Co-designing a smartphone app for and with farmers: Empathising with end-users’ values and needs

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A B S T R A C T

As the use of smartphone technology is becoming increasingly popular in the agricultural context, there is a need to consider how farmers have adapted to this form of technology. The current study examined the factors which influence Irish farmers’ engagement with smartphone use and new smartphone apps and explored the supports required to farmers to successfully engage with smartphone apps for agriculture use. Seven focus groups were conducted with a total of 41 farmers from four regions in the Republic of Ireland. Findings revealed that factors such as poor broadband internet availability, coupled with a lack of comfort with emerging technologies, technology trust issues, and a perceived lack of sufficient benefits deterred farmers’ engagement with smartphone technology and agricultural apps. Perceived benefits of smartphone engagement also emerged including an enhanced sense of empowerment, a more flexible lifestyle, a reduction in stress, an improvement in time efficiency, an enhanced level of communication between farmers and their respective governing bodies and, an ability to make data-driven decisions on the farm. Perceived support networks to aid farmers in using agricultural apps included farm advisors, family members and peers. The findings outline the importance of understanding the barriers and enablers of farmers’ engagement with smartphones and agricultural apps in Ireland. The findings are of interest to researchers in the field of smart farming technology, as well as developers and providers of agricultural smartphone apps, since this research is one of the first studies to provide information about the underlying factors driving or preventing smartphone and app use among farmers.

1. Introduction

Digitalisation has changed the ways in which people communicate and interact with their surroundings. Novel technologies, such as smartphones, computers and smart wearable devices have uniquely transformed how we access and share information (Fielke et al., 2019). These digital innovations affect every industry, and agriculture is no exception. Digital technology and innovation can help drive sustainable advances in labour productivity, farm incomes, food security and general economic growth, yet, these technologies are often not adopted immediately, completely or at all by the farming population (Maertens and Barrett, 2013). Transitioning to increased digitalisation involves significant social and behavioural disruption for farmers. It has been argued that ‘smart farming’ (SF) practices have a major impact on the cultural fabric of what it means to be a farmer given that SF involves less ‘hands-on’ management and instead is led by data-driven approaches, such as the use of smartphone apps and farm management and information systems (FMIS) which integrate and connect with mobile devices for easier monitoring and management, or recording and mapping technologies, which collect precise data for subsequent site-specific application (Eastwood et al., 2019; Knierim et al., 2019). As such, SF changes the workflows of farmers, affecting how and when they interact with different spaces of their farm. Different skills are also required of farming staff on farms operating SF practices, as they need to be able to adapt to SF technologies and adapted advisory structures (Higgins et al., 2017). Such changes will all play a role in farmers’ decisions to employ SF practices, given that technology can replace a farmers’ unique farm management style with a far more structured approach. Furthermore, Rose et al. (2018) found evidence that pressure to use emergent digital technologies is mismatched with the expectations of farmers about what farming is, whilst Knierim et al. (2019) reported that technology and infrastructure deficits affect farmers’ engagement with new technologies. With respect to the latter finding, Carolan (2020) recently argued that we need to think about what SF technologies do rather than fixate on what each is, while Bronson (2019) highlighted the need for a responsible research and innovation approach to guide the digital agricultural transition, to ensure that innovations are designed to deliver benefits, such as improved productivity and/or eco-efficiency that can be widely shared by respective end-users and external stakeholders of relevance. Additional research examining farmers’ SF adoption decisions has shown that factors, such as farmers’ age, education (Michels et al., 2020a,b,c), digital capability and connectivity (Paustian and Theeuwen, 2017; Baumüller, 2017), whether the technology fits to the farm (Kutter et al., 2011), or farm-related factors, such as economic

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gains (Long et al., 2016), farm size (Michels et al., 2020a,b,c; Kutter et al., 2011), or proximity to SF vendors and the high cost of many digital technologies (Reichardt and Jürgens, 2009) play a role. Indeed, understanding determinants of SF adoption is important in order to improve user-acceptance and use of technology, however, it is especially crucial that farmers can take part in the technological development process so that SF tools, such as smartphone apps, are developed and tailored to meet the needs of the end-user.

2. Smartphone and app use in the farming community

Smartphone technology and related smartphone apps are a particular form of innovation which has seen increased focus in the farming sector in recent years. In essence, smartphones are intelligent, portable devices with computer-like functions, traditional voice-call functions and internet access that offer the possibility to install or delete multiple applications (apps) according to user needs (Teacher et al., 2013). Developments in smartphone technology, access to mobile internet, and cloud services have led to an increase in the number of smartphone apps being developed and marketed to farmers to assist with the daily operational processes of a farm (Bonke et al., 2018; Rose et al., 2016), such as monitoring and forecasting agricultural performance, analysing market/weather information/data, as well as communicating with a range of stakeholders (Michels et al., 2020a,b,c). Debacke et al. (2019) also highlighted that animal monitoring apps provide farmers with essential information on an animal’s health, productivity and reproduction status, as well as their feeding and moving behaviour in real-time. A number of studies have explored the factors that influence uptake and use of software and smartphone apps amongst farmers in Europe. Rose et al. (2016) found that usability, cost-effectiveness, performance, user relevance, and compatibility with compliance demands affect the uptake and use of software and smartphone apps by farmers and advisors in the UK, while Alvarez and Nuthall (2006) reported that farmer objectives, personality, education, skills, learning style and business size influence uptake of computer-based information systems among dairy farmers in New Zealand and Uruguay. Specific to research in Germany, Michels et al. (2019) recently explored the use of herd management apps by dairy farmers and found that app functions rated as most useful included the observation of animal health, reproduction management and data gathering, while beliefs about the perceived ease of use and perceived usefulness of an app were significantly related to intention to use, which in turn influenced actual use. Interestingly, farmer’s age had no significant effect on perceived usefulness; signalling the value of exploring underlying motivations and beliefs, rather than relying on descriptive factors to explain farmers’ behaviour. Furthermore, Bonke et al. (2018) showed that German farmers are more likely to have a general willingness-to-pay for crop protection smartphone apps if they perceive them as useful for reducing externalities in crop protection and for decreasing production costs.

Research studies exploring information and communication technologies (ICT) more generally have found that inadequate computer skills, unawareness of the potential of ICTs to contribute to the farm business, and access to broadband in rural areas are the three main barriers constraining ICT adoption (Byrne and Wims, 2015). Research has also shown that different types of farmers have different ICT ownership and usage rates, with several studies showing that dairy farmers tend to be higher engagers than farmers from sectors such as cattle, sheep and arable farming (Lapple et al., 2015; Ryan et al., 2016). Moreover, Lapple et al. (2015) revealed that farm size and intensity, access to credit and agricultural education were found to facilitate ICT usage, while increasing age and being engaged in an off-farm job were identified as barriers to ICT usage and innovation adoption. Additional research exploring the role of personal information sources on farmers’ rates of technology adoption has reported that participation in formal institutions (e.g., farmers’ associations and organisations) and extension service affiliation are the most powerful determinants of farmers’ adoption of different types of innovations (Caffaro et al., 2020; Fecke et al., 2018), while Michels et al. (2020a,b,c) revealed that farmers’ colleagues have an influence on an individual farmer’s adoption decision, with respect to smartphone apps in particular. However, despite sustained interest from inter-disciplinary researchers on the use of technology in the agricultural sector, such as smartphones and smartphone apps, it has been reported that uptake amongst some, but not all, farmers is low (Mendes et al., 2020; Lindblom et al., 2017; Rose et al., 2016), particularly in older age groups (Michels et al., 2020a,b,c) and in developing countries where the use of basic mobile phones is more common than smartphone use (Krell et al., 2020). Understanding the needs and values of the end-user is a critical first step in developing successful innovations and technologies; a gap that is being increasingly recognised in the extant literature (Michels et al., 2020a,b,c; Inwood and Dale, 2019; Rose et al., 2016). Designing new technologies in partnership with farmers in a participatory manner is paramount, rather than simply enforcing such tools and expecting end-users to adopt and adapt.

