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Exploring the spatialities of technological and user re-scripting: The case of decision support tools in UK agriculture

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ABSTRACT

The use of decision support tools on-farm may help to deliver evidence-based guidance to farmers, helping to improve productivity and prevent environmental degradation. While much research has sought to increase the uptake of decision support tools in practice, largely by identifying desirable characteristics of system design, rather little work has used a spatial lens to investigate *how* they are actually used. Using Latour's notion of 'the script', this paper looks at the spatialities of technological and user re-scripting associated with the introduction of decision support tools on-farm. Although there is some literature on how technologies may be re-scripted by users, studies concerning decision support tools are more limited. Furthermore, while there are studies about how technology (not decision support tools) re-scripts agricultural societies, these are generally concerned with macro-level impacts (e.g. labour changes), rather than exploring life on individual farms. This paper, therefore, focuses on exploring the spatialities of re-scripting, investigating how tools themselves are co-constituted in various ways by different users in different spaces, but more particularly on how life on the farm may be changed by the introduction of decision tools. A case study of decision support tool use on farms in England and Wales demonstrates the need to explore spaces on individual farms if we wish to understand processes occurring at the interface between tools and farmers. Firstly, situated knowledge held by farmers and advisers leads to resistance, negotiation, and re-scripting of decision support tools, which are perceived to provide the 'view from nowhere'. Secondly, the introduction of decision support tools changes the workflows of farmers, affecting how and when they interact with different spaces of their farm. In signalling the need for more research to theorise the spatialities of re-scripting, we briefly explore how our work can inform policy and the development of decision support tools.

1. Introduction

The use of decision support tools by farmers has been the subject of research over the last two decades, particularly in developed countries, such as Australia, Belgium, Italy, the USA, and the UK (see Rose et al., 2016; Rose and Bruce, 2017). These tools provide evidence in a useable form and tend to be delivered in the form of computer software, mobile applications, or web-based interfaces (Dicks et al., 2014), but they can also be paper-based. They have the potential to improve decision-making by guiding a farmer through clear evidence-based decision steps towards a final decision. For example, farmers often need to make a decision about how much manure to spread on a particular crop. There are various decision support tools, including mobile applications, that can specify the quantity of nutrients found within manures spread at varying rates. Using a specially designed calculator, the farmer can enter various data into the tool – such as field size, crop type, spread rate, and manure type – and it will generate an evidence-based output that suggests how much manure to spread in order to meet crop nutrient requirements. The logical impacts of evidence-based decision-making are then increased production, reduced costs, and a lower environmental impact if yields can be increased without excess nutrients being lost to water courses.

Studies into the uptake and continued use of computer-based decision support tools, however, have noted low farmer engagement

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(Alvarez and Nuthall, 2006; Gent et al., 2013; Kerselaers et al., 2015; Lindblom et al., 2017; McCown, 2002; Rose et al., in press). In response to this problem, research has assessed how tools can be better designed and delivered to increase uptake (Hochman and Carberry, 2011; Kerselaers et al., 2015; McCown, 2002, 2012; Rose et al., 2016, in press). While it has proven popular to investigate *whether* decision support tools are used in agriculture (and how to encourage uptake), or their likely impact *if* used (Zhang et al., 2012), little attention has been paid to the question of *how* they are used. Rather, there is often a conscious, or tacit, assumption that a linear relationship exists between the production of scientific knowledge in the form of decision support tools and its uptake by the end user.

This assumption is apparent even in recent explorations of the relationship between designers of tools and users, despite the spatial shift in scholarship across the social sciences. This shift has seen the emphasis move away from technology transfer and innovation adoption, instead exploring the role of space, place, and situated knowledge, in the interpretation of technologies (Holloway et al., 2014). A further analysis of this work on the geography of knowledge and technology demonstrates that the presence of a linear relationship has been conclusively rejected; yet there appears to be little evidence that research into decision support tool use has shifted accordingly. Since farmers are increasingly being asked to use various forms of technology (Morris and Holloway, 2014), including decision support tools, it is important that research into tool use develops a spatial and social lens.

