliminary Results and Discussion

We arrange this findings section firstly around three main themes that emerged as hot topics of discussions around Smart Farming in our interviews: (1) Financial Winners and Losers; (2) Unintended Consequences and; (3) Data Ownership and Data Sharing. Within each of these three themes we discuss risks and benefits perceived by the different participants, and how they are distributed across different actors in the agri-food value chain. We pay particular attention to areas of opposition and divergence in opinion, highlighting potential areas of contention in wider debates. We then introduce the final theme – (4) Anticipating Impacts and Embedding Responsivity – which considers participants’ reflections on the process of anticipating positive and negative impacts of Smart Farming and their thoughts on whether and how responsiveness can be embedded into research and innovation in this area.

Financial Winners and Losers

Previous studies have highlighted how the narrative surrounding Smart Farming has largely been based on a productivist model, with a central focus on promoting the benefits of increased productivity and profit {Carolan, 2016 #323;Ge, 2015 #356;Eastwood, 2017 #347;Bronson, 2016 #336;Ge, 2015 #356}. Many of our participants when questioned on the benefits of Smart Farming also highlighted this benefit of increased productivity for farmers from the adoption of these technologies:

“So I think the benefits of Smart Farming for the farmer, like listening to people at smart farming or agtech conferences, they’re very focused on I suppose the productive element.” - Government / Policy

However, Smart Farming was not viewed as an easy or straightforward win for farmers – the financial risk for farmers investing in these technologies was a very real and genuine concern for some participants. Most participants made reference to the significant financial risk which would first have to be undertaken by farmers given the continuing high expense involved in purchasing and implementing these technologies – and the promise of financial return may not always be guaranteed, or may only come after a lengthy period of time. There was also a sense that only a number of ‘elite’ farmers would be in a position to invest in these technologies, although over time some of these technologies would inevitably become cheaper:

“Thinking about it, farmers don’t necessarily come out the winners of it especially if they have to invest a lot because these technologies can be very expensive and they could get into a lot of debt so it makes their life a little more difficult to have to service that debt.” – Social Scientist

“This technology is not cheap. So the ability to make a capital investment of a sizeable amount is only available to a handful of farmers. So that’s going to be the big barrier. Now saying that technology gets cheaper and cheaper all the time. A lot of this technology is about incremental improvements in margins. If your margin is relatively very low already an incremental improvement on a low margin is not much of a driver to adoption really. There isn’t the economic driver for a lot of farmers to make these investments, not for smaller farmers; for more profitable farmers especially in the dairy industry then yes but whilst it’s a very large component of the agricultural output you have only a fraction of the farmers in this area.” - Computer Scientist

There was also a concern raised by a small number of participants that some farmers may be too quick to invest in new technologies without first understanding their true value and application for their farm:

“I think it’s quite a danger around these technologies as well if they are being promoted to farmers – and I’m not saying that companies are bad or that industry is bad but if it’s to make a profit – that can be a good thing because these companies have a reason to make these technologies very usable and to promote them to farmers – but there can be an interest factor and kind of that they like a new toy or technology that might not be something that is necessarily beneficial for the profitability of the farm or their lifestyle but it comes with a certain cache of having a really high tech piece of kit as well – so there is that danger around what types of technologies are used.” – Social Scientist

Given these concerns, a large number of participants strongly indicated that for farmers to invest wisely in technologies and reap the promised financial benefits, it would first need to be shown and demonstrated that the technologies do actually provide a return on their investment – and would work well in the context of individual Irish farms. In this regard, some participants pointed to the important role of consistent, evidence-based information and advice from independent and reliable sources – including advisors, independent organisations, scientists or peers. There was a sense amongst some of the participants that this should not be left solely to industry. Some suggested the need for technologies to be tested and benefits proven in situ within demonstration farms, through focus groups or through impact analysis studies:

“Farmer discussion groups are really valuable as well, I think the monitor farms and the demonstration farms we were involved in – they were a good forum for farmers to question and talk about how they are using different smart farming technologies like GPS in the arable world when they get together. They are usually bamboozled by claims from people who are selling things and telling them how to use things. You don’t have much opportunity to get together and think well am I getting value for money and how are other people using it so I think just opportunities to be able to talk to each other. And sources of independent advice as well that are not funded by any particular industry. So organisations that don’t

stand to make a profit from the use of these technologies as well can foster trust.”