2.1. Co-design processes in technology and innovation

Historically, technology and innovation trajectories often neglected to understand and account for users’ contexts, values, needs and expectations (Ingram and Gaskell, 2019). This has led to several movements within science calling for greater engagement and inclusivity of societal actors in techno-scientific progress so as to ensure moral, social and ethical values, expectations and requirements are met (Owen et al., 2012; Von Schomberg, 2013). One response to such calls has been to involve the end-user during the technology development process; an engagement that has been successfully implemented by researchers in the co-design process of new smartphone apps, for example, in the fields of dementia (O’Connor, 2020) and mental health care (Hackett et al., 2018), dietary (Luo et al., 2019) and spinal cord injury management (Amann et al., 2020) as well as physical activity promotion (Harrington et al., 2018). In agriculture, some examples of participatory user-consultation in digital development exist; however, the objectives and extent of user-participation varies. Some studies have engaged end-users through a solicitation of user-feedback about tool performance and ease of use (Rossi et al., 2014; Lefvre et al., 2014; Husson et al., 2016; Ingram et al., 2016; Rose et al., 2018). Other studies have engaged users in the core design process. For example, Oliver et al. (2017) reported on a stakeholder-driven approach to the development of a decision support tool to visualise E. coli risk on agricultural land. By using a series of stakeholder workshops at every stage of the project (conception, design, testing, and plans for continued engagement), the developers were able to design a relevant tool with strong value and usability. Stakeholder feedback was welcomed and acted upon throughout the project so that the tool could be adjusted in line with user preferences. In the design of a decision support tool for vineyard farmers in Italy, Rossi et al. (2014) found that by involving potential users during development, researchers were able to gain insights into how users make decisions and where their tool might fit in with their decision-making routines. Higgins (2007) also illustrated how participatory engagement with farmers helped with the development of a dairy planning software system in Australia. In this project, farmers were invited to workshops to input their own data and the new software was configured according to this. Farmers’ input made the tool relevant to particular users and gave the farmers ownership of the process. As a result, farmers gained validation of their knowledge and felt empowered by being included in the research. The workshops also enabled farmers to give feedback on the tool, which was taken into account and allowed for subsequent modifications to be made. These studies collectively point to the value of a co-design process during the development of new digital technologies in agriculture; however, there has been limited studies reporting on the co-design process of agricultural smartphone apps specifically.

Co-design is a process of ‘joint inquiry and imagination, involving the
organisation of iterative processes of problem setting and solution finding’ (Steen, 2015). Involving end-users in the design process is a means to increase the end relevance and value of the technology as the end-users are actively involved in designing the solutions to their needs (Macken-Walsh, 2019). This process has grown in importance over recent years as the complexities and uncertainties of innovation for addressing challenges of sustainability and technological development are recognised and addressed (Sanderson and Stappers, 2014; Storm et al., 2015). There is a growing acknowledgement that multiple actors working together to combine different forms of knowledge and expertise can create practicable solutions to such challenges (Macken-Walsh, 2019). Scholars in the literature argue that co-design processes which involve end-users, leads to the development of innovations which are more suitable, diverse, appropriate, easier to adopt and adapt to, and are more rapidly developed than innovations generated through conventional approaches (Triomphe 2012). As such, the use of a co-design process is crucial to ensuring that new agricultural innovations are successfully developed, from the perspectives of all actors involved, and most importantly with end-users’ needs, values, knowledge and experiences in mind throughout the entire process.

2.2. Study context

The current study presents the findings from the first stage of a design thinking (DT) approach used as a grounding co-design framework for the development of a geotag photo app with and for farmers and other stakeholders in the farming community (e.g. farm advisors and farm inspectors) in Ireland. The premise of the development of this technology is to reduce administrative burden for the farming community, by digitalising the existing claims process and simplify the communication process between farmers and government bodies responsible for monitoring and inspecting farming activity under the Common Agricultural Policy (CAP). The app will integrate with existing Department (Department of Agriculture, Food and the Marine in Ireland; DAFM) architecture and software to create a seamless communication between the department and end-user. Instead of sending letters, emails and other forms of communication in response to a Departmental query, the app will perform all the necessary tasks. Specifically, the technology aims to move from on-farm inspections towards enabling the farmer to upload and submit geotagged images of land/farming activity through the app. The app will, in time, through on-going development, have the ability to integrate with precision farm machinery and sensors and as such, it will play a role in reporting on smart agricultural practices in the future. The development of this app is part of an initiative in which the government (DAFM) is involved in (https://www.niva4cap.eu/). Currently, farmers submit photographic evidence via email to DAFM, with respect to farming related queries undergoing inspection. However, the European Commission is now encouraging the use of new technologies within the systems used for administrating CAP payments. New rules have been introduced to allow Member States to use geotagged photos to support current methods of checks on aid applications. Currently, there is not a definitive list of activities that should be in these photos, however, farmers will, for example, be sent a request to submit a geotag photo if DAFM has a query on land parcel activity and/or in the event of a grant submission process.

An inter-disciplinary, multi-actor team of social scientists, software developers, and government stakeholders are responsible for the development of this technology and a DT approach was implemented to ensure end-users from the farming community were also involved in the core design process. The DT model consists of five key phases, namely (i) Empathise; (ii) Define; (iii) Ideate; (iv) Prototype and (v) Test (see Fig. 1) (Kembel, 2009). The first stage, empathise, is the centrepiece of a human-centred design process, as it serves to gain an empathic understanding of the problem under investigation. This step largely involves consulting experts (end-users) to find out more about the area of concern through observing, engaging and empathising with them and to understand such experts within the context of the design challenge (Alhamdani, 2016). As such, the empathy phase goes beyond merely involving users in a design process and considering their articulated wants and needs. It is also a crucial part of the design thinking process as it allows design thinkers to set aside their own assumptions about the world in order to gain insight into the users and their needs. This paper outlines the results obtained from the first phase (empathise) of the DT approach employed for the purposes of this research study. While this initial stage is part of a broader study and used to inform the overall technology development process, the findings from this stage are also of standalone interest for the broader community of scientists and practitioners, as they give insights into the underlying motivations driving (non-)engagement with smartphones and apps in the farming community.