In this paper we address this underdeveloped spatiality and social sensitivity. By using Latour's notion of 'the script', we argue that use of decision support tools should be seen as a co-productive relationship between designers, knowledge brokers, and end users; one in which tools are interpreted, resisted, and modified by users, whilst simultaneously re-scripting life on the farm. Although some work has examined how technologies are shaped by users, including how situated knowledge contributes to this, rather less has explored the way in which they might shape how and when farmers interact with different spaces of their farm. We are thus particularly interested in how technologies change the material nature of farming on an individual farm basis, for example by altering where farmers choose to spend their time or make decisions. The implications of the changing spatialities of farm decision-making with increased technology use are also discussed, including how they might affect the imagined space of farming. Based on our empirical example, we suggest that more research is needed to theorise how changes might take place on farms.

2. Technology and society

Latour's (1992, 1994) notion of 'the script' refers to the ways in which actions are mediated by artifacts. If we think of some common uses of 'scripts', for example in artistic production, sports management, or traffic control, instructions given in the form of a 'script' tell people how to behave – an actor is expected to learn and repeat lines, sports players may be expected to stick to a rigid formation and play in a certain way, whilst road users are required to pay attention to signs. Artifacts (e.g. text, diagrams, signs) are devised to prescribe the action of these users and designers usually hope that the script is followed without alteration. Yet, it is well-known that talented actors are able to improvise, change, or repeat their lines in a way not originally intended by the director, but beneficial to the performance. It is evident that some of the best sports players ignore the instructions of their manager and roam outside the set formation to great advantage. Furthermore, it is not uncommon for drivers to ignore road signs if they consider that the potential advantages of doing so outweigh the risks. Thus, while artifacts certainly do shape the lives of their users, they are, at the same time, mediated through user interpretation (Verbeek, 2006). Knowledge therefore rarely flows between two points without changing, necessitating a spatial lens to analyses of knowledge-practice interfaces (Finnegan, 2008).

Artifacts can also take the form of technology. Using the example of the smartphone, manufacturers have designed a number of functions, including allowing people to make phone calls, send text messages, take photos, and browse the internet. However, Oudshoorn and Pinch (2005) suggest that there is rarely a single 'correct' use of a technology since individual users decide upon their preferred mode of use. A smartphone, therefore, might only be a device used to make phone calls for one person, but represent a hand-held computer for someone else. Latour also noted that artifacts could shape user experience. Technology thus becomes a social construct, shaped by societal structures and by the ingenuity of individual users (Bijker, 1995). The meaning of a technical artifact can, therefore, never reside in the technical design of that technology alone; it is shaped by social interaction (Pirnejad and Bal, 2011).

Employing the same example of smartphone, their introduction has undoubtedly changed social interactions and the social conditions into which it has been launched. For example, research has suggested that personal relationships are affected as couples prefer to check their smartphones rather interact with each other (Levy, 2014), and that increasingly sophisticated problem-solving apps are restricting our ability to think for ourselves (Hadlington, 2015). The ability of technological artifacts to change social interaction is also discussed by Verbeek (2006) through the example of the microwave oven. After the introduction of the microwave into the home, he argues that social structures were changed, enabling users to prepare meals more quickly, but also encouraging people to cook individual meals. This had the effect of discouraging the preparation of food for a joint family mealtime. The microwave oven, therefore, offered time-saving benefits to busy people, but also changed the dynamics of the family home.

Impacts of technology, therefore, can be bi-directional; influencing the behaviour of users, but also shaping the nature of the technology itself. The theory of re-scripting has, to a certain extent, influenced some scholarship on technology use in agriculture.

3. Re-scripting decision support tools in agriculture

In many cases, research into the use of technologies, and specifically decision support tools, in agriculture continues to adopt a linear model of research translation. Such work is concerned with improving uptake, and removing barriers to use (see Rose et al., 2016). Yet, there has also been a proliferation of social science studies in agriculture that have moved beyond conducting innovation-adoption studies. A brief outline of this work is useful here, but more detail can be found in reviews such as the one by Bear and Holloway (2015).

From the 1980s onwards, innovation-adoption research, which had dominated scholarship to this point, began to be convincingly critiqued for being deterministic and linear (Hinchcliffe, 1996; Kirsch, 1995; Roling, 1985; Ruttan, 1996), in other words for assuming that technology improved on-farm decision-making and flowed unproblematically from designer to user without changing. These assumptions meant that research had a pro-innovation bias, and there was a tendency to blame the farmer for non-adoption rather than to criticise the technology for being poorly designed or surplus to requirements (Morris and Holloway, 2014).