– Social Scientist

“Some of this area is developing relatively fast, what we need to do is to validate that the technologies that they're using underneath a Smart Farming system are appropriate for our production systems, our climate, our crop types and so on. It's down to really what is I suppose validation research, in other words it's either us on our research centres or us going out to farms to quantify what, you know, benefit is coming from this because at the end of the day, you know, the technology has to bring benefit.” – Natural Scientist

A number of participants also spoke of benefits beyond profit which would emerge for the farmer from the increased efficiency of these technologies. These participants perceived that Smart Farming technologies would allow for more efficient farm management, less paperwork and fewer time-consuming administrative tasks which would then allow farmers to pursue and make time for other values and priorities in their life:

“I'd like to think that one of the benefits will be improved quality of life for farmers. That it will remove some of the labour intensive activities...maybe a reduction in their working hours. A reduction in the brute force that's required for so many agricultural activities.” – Social Scientist

For a number of participants, the actors who were viewed to be the main financial beneficiaries from Smart Farming included the burgeoning agri-tech industry in Ireland.

“Obviously the main winners are probably going to be the large multinational agri-suppliers. If you look at the way smart farming has gone in the last ten years the smaller companies that started the process have been bought up by the likes of Monsanto and Bayer and so on. It's about tying in farmers to a commercial ecosystem. So obviously the big commercial companies, they are going to be the winners, they always are the winners.” – Computer Scientist

A recent survey carried out with Australian producers indicates that the farming community is divided, and some are uncertain, about the benefits of big data for the producer – some see big data as favouring the farmer, others see agribusinesses gaining the most (Zhang et al., 2017). This divergence in opinions was also present in our study of expert actors.

Unintended Consequences

The structure and set-up of future smart farms and possible discrepancies between the values which drive farmers, and the values currently imbued by smart farming were discussed by participants with a view to considering potential unintended consequences brought about by the introduction of technologies. Participants held varying opinions on the level of change – both structural and social – that the widespread introduction of Smart Farming might bring about at farm level. Some participants felt quite strongly that farms could change significantly, whilst others were not as certain. Participants in the current study also held differing views on whether the changes introduced by Smart Farming would be positive or negative. A number of participants expressed concern about how changes to the farm may have negative unintended consequences. We consider some of these in the section below, along with counter arguments from other participants who failed to perceive similar risks.

Powered by big data analytics, farming activities are foreseen to become increasingly automated, leading to less manual work {Sykuta, 2016 #328;Wolfert, 2017 #302}. This has been argued to have knock-on implications for the role of farmers and the skills required. As observed by {Bronson, 2016 #336@ @author-year}, the image of Smart Farming put forward by agribusiness in their marketing materials is one of a tech-savvy farmer who readily adopts the latest technologies and is driven solely by profit maximisation. Similarly, in qualitative research with American industrial farmers and big data industry players, {Carolan, 2016

#323@ @author-year} discusses how participants' comments reflected that the 'good farmer' follows data to make decisions, rather than experience or their 'gut'. It is apparent that for some, data-driven decision-making encouraged by Smart Farming is changing what it means to be a farmer and the ethos which drives the sector {Eastwood, 2017 #347}. However, in our study, one Social Scientist raised concerns about how farmers may feel about smart technologies changing the nature of decision-making away from the inherent skills and heuristics that farmers pride themselves on having developed, acting as a reminder that the diversity of the farming community should not be underestimated:

“Often these technologies can replace ‘good farming’... they can replace skills that farmers see as important for themselves so the ability to look at an animal and be able to tell if that animal would be good for their farm and the health of that animal like the different characteristics of that animal; so that’s kind of a visual skill that farmers are really proud of and is really part of what it means to be a farmer and part of the farming community...because they replace these skills that farmers are very proud of and have built up over time...I wonder if you are seen to be bringing something in that’s replacing farmers’ existing sort of working patterns and skillset then that’s not going to go down terribly well.” – Social Scientist

However, other people were more positive around the changing role of the farmer, that rather than technology dictating to the farmer, the farmer would still remain at the heart of operations:

“The role of farming may be as the custodian of the country side but it’s also going to be the person that’s at the forefront of collecting this data or being the kind of the focal point for all of these sensors to be put in. And it will require customisation and change but it can’t be at the loss of traditional farming which is people outside putting their hands in the soil, you know it is still essential. You’re still going to have to do that, you know you’re still going to have to get into a cab and drive. Even with automated tractors, there will still be a requirement to get into cabs and program and assess and do all of this stuff as well. So it’s a blend of traditional and the future is where we’re probably going to end up with the actual you know.” – Farming Representative

For a few participants, another potential negative impact of increased technology use and digitisation of the farm was the potential distancing and isolation of farmers both from their animals and from their community, which was viewed to introduce a number of different risks mainly for the health and welfare of both farmers, and animals.