The development of this smartphone software takes place in an Irish farming context. Results of a recent survey suggest a growing trend in smartphone usage and ownership amongst farmers in Ireland (Cleary, 2019); however, there is a scarcity of representative data indicating the percentage of farmers currently using smartphones in the Irish farming community. In a study of Irish dairy farmers, Das et al. (2019) found a dichotomy of farmers, with some farmers indicating positive intentions to use a smartphone in the future, while others remained either sceptical or ambivalent about their use. Despite the proliferation of farming apps on to the market, research exploring smartphone and agricultural-related app usage amongst farmers in Ireland is scarce. In the studies conducted to date, researchers have focused on farmers’ attitudes towards the usage of apps and which latent factors play the most important/less of a role in the adoption process of agricultural apps (Michels et al., 2019, 2020a,b,c). In addition, Michels et al. (2020a,b,c) showed that farmers’ risk attitude and concerns about data security inhibit smartphone use intensity in terms of the number of agricultural apps used. Additional research has highlighted the types of agricultural apps that currently exist and how they can be used to the benefit of farmers (Michels et al., 2019, 2020a,b,c; Bonke et al., 2018; Rose et al., 2016; Dehnen-Schmutz et al., 2016). What is missing in these studies however, is an in-depth examination of farmers’ views and motivations underlying smartphone use, and their perceived utility and value for the farm. Instead of focusing on the promise of what smartphone technology can bring to the productivity and the profitability of farms, it is perhaps even more crucial to examine farmers’ needs and their attitudes related to digital technology, smartphones and apps. Whether, and why, farmers are willing to engage with new digital technologies, such as smartphones, is an important and timely contribution to the scholarship of SF, given that such an inquiry reflects the broader societal determinants (both the drivers and obstacles) behind the use of digital tools in the agricultural arena. Exploring the potential factors likely to shape smartphone ownership and use in phase one of the DT approach.

![Fig. 1. The five phases of Design Thinking adopted in this study.](image-url)
provides an insight on how to better develop and offer smartphone apps that are suitable to and meet the needs of farmers. Given such considerations, the current paper aimed to explore Irish farmers’ engagement with smartphone use and smartphone apps and identify their values, beliefs, needs and motivations with respect to these digital technologies.

3. Methodology

3.1. Sample selection and materials

Data were collected through focus groups (n = 7), conducted across four regions in the Republic of Ireland. A total of 41 farmers, consisting of 37 males and 4 females, took part in the focus groups. Purposive and convenience sampling techniques based on geographical location (focus groups were carried out in the East, West and South and one focus group was conducted with a young group of farmers living across all of these regions), age (cut offs: younger farmers were aged below 40 and older farmers were aged 40 and over), and farm type (dairy, beef, sheep, pig) were employed to recruit the target population. Agricultural advisors were used to recruit participants for five of the seven focus groups. The final two focus groups were recruited via convenience sampling to ensure inclusion of farmers from particular geographical regions, farm types and age categories: one focus group was organised through the researchers’ personal network and the second focus group was organised through an invite issued via a young farmers’ organisation. Details of the study and participant information sheets were sent to all potential participants. All participants had several days to make an informed decision on whether they wanted to take part in the study, and it was emphasised that they were under no obligation to do so. Upon expressing an interest in participation, respondents were provided with details of focus group dates and locations.

A structured interview schedule was used to guide the focus group discussions. The questioning sequence (inspired by Krueger and Casey’s (2014) recommendations) commenced with an introductory question, which served to facilitate open and free dialogue among participants. Once comfortable with the topic and settled into the discussion, a number of introductory, transitional, key, and closing questions were asked of the participants. Appendix A encloses the question protocol used across all 7 focus groups. Focus group questions were developed and reviewed by all members of the inter-disciplinary research team. Following two rounds of consultation, the interview protocol was modified and refined for the final version. During the consultations, some questions were rephrased for better understanding; whilst other questions were placed in a different order to enhance the interview flow. The focus group questions were developed with an aim to (1) explore participants’ perceptions of new farming technologies; (2) identify what factors influence farmers’ decisions to use smartphones and related agricultural apps (generally and for work); (3) explore what barriers and facilitators influence farmers’ adoption of newly developed agricultural-related apps and focusing specifically on the idea of the geotag photo app in particular and (4) identify what supports are required to enhance farmers engagement with smartphone apps (again, a geotag photo app in particular) for use at work. The research discussed in this article is one of the first phases of a larger interdisciplinary study that aims to develop a geo-tagged photo app for use by Irish farmers.

3.2. Data collection procedure

A qualitative research design was employed to explore the aims of this study. Focus groups consisting of 5–11 participants each, in a roundtable format, were conducted between October and December 2019. Focus groups are a form of qualitative research that involves collecting data through moderated group discussions based on participants’ perceptions and experience of a topic, predetermined by the researcher (Krueger, 2009). All focus groups were conducted by the same researcher (who held prior experience of focus group facilitation) to ensure uniformity and transparency in the interviewing style (Krueger and Casey, 2014). Focus groups were deemed a particularly suitable method of exploring the research questions associated with this study, as they create an authentic research setting that allow participants to co-construct meanings and produce multiple, and often conflicting, narratives and positions on the study topic under investigation (Krueger and Casey, 2014). Through this interactivity, a rich, in-depth understanding of farmers’ experiences and beliefs in relation to smartphone use and related apps, for work purposes, as well as an understanding of the meanings that lie behind those views was obtained (Gill et al., 2008; Morgan, 1997). Each focus group was reasonably homogeneous in nature; groups consisted of full-time or part-time farmers from the same farming sector (pig, sheep, beef, and dairy) and of similar age, in order to facilitate a comfortable setting that was cohesive to open conversation and discussion.

At the beginning of each focus group, researcher introductions were made and an informed consent form was signed by participants, with the knowledge that the discussion would be audio-recorded, and that the information obtained would be treated with strict confidentiality. Participants were also assured of their anonymity and right to withdraw, at any stage, if they felt uncomfortable or if they became distressed by any of the issues raised during the group discussion. During the session, the researcher followed the question protocol and occasionally used probing questions to clarify content or context, to deepen the perspectives voiced, and to stimulate the flow of discussion if participants’ statements were unclear or if the discourse came to a halt. Each focus group ranged between 45 and 60 min in total. Focus groups were conducted until theoretical saturation was reached; whereby, no new or relevant data were identified. No incentives were given to respondents for their participation.

3.3. Analysis

Immediately after each of the focus groups, the researcher compiled descriptive summaries of the group discussions, to capture instant impressions of the group content. Focus group data were transcribed verbatim and personal identifiers, such as names, were removed from the transcripts to protect participants’ confidentiality. Post transcription, the researchers thematically analysed the data using an inductive approach in accordance with the guidelines developed by Braun and Clarke (2012). Thematic analysis is a method of identifying, analysing, interpreting, and reporting patterns and themes within qualitative data (Braun and Clarke, 2012). The first step involved a thorough reading and re-reading of the transcripts, by both authors, which enabled them to become fully immersed in the dataset. Next, initial codes were developed and handwritten onto a separate sheet which formed the raw material for analysis. The third step involved examining the codes at first; and subsequently, organising them into broader themes. In the fourth step, themes were described, refined and defined. Next, the themes were critically reflected upon by two researchers, to ensure the data was well-represented across and within each respective theme. The final step involved selecting the most compelling quotes that accurately represented the experiences of the participants’ sampled. A thematic map was also developed to aid interpretations of the findings (see Fig. 2).