Since the decline of innovation-adoption studies in the 1980s and 1990s, expertise also started to be considered as something more practical, rather than being associated purely with scientists in research institutions (Collins and Evans, 2009). Livingstone (2003) demonstrates the spectrum of sites from which scientific knowledge emerges, such as laboratories, museums, botanic gardens, hospitals, and the human body. He shows the significance of these locations in shaping their scientific enquiry, and thus illustrates how science is always embedded in specific contexts (see also de Laet and Mol, 2000). Once we problematize expert knowledge in this way, and accept that it embodies a particular place and culture, the divide between expert and lay knowledges is no longer tenable (Wynne, 1996). Thus, science is always produced in a place and has a point of origin (Morris, 2017). These places are not restricted to scientific laboratories, universities and other research institutions; rather, local, situated, and more informal knowledges about the natural environment need to be taken seriously (Holloway et al., 2014; Morris, 2017). Such knowledge is generally created through the practice of everyday life, from experience of a landscape, and through social interaction within knowledge cultures.

This work has influenced agricultural studies which has argued that situated knowledges held by farmers should be taken into account in research projects (Oliver et al., 2012). This is important since scientific knowledge can often imagine the existence of a technical, rational farm environment without due social sensitivity, thereby providing a view from nowhere (Shapin, 1998; Wynne, 1996; see also a general discussion of demosphere v technosphere in Plough and Krimsky, 1987).

Since agricultural researchers have moved away from innovation-adoption research, and begun to prioritise the agency of farmers themselves in shaping innovations, the sentiment of Latour's work on re-scripting has influenced scholarship. Firstly, studies have assessed how technologies themselves are shaped through user interaction. As the intended end user of many agricultural decision support tools, farmers have their own situated knowledge on which they base decisions about their farm (Evans et al., 2017). This situated knowledge is contextualised, in contrast to tools that are designed to be broadly compatible across farming enterprises and landscapes (Evans et al., 2017). In line with the 'social construction of technology' approach (Bijker, 1995), farmers will therefore interpret tools and other technologies alongside their existing contextualised knowledge. Users are therefore able to transform technologies through resistance and negotiation, drawing on their own situated knowledge to interpret a piece of technology in place. Farmers are rarely passive participants in farm innovation, particularly if they feel that powerful 'outsiders' are trying to interfere in their management (Rose et al., in press).

Several studies have examined the capacity of farmers to shape agricultural technologies (Bellec et al., 2012; Lefèvre et al., 2014; Husson et al., 2016), with some of this work employing a participatory lens to investigate the use of decision support tools (e.g. Eastwood et al., 2012). Nelson et al. (2002) for example, provide an interesting example of a user-centred tool called 'Whopper Cropper', which was a demand-driven piece of software built through a participatory methodology, including iterative prototyping. They argue that systems which are able to facilitate collaborative learning and social interaction through discussion have a better chance of succeeding, a view supported by evidence from a number of sectors (Kujala, 2003; Evans et al., 2017). Likewise, Rossi et al. (2014) report on a project to design a DSS ('vite.net'®) for vineyard farmers in Italy. By involving potential users during its 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 illustrates how participatory engagement with farmers helped a Dairy Planning Software (DPS) system to be used in Australia. In this project, farmers were invited to workshops to input their own data and the DPS was configured according to this. This 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 project, facets which Nerbonne and Lentz (2003) argue are vital for the effective uptake of technology. The workshops also enabled farmers to give feedback on the tool, and the DPS was modified in response to criticisms.

Yet, despite the encouraging shift towards knowledge exchange and participatory methodologies in decision support tool design, the question of how farmers use systems, and how tools are transformed *vis-à-vis* situated knowledge, has rarely been considered outside of a project designed to encourage use of a specific tool. Thus, in many of the studies described above, there is still an inherent pro-innovation bias since researchers are keen to improve uptake of specific tools. Furthermore, there are comparatively few examples of studies describing actual system use, instead favouring a technical description of what a tool can do (Rose et al., 2016; van Delden et al., 2011). The methodology described in section five illustrates that the example used in this paper was not constrained by a desire to design a decision support tool. Rather, it was used to understand how farmers are using existing tools in combination with their own situated knowledge, in order to develop further concepts relating to 'the script'. This subtle distinction, which divorces research from a pro-innovation process, is important.