“I mean if you look down the future you can see the idea of farms increasingly being depopulated. There are fewer and fewer humans needed. Certainly this technology could lead you toward almost people free farms. And animals that don’t interact with people. That’s potentially a big worry for both animal health and the social and cultural dimensions of the landscape.” - Computer Scientist

“Change can be very traumatic. It’s not always positive. If we were to look at farming level, it has become particularly, with the creeping redundancy and the part-time-isation of farming. Farming is no longer a social occupation. There used to be a support network, there used to be a neighbour, friends farming. Farming can be a very lonely occupation now. You can be all day, all week without seeing anybody. And one of the effects of technology has been to make that worse. Okay we’re living in a more connected world. But it doesn’t mean we connect on a human level, with other human beings. It’s all moderated, mediated through a machine. That is a major problem lurking there in the future - isolation and the lack of social interaction and opportunities.” – Social Scientist

It has previously been considered whether Smart Farming may favour big, industrial farms more than small, family farms, with the former becoming much more commonplace, and the latter at risk of falling further behind – and in a worst case scenario, becoming obsolete {Poppe, 2015 #232; Carolan, 2016 #323; Kamilaris, 2017 #326}. It was also observed in our interviews that holding different motivations and values and having less access to the required resources, smaller family farms may be in a position where they are less likely to invest in the skills and technologies required to take advantage of Smart Farming trends. There was some discussion around envisioning how technology could lead to an over-emphasis on production and yields and detract from more traditional images of farming, which could be a risk for the image that is portrayed of grass-based Irish farming. Participants urged careful consideration of how we develop Smart Farming to maintain this image of Irish farming, whilst also making optimal use of technologies:

“I think one of the dangers with this is that a lot of these things promote scale. And data works best at scale. In some ways there’s probably a tension between that and the picture of the nice little farm and it’s all very natural and green I think there’s a version of smart farming that promotes that and says well isn’t it great that you can still do this but a sprinkling of technology here means you can bring in some of the optimisation that you get in these big industrialised farms. That’s one version. The other version is that well yeah by bringing in all this technology massively optimise everything and it becomes this big food factory. I think that’s, yeah there’s a tension there. My sense is that we promote outside of Ireland the small cows out in the field thing, and that technology might damage that in some way.” - Computer Scientist

“I think this is where, you know there’s a real need to first of all envision what you want to do, you know have some real key policy objectives. So with smart farming we don’t necessarily want less jobs in farming, we want rural and regional development where you have similar number of farmers, maybe being able to work in a smarter fashion with a higher quality of life, better safety, higher food quality. But not necessarily, you know taking away the good elements of farming, and you know we want to build on some of the strong elements that the market is interested, such as grass based production systems. So we need to monitor for this and we need to I suppose set out what’s the good things at the start. And the things we don’t want to lose.” – Policy / Government

Considering the wider perception of Smart Farming amongst society, there was some concern amongst a few participants that societal resistance to certain technologies would be an issue. It was evident that this concern was linked to how individual participants had chosen to conceptualise Smart Farming – that is, to include the area of genetics. However, participants felt that on the whole, there was little that consumers would be concerned about for the vast majority of Smart Farming technologies which they felt would only lead to benefits for consumers and society through more efficient, sustainable, safer and traceable food production.