4. Results and discussion

The current analysis aimed to (i) explore Irish farmers’ views on the use of smartphones and smartphone apps in agriculture and (ii) identify the needs, values and concerns to be considered in developing new smartphone apps for agriculture use. When we mention smartphone use in the following section, we do not mean that farmers are referring, at all times, to their own personal use of smartphones (although when they do, we explicitly highlight this), rather we are showcasing their general views of and reflections on smartphones and smartphone/app use for
Overall results from the study showed that a majority of farmers do not use new farming technologies (in particular, smartphones) for the purposes of work, largely due to perceived lack of capability and confidence to engage with new technologies. However, younger farmers, who declared they used smartphones, were particularly open to and confident about their use and the use of agricultural apps for the purposes of work. From the thematic analysis conducted, a total of seven overarching themes and thirteen subthemes emerged from this study (see Table 1 for breakdown). The first four themes and related subthemes are linked to farmers’ perceptions of smartphone use for agricultural purposes in general, while the final three themes (themes five to seven) and related sub-themes are specifically linked to farmers’ perceptions of a geotag photo app for use on smartphones. With respect to the latter three themes, farmers were asked to share their views on the potential introduction of such an app, how they might respond to it and what features/functions the app would require in order for it to be well-adopted by and adaptable to the farming community, as a whole. 

<table>
<thead>
<tr>
<th>Levels</th>
<th>Smartphone Users</th>
<th>Smartphone Non-Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Who?</td>
<td>Currently using</td>
<td>Open to use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not open to use</td>
</tr>
<tr>
<td>2: Why?</td>
<td>Positive about all technology in farming</td>
<td>Open to learning No access to a smartphone</td>
</tr>
<tr>
<td></td>
<td>Enhances farm work &amp; QoL</td>
<td>Appreciate benefits No perceived value</td>
</tr>
<tr>
<td></td>
<td>Reduces labour costs</td>
<td>Currently lacking in technological self-efficacy Strong fear/trust issues</td>
</tr>
<tr>
<td>3: Implications for new apps</td>
<td>Will be open to trialling May trial new apps if Unlikely to use</td>
<td></td>
</tr>
<tr>
<td></td>
<td>new apps if they are user-friendly</td>
<td>shown how and supported in their use</td>
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Fig. 2. A thematic map reflecting the landscape of smartphone and app use amongst Irish farmers and the key factors shaping motivations.
thematic map was also developed to further illuminate the landscape of smartphone app use (motivations for/barriers against use) amongst farmers in Ireland (see Fig. 2). The findings are grounded in the participants’ discussions of smartphones and apps broadly, and also their discussions around a geo-tagged app for farm inspections specifically.

4.1. Theme 1: farmers’ general attitudes towards smartphones and apps

Pro-tech: Of the seven groups who participated in this study, one group self-identified as being smartphone users and completely supportive of the role of smartphones and apps in farming. This group comprised of 11 young full-time farmers; 8 of which were male and 3 of which were female. Detailed accounts on their current use of technology for the purposes of work and their favourable experiences with using such technologies were given. Similar to other studies (Michels et al., 2019; Dehnen-Schmutz et al., 2016), farm management tasks, such as record-keeping, farm-mapping, developing diet formulations for livestock, calf-registration, herd management, as well as social networking, were highlighted as some of the key activities that this group perform through the use of smartphone technology. The following excerpt demonstrates how smartphones positively influence day-to-day agricultural activity amongst young farmers in this study:

“It (technology) makes our life easier as farmers really, a lot of the stuff that’s available at the moment”

Open to change: Despite past reports that uptake of SF technologies, such as computers and smartphones is still low on many farms in Ireland (Dillion, 2018), our study revealed that some of the farmers, who declared that smartphone use was not a habitual norm for them, were open to learning about and using one, if shown how. Many of these farmers expressed that they became open to the advantages of smartphone and app use, despite their uneasiness in doing so, because it will be “forced” upon them in time. This finding carries implications given that prior quantitative research exploring the factors that influence farmers’ uptake of Electronic Information Technology (EID) in England and Wales reported that those who feel under pressure to adopt EID are significantly less likely to do so than those who do not feel under pressure to adopt EID (Lima et al., 2018). Furthermore, the Technology Readiness Index paradigm (Parasuraman, 2000) argues that feelings of insecurity towards a technology acts as an inhibitor of acceptance and has a negative relationship with technology adoption (Godoe and Johansen, 2012). Considering this, governing bodies need to alleviate farmers’ insecurities about smart technology by training and teaching them how to successfully engage with, for example, smartphones for work purposes, so that they and their farming activity can benefit from its (future and continued) use.

“Yea sure we would have no choice, you know it’s (smartphone technology) going to come, it’s there already sure.”

Traditionalists: As agricultural technology evolves, this study demonstrates that, while some farmers will readily accept and adapt to this transition, others will have concerns (as evidenced in this sub-theme) about such a paradigm shift. In line with prior literature exploring how technologies change the material nature of farming on an individual farm basis (Rose et al., 2018), many older farmers declared that they did not own or use a smartphone and were not open to the use of new farming technology, such as smartphone apps. This group of farmers declared that they did not perceive smartphones to be of value, were more comfortable with operating their farm in accordance with traditions long followed (e.g. manual documentation of farming activity), were not satisfied with app developers profiting from their data and were happy to rely on someone else to operate a smartphone or smartphone app on their behalf, if required, rather than learning how to use the technology themselves. This finding clearly indicates that technology acceptance and uptake is complex amongst certain groups of farmers, tensions across farmer’s views of smartphone use for work purposes exist, and that farmers themselves may represent a barrier to technology adoption, demonstrating that internal factors may, at least, be as important as external ones. With respect to our findings, it is evident that much work is required to open up a conversation amongst the farming community regarding the appropriate use of smartphones for farming, transparency of data use resulting from smartphone engagement and changes which may be brought about by digital trajectories, reflecting on unintended impacts which could arise. Further, acquiring adequate knowledge of farmers’ inherent attitudes, values and beliefs related to technological innovation is crucial to fully understand what tensions may exist or arise for farmers in the context of digital agriculture, so that they can be considered by researchers and technology developers throughout an innovation process.

“Well we’re doing fine, we are getting there without them (smartphones), how more can I explain that, why use an app when you can use a book, maybe I’m prehistoric in that way but, you can revert back to the book.”