4. Spatialities of user re-scripting in agriculture

Research has also explored the question of how agricultural society is re-scripted by the introduction of new technologies, although not specifically in the context of decision support tools. Technological advances have altered agricultural practices significantly over the course of the last three centuries, from Jethro Tull's invention of a mechanical seed drill in the 18th century through increasing mechanisation in post-War western societies to the current interest in CRISPR-Cas9 technology. Goodman et al. (1987), for example, analyse how technological development changed American agriculture from the nineteenth century. They discuss how mechanisation changed the agricultural labour process in nineteenth century America as horse-drawn machines replaced simple wooden instruments that relied on human power. Moving into the twentieth century, they further describe how the introduction of sophisticated harvesting machines meant labour was no longer required.

Much social science work has investigated the shifts in rural societies caused by the introduction of new technologies, particularly in terms of labour changes (Bellec et al., 2012; Friedland, 2001; Husson et al., 2016; Lefèvre et al., 2014; Pfeffer, 1992) and animal welfare (Fraser, 2008). Bellec et al. (2012) refers to the 'Treadmill of Technology' (Cochrane, 1958) in which the cycle of improving technology displaces or replaces labour, affects the cost of production, and changes farm sizes. Social studies will also need to investigate the impact of emergent technologies, such as drones and robots, on agricultural communities; drones, for example, could lead to increased surveillance of staff on farms and create an ever-more pressurised environment, whilst robots could further limit the need for human labour. With these examples in mind, therefore, it is clear that technologies can change the social conditions in which they operate. Technologies can be actors in their own right (Latour, 1992), indeed sometimes replacing existing actors who work on-farm. In addition to a 'social construction of technology' framework therefore, a converse 'technological construction of society' also takes place.

Other studies have also begun to theorise the changing spaces of ethical relationships between humans, animals, and technology on-farm (e.g. Holloway et al., 2014). By looking at life on individual farms, this work looks at how technological change affects relationships between humans and animals. Holloway and Bear (2017) find that emergent robotic milking technologies are changing, or re-scripting, what it is to be a cow or human, and discuss the emergence of new rural subjectivities (Bear and Holloway, 2015).

In this paper, we firmly place the emphasis on the human farmer, and human advisory networks. Although the broad level impacts of new technologies on agricultural society have been widely researched, for example in terms of labour shifts, studies have not paid adequate attention to finer scales – particularly the space of the individual farm. If farmers, for example, are increasingly required to use computer systems in an office, how might this decision process vary from existing ways of making decisions? How far does it alter the spaces in which farmers choose to spend their time, and what are the impacts of this? These themes are further explored in a case study investigating the use of decision support tools in English/Welsh agriculture.

5. Decision support tools in agriculture: an example from England and Wales

A significant number of decision support tools are available for on-farm use in the UK (Rose et al., 2016). In a similar vein to other technologies, their use is being increasingly encouraged on-farm. An example of tool use in England and Wales was used to investigate the spatialities of re-scripting. A mixed methodology was chosen using 78 semi-structured interviews and five focus groups. End users in this case were defined as farmers, but also professional advisors. Studies have shown that a farm advisor's role in encouraging efficient farming practices is now more central than ever, and their advice is highly valued by farmers (AIC, 2013; Evans et al., 2017; Ingram, 2008; Prager and Thomson, 2014; Dampney et al., 2001; Winter, 1996). Indeed, Ingram (2008) suggests that the individual farm visit from an agricultural advisor remains one of the most powerful methods of communication in the farming community. One of their roles can be to encourage farmers to take up new innovations (Jakku and Thorburn, 2010).

Kitzinger (1995) describes focus groups as a useful way of finding out what people think and why they do so through group interaction. For this research, five focus groups lasting up to an hour were held with arable farmers in East Anglia (2), arable advisors in East Anglia, dairy farmers in Sussex, and livestock farmers in Central Wales. These made use of existing networks of farmer/advisor meeting groups. They were typically attended by 10–15 individuals and were audio recorded. The focus groups centred on the use of decision support tools and were run by the same co-ordinator in each case. All sessions were started with a general question about whether participants used decision support systems on-farm. Very little interjection was required from the co-ordinator, but where prompts were necessary, these encouraged participants to talk about what they used systems for and how/why they used them. The discussion was generally allowed to flow spontaneously and touched upon how and when decision support tools were used on-farm. The discussion was captured in the form of field notes, but supported through full audio recording. Specific sections of the discussion were transcribed, and were coded by-hand by the focus group co-ordinator. One interesting aspect to note was the inadequacy of using the term 'decision support tool' (or system) in focus group discussions with farmers and advisors. This term was not readily understood, and therefore interview questions were asked in such a way as to avoid its use.