“A lot of these technologies would have very little impact on the consumer. There’s very few of those technologies outside genetics, that would impact consumers I think most consumers wouldn’t concern themselves with it. At the moment the idea the smart farmer is presenting is one of the application of technology to the management of the farm. But that’s only one small component. So you’ve got to bring into it genetics. Which is a big component of smart farming. And that’s where you’ll get kick back from the consumer I think. I don’t think the consumer would be worried about robotic tractors or even drones.” - Computer Scientist

“Society will be the winners. We do not have enough resources to feed the population that we have. And the only way that we have beaten the Malthusian equation is because we have continually innovated. You know every 30 years or

so some innovation happened. So society will, we will be able to feed 9 billion people by 2050 because there's huge untapped potential in the developing world. Society will benefit. Not that it will be visible to a lot of people because we take it for granted. But economically and societally we will be able to meet those targets.” – Farming Representative

Data Ownership & Data Sharing

Many participants felt that the central challenge facing the area of Smart Farming is that of data ownership and data sharing. Some commentators have spoken about a dramatic power shift which could be brought about by the issue of data ownership in the farming sector {Carbonell, 2016 #335;Andrejevic, 2014 #340}. In our study, the main concerns around data ownership related to maintaining and assuring farmers' privacy, and the financial gain associated with data ownership.

Threats to the privacy of farmers' data concerned our participants. Many farmers, particularly those operating family farms, have an intense and personal connection to their farm. The farm business and farm household are often interconnected; as is the farmer's personal identity {Sykuta, 2016 #328;Vanclay, 2004 #352}. Thus, perceived intrusions of farm data privacy will often be viewed under a very personal lens by the farmer:

“Looking over the hedge or the government knowing about what you are doing or why does anyone have the right to know what's going on, on my land? That sense you get from talking to farmers is that privacy is very, very important. Whilst at the same time you have a local openness, the community, the back door being open, neighbours popping in and so on. There is a sense that from outsiders we want privacy - could be the government, could be regulators, could be inspectors, could be the EU” – Computer Scientist

Particular areas of sensitivity that participants felt farmers may have particular data privacy concerns related to animal health – associated with a fear of being stigmatised; and regulatory compliance – associated with a fear of being penalised. In particular, the latter was raised as an issue of concern by many participants.

“In terms of data privacy and access to data as well I think particularly around animal health, I think that's tricky, having access to farmers' animal health records...it could end up happening that we stigmatise or target farmers that have known disease problems on their farms, and that's something that causes mental health problems for farmers and is difficult for farmers. So I think that issue about how data particularly around sensitive issues like animal health is going to be used is pretty problematic.” – Social Scientist

“Two fears that come up all the time in the data sharing area are one that my data will be shared with people I don't want to see this. And the other one is that people who see my data - this will come back to me negatively in some way - somehow this data will be used against me. And you can imagine that probably for someone who farms where things like CAP payments and grants, I don't know how they work, but that someone would have a reluctance to say well someone will look at this data and will now reduce my grants because of something they will see in the data. So something like grants will be reduced because people will see something in the data that maybe I didn't want them to see. I guess it depends on who the aggregators are, so what's the relationship between say the farmer and the person who is aggregating the data. And are they going to be comfortable and trust that these are people who are going to look after this properly. ” – Computer Scientist

It is likely that a primary driver of risk perceptions related to privacy and data ownership will relate to the context of their development and application (for-profit, non-profit, or public use)

{Bronson, 2016 #336}. For many participants, the issue of data sharing – in particular where third parties are concerned - was dependent on *who* was going to have access to the data and how they were going to use the data. Not everyone viewed privacy issues as a perceived risk for farmers – some felt that farmers would not have significant concerns in sharing their data with others. Some participants made reference to the fact that farmers' are already sharing their data with others and have no issue with it. However, this was generally caveated by the presence of pre-existing, trusted relationships and well-known processes:

“If you start off with the idea that you are aggregating across farms there's already lots of resistance to the idea of a data sharing, who owns the data? Now obviously within things like coops data sharing already exists, if you are part of a milking coop you are sharing your yield data and the health of animal data. There's some technology gathering that data already from the milking parlour. But those are individual contracts about a specific element of the farm. It's not my farm wired and everyone can see it.” – Computer Scientist

Along with pre-existing relationships, certain value propositions may speak to farmers' more than others when it comes to data sharing. For example, there is evidence to suggest that farmers' are positive about citizen science initiatives and are willing to use their smartphones to share their data for scientific objectives which ensure collective benefit {Dehnen-Schmutz, 2016 #349}. There was evidence amongst our sample, particularly from scientists, who echoed these sentiments of finding it quite easy to collect data from farmers for use in publicly-funded research.