4.2. Theme 2: value propositions - smartphone app usage

Improves QoL: Results of this study demonstrated that specific value propositions motivate farmers, who currently own and use a smartphone, to engage with agricultural apps. Many expressed that smartphone apps help to reduce feelings of stress and exhaustion that accompany the task of doing paperwork, enables them to manage their time more efficiently and lead a more flexible and balanced lifestyle; all of which were perceived as having a positive influence on QoL. In a recent qualitative study exploring the perceived risks and benefits arising from the development of SF in Ireland, Regan (2019) reported that key decision makers and governance actors believe that SF technologies allow farmers to manage their time more efficiently, lead a better work-life balance and enhanced QoL; perceptions that were clearly echoed by farmers themselves in the current study, thus extending this body of work. Other users welcomed not having to worry about postal loss fears when submitting paperwork via an app, and being in a position of greater control over how one’s day unfolds (doing what one wants, when one wants), due to the freedom afforded by a smartphone. For example, one farmer shared his experience of being able to control farming activity on the smartphone, at a distance from the farm, whilst working part-time elsewhere. Consistent with the Technology Acceptance Model (Davis, 1985) which argues that perceived ease of use and perceived usefulness are key predictors of technology adoption, and to
other reports on app use (Michels et al., 2019) and EID technology (Lima et al., 2018), factors such as practicality, ease-of-use and usefulness were listed as key drivers for choosing to engage with certain agricultural apps amongst the younger farmers in this study. Younger farmers also favoured apps that were compatible with their existing farming operations, equipment, and work routines; a finding that has been shown to have a significant effect on farmer perception of ease of use of technology, and indirectly on technology adoption (Aubert et al., 2012). Older farmers did not contribute much to discussions about their preferences for choosing specific agricultural apps or perceived favourable app features due to their declared lack of engagement with these apps. In light of this, going forward, governmental messages focusing on the beneficial effects and the ease of use of smartphone technology, as well as the usefulness of agricultural apps should be directed at older farming cohorts in order to strengthen technology uptake amongst this group of farmers in particular.

“Sure do you know touch of a button there you have a lot of useful information to know about your cows, about your herd, what’s going on kind of thing. And I suppose using your app, whatever it is for recording… I suppose basically. It makes life an awful lot easier and you can have it done registering calves. Have it done there, a couple of seconds and there’s no sort of running out of paper, wondering did you put it in wrong, what did you do like. Sending off photos into the post box and that sort of thing.”

Facilitates Data-Driven Decision Making: A recurrent view among the younger farmers, who reported regularly using agricultural apps, was that smartphones apps provide a platform through which up-to-date information can be sought, agricultural predictions and economic monitoring performed, and benchmarking against others established; views that corroborate findings in the current literature (Michels et al., 2020a, b, c). Some believed that such activities directly lead to an enhanced level of farm efficiency and profitability, and thus, allow one to become a better farmer, overall.

“In terms of monitoring economic performance as well. You have a better handle of your inputs, what’s going in on the farm. So you might identify something, but without that technology you might not identify them, wasting money on this. So I can have a look at this and alter your farm practices altogether, thanks to technology as well.”

In line with Identity Theory, which postulates that a person’s identity can influence their attitude and that these identities can influence behaviour (Stryker and Serpe 1982), results of this study revealed that not all farmers held the belief that smartphones give rise to one becoming a ‘better farmer’ – a view that was common amongst those who declared that they did not use a smartphone for agricultural purposes. Unlike prior reports that have shown that farmers engage in new agricultural schemes in order to be seen ‘to be doing the right thing’ (Mills et al., 2017), some of our farmers instead expressed that a good farmer was one whom was out ‘walking his field’, knowing ‘what is happening around him’ and was not distracted by or engaging with a smartphone when conducting and fulfilling farming tasks. Although it seems, based on this finding, that the farmers in our study were somewhat influenced by psychological factors and cultural beliefs, research has also shown that farmers tend to be strongly influenced by perceptions of what constitutes ‘good farming’ amongst their farming peers (Cullen et al., 2017, 2020). More work is needed however, to fully explore and understand the link between farmer identity and the manner in which it affects whether and how individuals engage in smartphone/agricultural app use for farming activity.

“It’s better to be walking across your field looking at what’s going on in the field rather than looking at smartphone, which you see most people doing if they have a smartphone, I’m sure we all have smartphones now but like leave them in your pocket. Look at your environment, know what’s about. If the app says everything is okay in the field, is that okay? That would be my thinking now.”

Promotes social interaction: Socially connecting and interacting with other farmers, nationally, was considered a key benefit of the smartphone by younger users in particular. Participants claimed that they engaged in social processes, such as peer modelling, peer observation and peer support, via the smartphone device. Some mentioned that smartphones have made it more accessible, for them, to seek support from other farmers, in a “Q&A” style of contact, via social media platforms. Furthermore, others expressed that observing the types of farming practices used by other farmers, via Instagram, YouTube or Twitter, reassured them of their own farming practise or encouraged them to employ similar codes of practise on their farm. Previous research on the adoption of SF technologies has attributed a major role to the exchange of information and experiences among farmers (Feck et al., 2018; Pignatti et al., 2015; Marra et al., 2010; Reichardt and Jürgens, 2009). Likewise, Brudermann et al. (2013) confirmed the relevance of social networks between farmers as a driver for the adoption of photovoltaic plants in Germany. The current study however, further highlights that the use of smartphone apps, in particular, provide farmers with an additional forum of communication through which inter-farmer advice and support can be readily accessed and used in order to solve respective concerns about new farming technology and/or other farming-related queries.

“Yea in general there’s been a big change, like towards Instagram and things like that. People just learning from other farmers. And you can just; a lot of them would put up what they’re doing day to day. And asking questions, where if you didn’t know why a cow was doing something, you put it up and someone else maybe in the north has an answer for you, things like that. That’s becoming very popular.”

4.3. Theme 3: self-efficacy

Technological capital, proposed by Carlson and Isaacs (2018) highlights that an individual’s ability to benefit from their technological history consists of four factors: awareness, knowledge, access, and technological capacity of the user’s social collective; in our study, we observed evidence of a divide emerging with respect to similar factors, such as age and self-confidence related to digital literacy levels, as well as infrastructure available to individual farmers and farms. Specifically, results showed that there is a difference between age and ownership of smartphones and the usage of agricultural apps amongst farmers living in the Republic of Ireland. This trend is no different to what has been shown in the general farming population internationally (Michels et al, 2019, 2020a, b, c; Bonke et al., 2018) and in Ireland (Cleary, 2019; Byrne and Wims, 2015; Lappel et al., 2015) in that younger farmers are more likely than older farmers to own and use a smartphone, generally, and for farming activity.

Self-Confidence: With respect to self-confidence, our results also corroborate recent research that has shown how lower levels of digital skills disempower farmers and impact their capacity and confidence to adopt emerging technologies (Barnes et al., 2019; Saleimink et al., 2017), such as smartphone apps (Michels et al., 2020a, b, c). In the current study, farmers who did not use a smartphone openly expressed that they were more comfortable sticking to the traditional methods of conducting their farming-related tasks (e.g. submitting paperwork via the post, keeping record of their activities in a paper based journal, storing physical copies of receipts at home) as they lacked confidence in operating smartphones and agricultural apps due to low levels of digital literacy and fear of technology. Likewise, Lima et al. (2018) reported that a majority of farmers use a notebook/diary to record farm information, while a relatively smaller percentage use a smartphone to conduct this task. A particularly novel finding in our study however, was the sense of distrust that farmers held towards technology (technology
breakdown/unreliable) – a finding that was recurrent amongst non-users. Prior negative experiences (e.g. smartphone breakdown and subsequent data loss) appeared to give rise to farmers’ sense of distrust in our study. In contrast to other identified barriers, such as a lack of technological self-efficacy, the issue of distrust has perhaps received comparatively less attention within the agri-smartphone use literature to date. This could stem in part to the predominant focus in the literature on identifying demographic trends that are associated with smartphone use among farmers; our study points to a need to move beyond such factors and instead work towards further understanding and addressing farmers’ sense of distrust in using smartphone technology and agricultural apps for work purposes. It is also possible that the feelings of distrust evident in this study were compounded by a lack of recognition of farmer’s own forms of expertise and experience in the design of new technologies. One way to negate these negative feelings of distrust is to give farmers more ownership over innovation design processes, such as the development of agricultural apps, rather than using top down measures which farmers might find problematic. Co-producing smartphone apps with farmers may in turn enhance farmer’s capability in the use of apps for work and is likely to enhance both farmer’s trust in technology and its subsequent adoption.