For a more in-depth personal view of the use of decision support tools, 78 interviews lasting up to an hour were conducted with farmers and advisors in three different study regions across England and Wales (Wensum in Norfolk, Taw in Devon, and Conwy in North Wales). Of these 78 participants, 33 were arable or livestock advisors, and 45 were farmers covering the arable (14), upland livestock (Less Favoured Areas (LFAs) – 19), and lowland livestock sectors (9), but also including dairy (3). These participants were not involved in the focus groups. The enterprises were chosen as they covered the largest area of land in the UK as compared with enterprises such as horticulture, pigs, and poultry. The farmers were recruited from a survey completed by 244 farmers (across 7 study regions, see Rose et al., 2016). The advisor sample was generated with assistance from ADAS (a private agricultural consultancy), who used existing contacts and search engines to develop a list of advisors covering each of the three study areas. These included advisors who provided technical, business, or environmental advice, and included both commercial and independent advisors. ADAS found relatively low numbers of advisors in each area, and made contact with individuals from every major group. Therefore, this methodology was considered robust.

The interviews asked a number of questions relating to use of decision support tools, including what systems were used for, how they were used, and the impacts of using them. All respondents were also asked where they were located when they made the majority of their decisions. All interviews were transcribed in full and coded using Atlas.Ti software.

6. Re-scripting decision support tools: resisting the view from nowhere

Our study supported a point made in the literature review concerning the passivity and freedom of autonomy (Rose et al., in press). There was little evidence that advisors or farmers would do exactly what the tool told them to do; in other words, dynamic tools were never blindly followed. As one farmer argued, "you can't just have blind faith in it. If you let them control you and you just do exactly as they say, well I think you're on a hiding to nothing" (Arable farmer, Wensum, 52,009). Another said that "it's a tool for decisions. I don't think you'd actually do exactly what it said" (Arable farmer, Wensum, 52,039). Advisors tended to agree arguing that "an app is a tool to help you to do things. You're not going to make informed decisions through just what an app says" (Livestock advisor, 2). For those using these new technologies, therefore, they often represented a component of the decision-making process, but never the full part.

As such, decision support tools were not always used exactly as intended by the designer, but were instead re-scripted by the user with situated knowledge of individual farms. As previously discussed, scholars have long argued that place-based, situated knowledges are powerful ways of knowing, providing unique insights in contrast to so-called universal, 'placeless' knowledge (Finnegan, 2008; Shapin, 1998; Wynne, 1996; Oliver et al., 2012). In our study, respondents regularly referred to the value of knowledge created on the farm. A lowland livestock farmer (10,011) in the Taw region reported that he made decisions based on "experience in the field". He learned, in his own words, from "the university of life", not from so-called clever experts who may not have ever visited a farm. The value placed on experienced-based, situated knowledges was strong, which was the most significant reason why farmers (and advisors) did not use decision support tools or, if they did, why they failed to put complete trust in their recommendations. One farmer (LFA, Conwy, 20,018) said that 'sometimes you just feel like they're talking about somewhere else'. In contrast, advice offered by peers or trusted advisors contained this place-based element. One livestock farmer argued that his peers were the best decision support tool he could ever use. He reported that:

> "if I sat next to …[name of farmer] and he told me had had tried this with his sheep and it had worked, then I'd give it a go. So that is training and decision support isn't it? Chatting with mates is the best way to get support on decisions and they [Defra] need to support this more." (Livestock farmer, focus group).

In a further revealing statement on the value of situated advice, an arable farmer compared the quality of advice offered by his agronomist of forty years with a decision support app:

> "Advisors are the old fashioned apps aren't they? You can talk to them and they can talk you through things, whereas an app [can't] …you put so many variables into an app [which] would be time consuming and then it probably wouldn't be right I don't think. You don't have the right information in the right scenario in your app to be able to do that, whereas the agronomist would build a mental history of your farm and individual fields over time." (Arable Farmer, Wensum, 52,039).