One major concern which was raised was how farmers' data may be used for alternate purposes by industry specifically. Data collected from the field or the farm may not be restricted only to use at the farm level, but extending right across the entire food supply chain, with potential for it to be used for means beyond what farmers' may have originally intended or believed it to be used for, in particular this related to industry use of data. Big data in agriculture is known to be of interest to agribusinesses where predictive analytics can act as a decision support mechanism for industry {Carbonell, 2016 #335}. Data can be gathered by industry enabling them to gather previously unknown insights into farmers' behaviours and activities – for example, what products the farmer is using, how much they are producing, and the profit they are making {Carbonell, 2016 #335}. With regard to industry usage of data, concerns were raised by a few of our participants as to whether agribusiness could potentially use knowledge of local farm operations and attributes to engage in discriminatory and customised pricing or product recommendations, as has been previously suggested in the literature (Lynch & Quealy, 2017; Sykuta, 2016):

“I think there is certainly concern where people, maybe processors, supermarkets, companies like that can acquire data and use data in a way that could be negative to the producer. In other words, the person who is going to purchase the product from the farm could know almost everything about that product, including its production cost and that then gives them a huge leverage that if they know to the nth cent what it costs to produce well that's the price that's going to be offered and nothing else. So I think there is concern there.” – Natural Scientist

Relevant here is the issue of contractual agreements between industry and the farmer which are subject to terms and conditions and which lay out the rules regarding data privacy, data ownership, and data usage – and often, this agreements tend to differ greatly on a case-by-case basis {Ge, 2015 #356; Kempenaar, 2016 #330}. The onus for understanding these terms falls on the farmer, and at present, with every different technology they adopt and every agreement they enter into, the terms and conditions are likely to change {Schuster, 2017 #338; Ge, 2015 #356}. Research with Australian farmers has shown that the majority of those surveyed knew nothing at all or very little about the terms and conditions of their data collection agreements {Zhang, 2017 #350}. Indeed, this was a concern amongst our participants also, who feared that farmers may have a lack of awareness as to the extent to which their data is shared and used by third parties. There was a sense amongst the participants that this is a particularly uncertain area and that the concept of privacy is multi-

layered, with a lack of transparency and a potential unaware audience in the form of farmers who may not know the means to which their data is being used or distributed:

“The question is who owns the data? The farmers don’t even realise the significance of the ownership issue and how significant the problems could be that would arise – we don’t know ourselves what issues might arise; but my genuine belief is that farmers should own their own data” – Natural Scientist

“From a computer science point of view you have privacy issues from I suppose a visual and a non-visual type, so your privacy can be invaded by someone taking a photograph of you and distributing that - could be a drone taking photographs of your land, your holdings, your livestock etc., and using that in some way against you or maybe to their own benefit. Then the non-visual way is, for example, if you have a machine that is collecting data using sensors, who actually owns that data, when you download the data on to your own computer are you the, the person with the sole copy of that data, let’s say, just for arguments sake, a contractor who’s going around maybe doing again fertiliser application, and as they apply it to a field, when they go back to base that they’re suddenly building up a huge data base of everyone’s data which then maybe at a different level could be taken by someone else, so I think the privacy is, is multi-layered - with the drones you know, you can see a drone flying overhead, it’s not so easy when, let’s say a USB is taken out of a machine and brought somewhere else well it’s nearly impossible to know where these things go.” – Computer Scientist

Terms and conditions and contractual agreements generally require time, high literacy skills and knowledge of legal and/or technical speak. When faced with complex information, people will generally rely on heuristics to simplify their decision making – for example, to make a decision to share their data with other parties, farmers may assess their level of trust in the service provider or the regulatory mechanisms governing the process {Payne, 1976 #4; Yaniv, 2007 #3; Regan, 2015 #1268}. Trust is influenced by many different factors including perceptions of the capabilities and motivations of the actors involved {Siegrist, 2000 #61; Walls, 2004 #854} and perceptions of transparency. Transparency in the process and being clear about the end use of farmers’ data was viewed as particularly important by our participants – for the overall success of Smart Farming:

“If there’s scandals of the Facebook type like where farmers find out that their data has been used for X or passed on to different companies or to the government then that really would dent trust in the use of these technologies.” – Social Scientist