“If you’re dependent on the phone, I had problems when the phone just went dead and I lost everything, that’s one thing that I’d prefer to have the paperwork rather than depending on the phone. And it has happened me twice and I lost valuable information. So I don’t have the confidence of the phone.”

Some farmers, who did not own or use a smartphone, felt personally responsible for their lack of self-confidence in using technology. Some declared that they have ‘buried’ their ‘heads in the sand’ with regards to learning how to operate a smartphone. They also mentioned that a requirement to train farmers, especially those from an older generation, on the use of new technologies is needed, in order to enhance confidence levels and promote use. Comparisons with other farmers, particularly those from younger generations and specific farming sectors, as well as farm inspectors, also reflected their lack of self-confidence with technology use. Older participants claimed that younger farmers were at a technological-advantage, as they have been born into an era of technologies. One way to negate these negative feelings of distrust is to give farmers more ownership over innovation design processes, such as the development of agricultural apps, rather than using top down measures which farmers might find problematic. Co-producing smartphone apps with farmers may in turn enhance farmer’s capability in the use of apps for work and is likely to enhance both farmer’s trust in technology and its subsequent adoption.

“I definitely think you’d have to train people first, the majority of farmers in this country are elderly and they’re not au fait with modern technology and you know you’d need to have somebody younger doing it for them or get training to learn how to do it themselves.”

4.4. Theme 4: accessibility

Cost & Internet connectivity: A number of preventative factors that appeared to be beyond the control of farmers were alluded to, with respect to smartphone technology use, by both users and non-users. Factors such as, poor internet connectivity in rural communities and the cost of smartphones were raised as key preventative factors by participants in this study. Relying on local establishments (e.g. pubs, shops) in one’s residential town/village or on nearby neighbours for internet connection was a common occurrence for many of the users. The cost of smartphones was also given as a reason for not adopting the technology, by those who declared that they did not own a smart device. Some of the non-users also stated that the risk of breaking an expensive smartphone outweighed the benefit of having one at all. A cheaper phone was perceived as being much more appealing, as the risk of it being stolen is largely minimised due to its undesirable and outdated nature. Some of the non-users also expressed that being in possession of a more traditional style of phone renders them less liable to bear the cost implications associated with the breakdown of an expensive smartphone device. Furthering concerns around digital inequities and deepening digital divides, our finding that farmers still have a demand and need for faster internet in rural areas corresponds to other reports in the current literature (Michels et al., 2020a,b,c; Rose et al., 2016). Without functioning mobile coverage, the idea of smartphone apps may be perceived as redundant by many farmers.

To address deepening digital divides brought about by digital literacy and access, responsive action is required. Sufficient public access to and support in the form of material resources and training needs to be provided for certain groups of farmers so that they are less likely to be and/or feel (further)/marginalised across the agricultural sector. Policy makers need to consider placing a higher focus on developing mobile internet coverage in rural areas, and app developers and providers need to consider designing offline options when developing apps, so that farmers lacking internet access can equally benefit from their use.

“I’d be using just the phone, I don’t have, you have to have a special laptop to be able to get into the Department of Agriculture and don’t have that or didn’t have great coverage one time and abandoned it, be wasting so much time waiting for it to come up. Lost interest in it then.”

4.5. Theme 5: socio-cultural beliefs

The current theme, the remaining themes and sub-themes that emerged from this study are specifically linked to farmers’ perceptions of a geotag photo app for use on smartphones. These themes highlight the need to not just understand end-users’ needs and values in relation to a technology; but also to understand their views in relation to specific contexts and purposes of use of a given technology. One aim of the geotag photo app, being developed as part of this study, is to improve the communication process between farmers and their respective governing body. As such, much of the conversation in this theme reflects the socio-cultural beliefs that emerged with respect to this interaction.

In line with prior reports (Oreszczyn et al., 2010; Hall and Pretty 2008), farmers did not always consider their governing body to be a trusted source of advice, and felt that the relationship between both parties was constrained. Many of the farmers shared similar experiences of being passed from one governing staff member to the next, when attempting to make contact regarding a farming-related query. The issue of inconsistent staff working for and/or a lack of response obtained from the national farming authority seemed to stir feelings of dissatisfaction and mistrust among the participants in this study. A lack of control over the communication process contributed to this frustration. In particular, farmers mentioned that they often had to call the national governing body during a 9am-5pm time-window; a period they deemed unsuitable to them due to the busy nature of their own farm work. They also expressed a sense of frustration when they had missed a call from national farming authorities, as they judged it unlikely that they would receive a response when an attempted call back was made. Based on these findings, we argue that if the governments’ objective for an enhanced communication process is to be achieved via the geotag photo app, the views and voices of farmers who participated in this study should be accounted for, valued, and acted upon, prior to and once the app is developed and deployed.

In addition to the communication issues, farmers voiced personal fears regarding farming inspections. A perceived lack of control over the farm inspection process appeared to give rise to feelings of fear, as
farmers felt that an inspection weighed heavily on the ‘mood’ of the farm inspector, on a respective inspection day. To them, the implications of this were extremely high, as their livelihood depended on the single farm payment granted, on the basis of a positive farm inspection outcome.

**App Improves Communication:** A shared hope across all focus groups, that a geotag photo app could improve the current communication inefficiencies between farmers and their national governing body, was expressed. Many of the participants delineated how they would benefit from a more efficient communication process including: (1) applications would be processed, decisions would be made and payments would be granted in a speedier manner; (2) reduced stress (due to a reduction in paperwork burdens); (3) reduced fears in having to communicate with the governing body; (4) increased motivation to apply for grants; and (5) reduced delays in responses received from the governing body (due to the app being able to capture a real-time process and thus a more instant form of communication).

“I just find that it’s kind of frustrating when you’re trying to get through to the department and you’re there for a long time. And you’re credit runs out and they don’t get back to you and you’re doing. You’re getting on to them the following day, so if you had your little app, you send you’re whatever you have to send. And you wait until you hear from them. That’s going to simplify things, speed up the job as well.”

**App Empowers Farmer:** Likewise to other studies (Agyekumhene et al., 2020; Vijayasekar, 2018) a welcomed sense of empowerment, afforded to farmers through the use of an agricultural app, was a common viewpoint shared amongst participants in this study. Many expressed that using a geotag photo app could eliminate human bias, given the neutrality of its design (photograph submitted will either be ‘right or wrong’). They were also particularly positive about the sense of freedom a geotag photo app would create, in that photographs could be taken at a time most convenient to them, as opposed to being under the scrutiny of a farm inspector during an ad-hoc farm inspection. This seemed to be of particular importance, as there was a sense amongst participants that they valued being able to structure their day in accordance with times that best suited them and their farming tasks at hand. Others also mentioned that a geotag photo app would provide them with an opportunity to develop an evidence trail of their farming activity. The ability to take and store photographs of farming activities conducted on the farm and supply them to the national governing body with their respective time stamps, was considered a particularly attractive potential app feature, among the participants. Additional positive perceptions of a geotag photo app, such as being able to store all paperwork in the one place and reducing the number of potential farm inspections (yet not completely eliminating their occurrence) were expressed.