Here, the farmer alludes to the crucial difference between his agronomist and a decision support tool. The agronomist had been visiting the farm, and other farms in the local area, for over four decades. As such, he had developed a mental history of his client's field and a place-based memory of the management interventions that had worked or failed in the past. Over time, he had built a trusted relationship with his clients and created knowledge of the intricate differences between farms. Consequently, farmers felt that advisors knew their land, a compliment not extended to decision support tools. In the case of the app used by the arable farmer mentioned above, and many others interviewed, non-human decision support tools were considered to be placeless, and thus to provide the view from nowhere. These tools were designed and developed in a scientific laboratory, not placeless *per se*, but certainly removed from the context of individual farms. Many tools are designed to be rolled-out across regions, countries, even continents, and so must be relevant to a wide user base. Re-scripting of tools can take many forms, including simply using it in a different way than intended by designers; this would include, for example, farmers or advisors ignoring the advice of the tool in favour of their own experiential and situated knowledge.

The perception that tools were not targeted towards individuals, and instead were aimed at an imagined farmer with a workflow and skills suited towards to their use, was one important reason behind the resistance, negotiation, and ultimate re-scripting of tools by users. A farm advisor was interviewed who trained local farmers to use decision support tools. One software package designed at improving fertiliser application ('Tool X') was found to be particularly difficult to use. The advisor reported that he "gave up on" this system because farmers "just couldn't understand it" (Livestock adviser, 11).

'Tool X' received critical comments from other respondents who thought that it "was unnecessarily complicated" (Arable advisor, 15), whilst another advisor described it as a "beast" (Livestock advisor, 2). With help from farmers, the advisor took the decision to design a different tool himself. Crucially, the re-design process was conducted in a participatory fashion with real users; farmers who could convey their grounded preferences and requirements directly to the designer. This tool ('Tool Y') involved users in the design process and made a series of improvements to 'Tool X'. These included: (1) the inclusion of a simple calculator to covert hectares to acres, (2) ensuring that when data entry for one field was completed, a new line automatically appeared for the next field, (3) enabling mistakes to be undone quickly, (4) the ability to input fertiliser for several fields at the same time – this sped up the process of data entry, (5) A mechanism to respond to technical queries, and (6) a more usable interface, including more simple navigation.

Reflecting on our data and previous research, knowledge cultures within farming have always been multi-faceted, informed by place-based knowledge, local experiences, and scientific knowledge (often less place-based). It would be naïve to think that the use of decision support tools would not be similarly multi-faceted. As with any new innovation, decision support tools are co-designed on farm. Farmers and advisors may try them out, realising that they can be a useful source of information, which may enable them to form a key part of the decision-making process. Yet, they are always going to be interpreted in place and interrogated accordingly with questions such as: are these recommendations relevant to my farm or somebody else's? Does this tool understand the complexities of my land? What can't this tool tell me about my farm? On reflection, a farmer or advisor will find that their own experience-based knowledge, and the advice of local, trusted peers, adds something to the decision-making process that a decision support tool cannot. Thus, for farmers and advisors using tools, decisions will be a hybrid of different forms of knowledge. As part of this negotiation, technologies such as decision support tools will be interpreted in place, and sometimes they will be resisted and changed.

7. Re-scripting the user

Our study found evidence that decision support tools had the potential to change the spaces in which farmers made decisions. In turn, this affected how farmers interacted with the different spaces on their farm, leading some to reflect upon the imagined space of farming itself. In this section, we break down the spatialities of how farmers are re-scripted by decision support tools, and other technologies, starting with life on individual farms.

7.1. The changing spaces of on-farm decision-making

Woolgar (1990) conducted an ethnographic study of a company who designed decision support tools. The desire to configure users, in other words to change and shape user behaviour, was a central component of the design process. Designers, who were removed from the place of implementation, were observed by Woolgar as preferring to configure users, rather than trying to make their tool fit into existing workflows. The objective of re-scripting users, therefore, is undoubtedly an aim of many decision support tools, even if more recent work has looked at how to design tools more suited to existing decision environments (Rose et al., in press).

Each farmer in our study was asked the question 'where do you tend to be located when you make the majority of your decisions'? A list of relevant responses from farmers is shown in appendix 1, but a selection of quotations illustrates some interesting patterns. The majority of the responses show that the premise of the question itself is flawed – that is, if the researcher desired a firm answer. When making a decision, an arable farmer in Wensum (51,084) said:

> "I might be anywhere. I am not in the office. You dream it up I think because you live here, because the office is the farm, the car, the truck, bed, whatever, you are living…it is not like you shut the door when you go out at half past five and shut your work away, you don't, you are there the whole time. So it can be anywhere."