Participants had varying thoughts on business models for Smart Farming technologies, and issues of fairness and equity arose - particularly whether ownership of data should remain with farmers who are providing the inputs for collection of data, or with industry who have built the software and technologies which enable the collection of the data. However, most were in favour of farmers receiving some form of reward for their role in this data value chain:

“I think personally that the data created on a farm should be produced in such a way that it can be introduced into a system that it can be used and analysed. It can be something that can be brought into wider platforms, either in public or private ownership. But in such a way that it can be taken out if, so they’re portable, and can be used in publicly available databases or private databases that could be run by you know one of the big technology provider companies. But farmers should retain ownership of that. And I think a business model should be developed that there is value in this, even if the value is deemed as minimal, it shouldn’t be for free. There should be a value provided for it. It shouldn’t disincentives the flow of this data but it should show that it has value and show that it will be used properly and respected.” – Government / Policy

As in the preceding quote, open source business models of data collection and sharing have been previously suggested as ways to empower farmers (or those acting on behalf of

farmers' interests) to have more say into what data is collected, how it is analysed and what it is ultimately used for {Carbonell, 2016 #335; Wolfert, 2017 #302}.

Some participants felt that whilst data ownership should remain with the farmer, a model should be constructed which still enables others to access that data so as not to prevent innovation and progress:

“A risk is stopping progress if you ban the use of data; you need variability in data which you get in huge amounts of data – this is needed to advance research and innovation, companies do need access to data. But if farmers buy equipment from a company then they should be allowed to own that – that’s a basic right; a company should not be taking advantage of this” – Natural Scientist

Amongst almost all of our participants there was a sense that the issue of data ownership is particularly grey, contested and uncertain; but that action is urgently needed – and action that is specific to the context of agriculture:

“Lots of mixed messages have come out in the media in recent times where it seems as if social media has managed to track your every movement, no matter how hard you try to prevent that - that could be a worry that, you know, do I retain control of the data and information about my farm, about my actions on the farm, my family’s, my employees or whatever. Something like using smart phones apps, that to allow the farmer to retain a level of control, that they can share what they feel happy with sharing, and I think we are not far enough down the road that we can actually do something about that at the moment. But if we just ignore that problem for another few years, for five or six years, then suddenly things get away on us, a bit like, I suppose, if you think, if you roll back the whole Facebook saga for five or six years ago, if things were, if someone said stop, can we have a closer look at what’s happening five years ago what we’ve seen in the news recently may never have happened.” - Computer Scientist

“Well I think we have to be really careful about this....I think the system is moving but we just have to, again this is one of the things we have to really try and foresee and work with all partners all around the world. Like Ireland doesn’t have to do this on its own. And we have to draw companies into this type of discussion” – Policy / Government

Anticipating Impacts and Embedding Responsivity

There was widespread agreement amongst participants regarding the need to anticipate both the negative and positive impacts of Smart Farming technologies. However, in practice, it was viewed as a particularly challenging task.

“Knowing what technologies are worth adopting I think is quite difficult. It takes about 100 years before the full implications are known by society so there’s a huge lag between something being embedded and what the implications are in terms of the social implications, the environmental implications, the economic implications so I think smart farming is quite a young technology still. The implications on farm lifestyle, on farm profits, on systems are still quite unknown.” – Social Scientist

“I think we have a duty and a responsibility to anticipate. It’s not that we’re going to stop the world of technology, we’re not going to keep the tide out. But perhaps there are preventative measures that can be put in place. To deal with the negative consequences. Or to take advantage of opportunities that may come down the line.” – Social Scientist

On the question of who has responsibility for leading work around anticipating and responding to broader impacts of Smart Farming, participants were again divided. Some felt

it was the responsibility of the publicly-funded researchers developing new technologies, although it wasn't a clear-cut issue:

“As individual scientists of course we do have a very strong ethical driver to think about the potential of what these things could do. So if you are working in genes or in automation technology you do I think have to think about what will be the consequences on rural life, on the population of the animals and so on. Now whether individuals do I highly doubt it because if we did we wouldn't be at the point we are now. Most of us scientists and technologists are driven by improving the technology. And worrying about the consequences afterwards. But certainly we should be thinking about it but I don't think we do. So we should definitely be thinking about what happens if our knowledge is used. And we do, but I think we only ever think in a positive direction. If I do this how will farmers lives be improved. We never really sit down and think okay if we do this ignoring the improvements what will the negative impacts of this technology be or this piece of information or knowledge.” - Computer Scientist