On the other hand, however, some held negative perceptions of the potential introduction of a geotag photo app; in that it will not benefit them, lead to an increased incidence of self-implication (photograph displaying something undesirable on the farm) and/or farm monitoring. This finding extends the work of Kutter et al. (2011) which explored farmers’ communication and co-operation strategies in the adoption of Precision Farming and their relation to farm attributes. Results revealed that several experts (employees of agricultural technology firms related to PF, experienced researchers, staff members of the farmer union in the field of crop farming technology, governmental and private agricultural consultants, and farmers) do not feel that older farmers consider the online submission process of farm documentation to be of benefit to them, and that such farmers are, in many cases, against submitting sensitive information through this means.

We acknowledge that it is a challenge to change an individual farmer’s deeply-held values and beliefs. However, as previously documented (Sutherland et al., 2013), change can occur through extended periods of personal interaction with a known advisor and/or peer group and, can lead to a building up of trust over time. Further, the higher the credibility of the advice source, such as people from farming backgrounds or trusted networks, the higher the persuasion factor will be (Blackstock et al., 2010). As such, we argue that trusted advisors are availed of once the app is developed and deployed, to not only offer help to farmers on how the new app can be operated, but also to communicate the genuine benefits that can be reaped, on and individual level, by engaging with it for future farming activity.

“Like the thing about it is like, if it came in like it eliminates that whole, what kind of an inspector am I going to get, like do you know. Like there’s, like I seen it with my father at home like he was terrified of inspectors. And we were doing nothing wrong. But he was afraid to move cups on the table because Jesus if an inspector came in and seen this or whatever. But he was paranoid about him. And it stopped him from progressing on as a farmer. Whereas I suppose it just, I have confidence with what I was doing on the farm or whatever. And it’s just; it would eliminate that kind of person in a bad mood I’m going to do a farmer mentality that certain farmers have like. There is a fear factor with the department that you know they could take (the single farm payment). Because there’s so many farmers that are dependent on the single farm payment as their livelihood. You know, if, it’s just I think if you get into a technology where you’re right or wrong, you know what I mean. It’s not down to this guy (inspector) you know.”

### 4.6. Theme 6: keys to success

Throughout each focus group, farmers instinctively described and offered suggestions for what they felt a successful geotag photo app would look/feel like to them, as end-users. They deemed that a number of ‘ingredients’, with respect to app function, content and design are needed in order to develop an app that will be well-adopted by and adaptable to farmers. Also highlighted across all smartphone users and non-users was the view that farmers need to be sufficiently trained on the use of a new geotag photo app in order to enhance its ultimate success.

**User-centred Design (UCD):** Technology development has often been dominated by top down, non-inclusive approaches, rarely including relevant stakeholders, such as end-users, at an early stage (Owen et al., 2012). Inclusion of stakeholder perspectives in technology development studies in particular, has been suggested as a method for improving stakeholders’ trust in the innovation process (Asveld et al., 2015) and supporting the development and spread of technology that is appropriate and accessible to them (Jones et al., 2014). In particular, a UCD (Gulliksen et al., 2003) captures and analyses the preferences and needs of anticipated end-users of a product or service early in the process, in order to maximize usability. The future users of the service (e.g. farmers, advisors) are involved in the design process, including in the specifying the problem, selecting partial solutions and providing inputs for refining a viable new tool or service through iterative trials. Previous research has demonstrated that the use of UCD leads to the successful development of novel smart farming tools (Ortiz-Crespo, 2020), however in our study, it is interesting that farmers, themselves, expressed that the success of the geotag app would be dependent on the use of a UCD approach at the stages of pre- and post–design, as well as expressing users in the initial launch (short window) period. To our knowledge this is one of the first studies whereby farmers alluded to the importance of UCD in developing agri-technology.

Interestingly, participants expressed views on what a favourable app would look like, and mentioned design features such as, simplicity, user-friendliness, offline options, auto-recognition, support chat boxes, verification checks, back-up systems and data security measures (verification log-in). Similarly, Rose et al. (2016) emphasise, based on qualitative interviews with farmers, that smartphone apps for agricultural purposes should be simple and user-friendly, whilst Michels et al.
(2019) showed that dairy farmers’ perceived ease of use has a positive effect on the frequency of dairy herd management app use and more recently, that if farmers perceive the usage of agricultural apps as relatively effortless, they have a higher intention to use them (Michels et al., 2020a,b,c). Farmers in the current study also listed the features they would render the app unsuccessful, such as poor design, information overload, repetition, errors within the app (technical mistakes), a lack of understanding on how to use the app, lack of transparency when issues arise (e.g. if app is closed down, users need to be informed of why and when it will re-open) and complexity. There was an element of fear regarding complexity in particular; as some of the participants who currently use agricultural apps expressed that they have experienced difficulties with the use of such apps in the past, due to the complexity of their design and overall nature. The perceived (un)/desirable app features are apparent across the quotes below:

“It needs to be friendly; like it needs to be user friendly and I’d say like a pilot programme to launch it or something. Like there’s not, it’ll fail completely if the first twenty farmers that use it and it’s a disaster. Because they’ll talk to the twenty lads in the mart, twenty lads in the co-op.”

Training and Support: Beyond desired interface and usability features of a technology itself, it is also important to be cognisant of the context within which a technology is being introduced. Farmers in the current study highlighted the need to support farmers on how to use the app in a targeted manner (e.g. deliver training to those with poor IT skills, separate to those with advanced IT knowledge) in order not to frustrate group members, and to deliver streamlined training sessions. Similar to Michels et al. (2019), training sessions in the form of workshops and smaller group discussions were considered an effective method of delivery. Recruitment of speakers who have previously designed good apps to deliver the training was also mentioned, as well as virtually delivering training via channels such as YouTube; strategies which have been shown to be successful in the past (Wright et al., 2018). Furthermore, the role of farm advisors in equipping farmers to navigate the new app was raised. Farm advisors are known to be important in digital innovation (Eastwood et al., 2017; Kivima et al., 2019), as they work to mediate between farmers and new sources and types of information, skills and technical devices in farming. Given this finding, we contend that, going forward, there is a unique aspect to the digital innovation work of advisors in equipping farmers with the knowledge and skills needed to use the new app being developed as part of this study.

Peer-to-peer training was also considered an opportune method of mentoring farmers on the operations of the new app. There is evidence that messages passed through a group can create a positive social norm (if most farmers in the group take up the message). Through group sharing of information and best practice with their peers, perceptions of what is deemed appropriate behaviour become more accepted and this increases feelings of personal responsibility (van Dijk, 2020). However, for advisory approaches to work at peer-to-peer level, an understanding of who is in the farmer’s network (their reference group) and whom they trust is first required.