Similar responses were given by other farmers. When taking a decision, an LFA livestock farmer in Conwy (20,009) said that they "could be anywhere", whilst a lowland livestock farmer in Taw (10,003) reported that it could happen at "two o'clock in the morning in bed". A further arable farmer in Wensum (51,072) reported that they 'could be driving around…in the field…there is no specific place…but probably more often than not in the office'.

The quotations from farmers in appendix 1 illustrate the spontaneous nature of on-farm decision-making, and the flexible workflows of farmers. Although the arable farmers studied used office-based decision-making more often, many farmers took decisions in several different locations on the farm – in the field, in the farmyard, around the kitchen, in bed, in the tractor, or in the office. Farm advisers tended to report a much more structured style of decision-making, discussing decisions with clients in the field, or at the client's home, before making a more considered decision in their professional office.

In interviews and focus groups, farmers generally perceived that using decision support tools necessitated a different workflow. Although decision support tools are available in a variety of formats, including mobile applications and other formats seemingly suited to portable decision-making, farmers generally assumed that they were office-based tools. Mobile applications and hand-held computers were often considered to be dangerous for a life in the field, where they could be easily broken.[1] The following extracts show that there was a perceived conflict between spontaneous farming workflows and patterns of work associated with use of decision support tools:

> "When it's daylight you've got to get out there and be doing things you know, I'm more or less a one-man band, the wife works full time, two lads, well one's just finished at university, the other one's in university and the daughter's in school most of the time so you know your time is very limited these days." (LFA farmer, Conwy, 2006).
>
> "I farm evenings and weekends so the pressure to do the work out there is more than to go searching about on a computer really." (LFA farmer, Conwy, 20,028).

[1] "I can afford a phone but you know it's in my pocket with my knife and maybe there's a staple in my pocket or whatever, if you understand me?". *So you wouldn't want to carry around a smartphone and break it.* "No" (LFA farmer, Conwy, 20019 with prompt in italics).

> "But if you went outside, you'd have no signal at all, you see. So I'm not against smart phones or against that technology, it's just something I haven't done because it's not that reliable, in a sense. If I've got to come indoors anyway, I might as well go on my laptop and have a look anyway." (Lowland livestock farmer, Taw, 10,019).

All of these farmers make a similar point – they want to be out on their land, making decisions, and implementing them. This style of farm management is contrasted with the use of decision support tools for which you may have to "come indoors" instead of being "out there". This suggests that the spatialities of farm decision-making will change under emergent technological regimes. Further research is needed to understand how the use of different technologies change where the farmer spends time, and how this might differ between different farm enterprises and farm profiles. Here, our findings suggest that arable farmers might be more used to an office-based environment, although this is not true of all arable enterprises.

7.2. Potential impacts of changing spatial workflows of decision-making

The impact of the changing spatiality of on-farm decision-making is also worth considering. Since it has been discovered that farmers construct identities in relation to the farmed landscape, a close connection with the land is an important underlying motivation for farming itself (Baldwin et al., 2017). If new decision support tools are introduced with a requirement for farmers to use them material relationships to the farming landscape are likely to change. Studies have found that a farmer's love for his/her job is the key driver behind why they continue to farm (Pilgeram, 2011). Pilgeram (2011, 381) found that even though farm-work was often exhausting, difficult, and without reward, farmers conveyed a 'real love of the work they were doing'. One farmer from Pilgeram's study was reported as saying '[t]hat's a long way to say, I can't possibly work in an office. It would drive me crazy (381)'.

In our study, some respondents similarly linked their passion for farming with the ability to spend time out on their land. In a focus group, a livestock farmer said:

> "I make my money getting stuck in with my stock. I love doing that. I love getting stuck in, getting out on the hill, getting right in there. Now with all these things [referring to decision support tools], all these fancy technical things, I'm having to spend more time away from my stock. I'm not enjoying farming as much these days." (Livestock farmer, focus group)

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Furthermore, when asked about the place for computers on-farm, one farmer responded, "I think we are getting too dependent on computers…see you can put the man on the land with a computer, but if he hasn't got a love of the land he won't do it as well as if he had" (Arable farmer, Wensum, 51,087). Even for those applications that could feasibly be operated in-field (e.g. apps), one could still argue that their use increases the disconnection between farmer and land. An arable adviser in a focus group remembered a further example of where tension had been created by the requirement to perform an activity through the use technology. Here, the adviser reported that his client's whole day had been ruined:

> 'The probably with some of the online systems is that farmers could never get them to work. I've spoken to some farmers who have had their Sundays ruined by an online system. Whereas if you could ring someone up, and you had a list of people who knew how to do it, then it could be done in 5 minutes'.