Some felt that regulators had a responsibility to consider the impacts of technologies, although again difficulties can arise:

“Well I suppose regulators are responsible for anticipating negative consequences. But all these technologies are regulated by different people, There isn't a smart farm regulator. The drone technology is regulated by the Irish aviation authority, the smart tractor is regulated by the dept. of transport. There isn't someone looking at okay what happens when you bring all these together on the farm, do you get further potential for damage or mishaps.” – Computer Scientist

On being more responsive to the needs and concerns of farmers and societal actors more broadly, participants were largely supportive of the need to be aware of societal needs and concerns; the primary driving factor for this support was the view that unless a technology is developed with the end-user in mind, it is not going to be effective or adopted:

“Well I think when developing technology we have to keep in mind who's going to use this technology and for what purpose. Part of the process of development has to include this loop that says well who's going to use this. How are they going to use it. What are going to be their opportunities, what are going to be any difficulties that they are going to experience? What are the implications for them? The process is not complete until the end user is incorporated. Whether they have an opportunity to try it out and to see and to give feedback on their impression of the technology” – Social Scientist

Different mechanisms for embedding responsiveness into the research and innovation process were suggested, primary of which was to engage and involve the farmer in some manner. When developing smart technologies, participants felt that methodologies should be implemented which involve the end-user, the farmer, in the design process {van der Weerd, 2016 #337}. This approach was viewed to ensure that the technology is compatible with both the farmers' needs and the context in which they will use the technology, as a result increasing the value and acceptance of the technology to the farmer. Different mechanisms were suggested with varying levels of engagement for this including social science research; citizen panels or forums; having farmers sitting on advisory boards; user-centred design; and informal feedback:

“I guess we being computer scientists the first thing we ask is can we do it? Rather than should you do it? That's inevitable, that's the question that's always going to be in our head. So can you have a robot that ploughs fields that's great? Technically can we do it? Brilliant. Whether that's a good thing or a bad thing and the impact of that in terms of jobs, all that stuff, that's not going to be the top thing at the front of our heads. And those things are important and if you take the H2020 EU funding I think they changed some of their rules that social science needed to come into everything. And I think that's an interesting way to do that,

and a good way to do that...so in parallel with these technical projects we have to do this other work as well and it gets done by people who know how to do that. And who are really expert in that. I think that's an interesting way to try and do that." – Computer Scientist

Beyond engagement for making technologies more user-friendly, the issue of how best to consider and respond to broader social and ethical considerations was viewed as a much trickier endeavour and it was not clear-cut as to where responsibility lay for considering these issues, but it was felt by some that the responsibility inevitably would lie with publicly-funded researchers and government. Others felt that increasing societal demand for accountability would force industry to start considering broader ethical issues:

"It's important to engage farmers just to make it more democratic. It's a difficult thing to do – like what's the right form for that and how do you go about doing that? And what's the difference in a focus group or a marketing exercise that's about making the technology fit for purpose, and it's not about ethical outcomes but about the efficacy of the technology versus having discussions about the ethical aspects of the technology. And that's not something that private companies have to do – they don't have to have to engage in those discussions whereas publicly funded research or researchers in a university setting do have more responsibility to do that. I suppose you can't compel private companies to have these ethical discussions really." – Social Scientist

"Private companies do have a responsibility I suppose, with the latest facebook think, I think they are realising that they have a public, that they are not just a platform for people to say things, that they are a publishing platform so they have a responsibility for the content similarly these companies aren't just producing what farmers want, they have a responsibility around the effects of the technology as well. And it's not just the responsibility of government that these technologies are done without having massive harm to the environment or to people because that's a massive thing for them to have to do. But I suppose companies aren't really seen as having that responsibility and it's difficult to enforce that." - Computer Scientist

Some participants felt that engagement and responsiveness needs to start earlier in the process – before a research project begins so in order to be able to make a meaningful contribution to the direction and shape of research and innovation in Smart Farming. The funding of research in the area of Smart Farming was also introduced by participants as an issue to consider, although participants held varying views on this:

"It's a question of could the research prioritisation funding process be improved, would that process be improved by including a wider set of stakeholders. The policy people would say that already exists because anyone could write in when they do their five year development, anyone could write in their objections or their opinions into the process. But that's a very passive way of getting people's opinion. So if you were concerned you'd have to do it in a more active way. Maybe I was thinking, the body that has been reviewing things for the last two or three years, the citizens' assembly, maybe there is something to be said for a citizens assembly approach to some of these issues for funding for Ireland. I can only imagine if people are aware of how much money is going on they would have their own opinions as well." - Computer Scientist

Dialogue is particularly important where the situation is characterised by complexity, uncertainty and potential political and cultural conflicts {Leeuwis, 2011 #303}, as is the case with Smart Farming. Reflexivity was an important aspect which came up in the dialogue of a number of participants discussions around responsible innovation:

"The entire agriculture innovation system, every actor involved needs to think about it from multiple different perspectives. And more than anything else we have to have empathy to understand each other's roles. We need to be able to understand. Because then we can develop solutions that will kind of fit as many

of these different perspectives as possible. And again its human nature, if people are listened to and its observed, well then there's some chance of us having an even keel when it comes to understanding or synthesising the knowledge around all of this stuff as well. So I think everybody in the AKIS has a role to play in this."
– Farming Representative

"Social scientists being embedded within bigger projects about smart farming is important and getting researchers to reflect on their own role, and their objectives and what they want to do – like in one research project, we want to do workshops with scientists about how they are going to use data and the ethical issues around it. So workshops, areas for discussion, presenting their work on these ideas around RRI to the scientists as well, things around scientific ethics and discussions around where funding comes from as well... these discussions would make them reflective about what they were doing." – Social Scientist

Interacting with farmers triggers other actors (e.g. scientists, industry) to understand potential areas of divergence in opinion with the farmer, and it reduces the risk of making incorrect assumptions about their values {Pannell, 2006 #1267}. As advocated under RRI, reflexivity also necessitates responsiveness – where technologies or research are incongruent to the values of the farmer, corrective action needs to be taken. It is argued that social and behavioural scientists may have an important role to play in this regard {Eastwood, 2017 #347}. Embedding these scientists into Smart Farming initiatives could help bring a different perspective which would encourage reflexive thinking and also facilitate the participatory mechanisms required to ensure the voice of the farmer is heard – a number of our participants found value in this approach.

Conclusion

The advent of Smart Farming in agriculture offers exciting developments but also potential challenges and risks, as is the case where any new technologies are introduced into society {Sonka, 2014 #274}. The findings from the current study can help to inform suggestions regarding good practices for future governance of Smart Farming in Ireland. Smart Farming is at an early phase of development (Kamilaris, Kartakoullis, & Prenafeta-Boldu, 2017), however reports such as the recent Teagasc Foresight exercise carried out in Ireland envision digital technologies to have a major role in the future of the agri-food sector (Teagasc, 2016). Anticipatory governance is important and the decisions that are made now will shape how smart farming is going to unfold for the years and decades to come. It is important to ensure that the perspectives of key actors in the network, in particular the farming community, are central to conversations on the development of this field {Eastwood, 2017 #347}. It is necessary to understand, acknowledge and support the decision-making processes of all of relevant stakeholders involved in making this digital revolution a reality – farmers, industry, policymakers and support organisations – so to prevent the backlash and exclusion which can often accompany the introduction of new technologies in society; and instead, promote fairness, transparency and informed decision-making. The current study highlights how a diverse range of expert actors currently view the distribution of risks and benefits of Smart Farming, along with insights on the actions and processes which will need to be put in place to ensure the responsible growth of Smart Farming in Ireland. New technologies and innovations bring with them uncertainty, risk and importantly - far-reaching and sometimes unpredictable or unforeseen impacts and social changes {Asveld, 2015 #133}. The current study is a first step in outlining how those actors working within the Smart Farming domain in Ireland are currently considering and anticipating the potential impacts of this area for Irish farming, and society more broadly.

There remains a dearth of empirical data and knowledge on farmers' explicit attitudes and behaviours in this area. future Research is needed to address this gap. Directions of future investigation include moving the field from atheoretical studies to comprehensive psychosocial models of behaviour which consider various levels of influence on human behaviour . The design, implementation and evaluation of person-centred technology development will

also be important. Both qualitative and quantitative research will be required and interdisciplinary efforts will be crucial.

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