Finally, participants also expressed that there would be a need to train farm advisors and staff at the national governing body to ensure that a speedy submission and review of applications can take place (with some suggesting a need to move towards artificial intelligence/machine learning in the future). There was a feeling amongst the group members, that supplying the technology alone is not enough; this needs to be matched with an efficient level of manpower supplied on the administrative side, to review submissions and ensure efficient processes. This was viewed as essential in order to instil confidence amongst the end-users in the overall process. This finding points to a solution which is required outside of the technology development itself, to ensure that governmental staff are trained and supported to efficiently process applications so that farmers trust this new means of technological communication and that past socio-cultural beliefs around inefficiencies can be overcome.

“The thing with the training or workshops is you want to have people with similar computer skill level at the one training. Because if the likes of us here, we’ve got enough knowledge of how to use apps and stuff. With older people either we’ll be going too far ahead of them, or they’ll be holding us back. And one group will lose interest.”

4.7. Theme 7: Digital divide

Inequity concerns: There was a clear digital divide across the participants in this study; an implication they perceived would influence the (non-)use of the app. Some farmers were extremely aware of how to use a smartphone and related apps, whilst others claimed that they had either never owned a smartphone, do not plan to own one, or do have a smartphone, but only use it for basic purposes (e.g. making a phone call).

“Well I suppose if the iPhones are too complicated for them to use, some of them that could be a factor. You’d see some phones and have so many icons on it. You’d hardly know what to press, so if lads are not comfortable with the phone in the first place, then they mightn’t be comfortable.”

The earlier inability or lack of confidence to use smartphones had direct implications for how farmers viewed their own personal engagement with the proposed geotag app. Some of the non-users declared, with little concern, that they would have to simply rely on others to perform the geotagging photo activity for them; whilst others expressed annoyance at being left with no choice but to rely on others, once the technology is ‘forced’ upon them. It was also discussed that not all farmers would have this required form of social support to rely on, and thus could be isolated or marginalised as a result of the introduction of such an app. Old age and living alone were considered as particularly vulnerable demographics for this potential marginalisation. Our findings clearly thus demonstrate that some farmers feel that a move towards digital monitoring is occurring at the expense of farmer equity and fairness. In light of such views, we argue that while the digitalisation of agriculture is promising for many farmers, it may also lead to an increased rate of marginalisation and exploitation of farmers who believe they do not have the capability to adapt, or who are unwilling to adapt to new technologies. Given this, several social questions arise that require further consideration, including (i) how will the new app impact rural communities in the future? (ii) who exactly is able to access the opportunity of farming differently via the use of the new app, and who is not? (iii) will the new app restructure farming activity and labour in agriculture for better or for worse? and lastly, (iv) how can policy and research help support more equitable app development for the perceived (by farmers) marginalised groups in this study? Such questions form the basis of continued end-user engagement in the Design Thinking study, and highlight the value of reflecting on different perspectives during the technology design process.

“I suppose first of all a lot of farmers wouldn’t know how to find it, you have to search to find the app and download it. That would be a start, if you started and then after that whatever you have to do to use it be it out in the field or whatever.”

5. Future research directions

Based on the current study findings we argue that various starting points for further research can be identified. Future research should focus on quantifying findings identified in this study with respect to smartphone use for agricultural activity, in order to fully explore their level of significance relative to one another, including for example,
exploring the extent and range of potential digital divide impacts. Moreover, this study was conducted with farmers in the Republic of Ireland, thus, an opportunity to repeat it in other countries should be considered, since the importance and magnitude of the individual factors identified may differ with respect to smartphone and agricultural app use amongst farmers living in different regions. Finally, given that developers of smartphone apps mostly address the functionality of the system and the visualisation of data, little attention is paid to the user’s needs (Resch et al., 2014). We suggest that future research and development of agricultural tools should ensure that user needs, preferences, skills, and capabilities are taken into account and focus on co-creation and co-development approaches for the design of new agricultural technologies. If agricultural apps are designed in a user-oriented manner farmers will be empowered to use them independently, without the need for facilitators.

6. Conclusion

The current study reports the findings of the empathise stage of a DT approach used in the development of a geotag photo app to reduce administrative burden for and simplify the communication process between farmers and government bodies responsible for monitoring and inspecting farming activity under the Common Agricultural Policy. Initial engagement with target end-users – farmers – was enabled through a series of focus groups which allowed the inter-disciplinary team to hear from and understand the problem and technology under investigation from the perspective of the end-user. Setting aside prior assumptions and engaging with the end-user in such a manner allows the technology process to progress in a trajectory which will be more cognisant of and responsive to the end-users needs, wants and concerns. The current study reports only the findings from a single point engagement reflective of the first stage of the DT framework, and subsequent learning’s and reflections from further and continuous multi-actor engagement which took place in this project will be reported elsewhere (forthcoming). The project team in the current study considered the user-centred approach crucial to openly and actively obtaining critical input from farmers on the app development process and encouraging transformative mutual learning between farmers, researchers and app developers. Rather than being merely treated as recipients and beneficiaries of the new technology, farmers in this study were considered important actors who would ultimately influence and provide key inputs to the app development process.

To conclude, this study provides a greater understanding of the adoption and use of smartphones and smartphone apps by Irish farmers. Results revealed that smartphone usage varies across different farming sectors and ages; and apps that are simple and effortless to use, accessible to and understood by all and free from technical error are considered most attractive by farmers. As such app developers and providers should focus on these functions for future development of agricultural apps. Since not all farmers in this study used smartphone apps, there is potential for increasing the adoption and usage of the device through effective training and marketing; for which the results of this study can be used. In line with that, the provision of information about and training on the use of apps should be kept as simple as possible to make them as attractive as possible for farmers, regardless of educational background, IT skill and previous knowledge on app use. Lastly, the use of a user-centred design to enhance the capacity of all farmers to participate in, contribute to, and benefit from agricultural innovation development is essential; as demonstrated by the results from phase one of the DT Approach employed in this study. The DT approach we used not only encouraged us to think of what agricultural apps are used for, but also, who they are serving, and who is driving the process. We believe that after the first step in the DT process (the current study), we can now move towards the second phase, which is focused on engaging farmers in additional participatory activities (workshops) to further provide a platform for farmers to share information and interchange ideas on how to better design the app for eventual use, once deployed.

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Authors statement


Declaration of competing interest

None.

Appendix A. Focus Group Question Protocol

1. Can you explain how aware you are of new farming technology?
2. How do/would you feel about using new farming technology?
3. What particular experiences have made you feel this way?
4. For what types of farming activities would you be most comfortable using technology?
5. What is your opinion on Smartphones?
  ➢ Do you use a smartphone for farming activities at work?
  ➢ If yes, what type of Smartphone do you use and what exactly do you use the smartphone for?
  ➢ If no, why do you not use a smartphone for the purposes of work?
  ➢ What influences your decision to use/not use a smartphone for farming activities?
6. How comfortable are you with using smartphone apps?
7. What agricultural related smartphones apps are you familiar with, if any?
  ➢ How did you become familiar with this/these apps(s)?
  ➢ Do you like/not like about this/these app(s)?
8. What would you think about a smartphone app being used to reduce the paperwork associated with scheme applications?
9. What factors would encourage you to use this type of app?
10. What would prevent you from using this type of app?
11. What training do you think you would need to use this type of an app?