Clearly, therefore, the requirement to use decision support tools in a setting away from where decisions are currently made would be resisted by some farmers. For some, the material impact of being 'removed' from their land would negatively impact upon their quality of life on the farm. On an individual basis, this is concerning, but our findings also indicated that changes felt by individual farmers on specific farms could affect the wider imagined space of farming. Thus, farmers, and farming, may be re-scripted by technologies on individual farms, but the consequence of this may lead to the re-scripting of agricultural society (at least its imaginaries) at wider scales.

7.3. Impacts of changing spatial workflows on the imagined space of farming

Impacts of changed decision-making spaces also, therefore, influences the imagined space of farming at a much broader scale. This sentiment was clear in many of the interviews conducted for this project in which farmers complained about the increasing administrative burden being placed on them, including the requirement to use new technologies. A livestock farmer in Conwy reported that:

> "they're just putting things [technical systems] in front of you, and we just want to farm. I can't afford to have a secretary coming in once a week, four hours on a Friday to go through all the bloody paperwork and get everything right and keep it the way they want it you know, so I have to do it. Technology is supposed to make things easier, not harder…but I'm stuck in here sorting it out." (LFA farmer, Conwy, 20,034).

Other extracts also refer to the imagined space of what farming is

> "What is driving farming? Doing all these things [e.g. use of technology] is what gets you down. If you have more paperwork to do, our attitude is difficult towards it. We are always wanting to be outside doing work on the farm, whereas a lot of other industries are computer and office-based or have someone that can do that type of work." (Arable farmer, focus group).
>
> "We shouldn't assume that if farmers aren't using the online tools, that they're not innovative. I met one farmer who was very switched on and had some good ideas, but he didn't use emails or anything." (Arable adviser, focus group).
>
> "It's a lifestyle. It's not a job it's a lifestyle. It's what we've always done, what we've always know." (LFA farmer, Conwy, 20,021).

These quotes suggest that there may be a mismatch between what farmers imagine farming to be, and the imagined space of farm decision-making as conceived by developers and proponents of technology. In other testimonies, there was clear tension between some farmers' understanding of their enterprise and the perceived direction of travel of the industry as imagined by these farmers. Two arable farmers in Wensum criticised the reliance on computers in the following way:

> "You put it in a computer, you get an answer, but it is not like being hands-on is it? I had a fella from college and he trundled through all the books and computers and he found it wasn't as simple as that, I mean the practical experience is what they need, yeah. No. I think we are getting too dependent on computers and this, that, and the other." (Arable farmer, Wensum, 51,087).
>
> "There's a whole generation out there now who if you gave them a string of numbers they wouldn't be able to add them up, I think, or carry out mental arithmetic, unless they worked behind the bar. Can we think for ourselves these days?" (Arable farmer, Wensum, 51,072).

Younger farmers, however, may think of farming as a more technical enterprise than older generations. For them, the imagined space of farming is different and the increased use of decision support tools might fit much better within it. Our findings suggest that further research is needed to understand how the changing spatialities of on-farm decision-making associated with decision support tools will affect the ways in which different farmers perceive their industry.

7.4. Re-scripting advisory networks: decision support tools versus advisers

Although not directly related to spatial re-scripting, one further issue was raised in our study. As mentioned in the previous section, many farmers referred to their advisor as the best available decision support tool. Several farmers said that 'you need a human processing the information on the spot' (arable farmer, focus group), and that it was important 'to look a person in the eye when they tell me how much money I need to spend' (arable farmer, focus group). Reflecting on the potential for decision support tools to become more sophisticated, advisors considered the potential knock-on impacts of this. In a focus group, a number of advisors made a similar point, arguing:

> "Well you don't want decision support tools to become too good, do you? Otherwise we will all be out of a job. I don't think for one second that they will ever replace an advisor, or a farmer, in the field, but logic tells you that if technology goes on improving, then what's the need for Joe Bloggs to come and tell me what to do anymore. So we don't want them to become too good." (Arable advisor, focus group).

This is an interesting point, which echoes the arguments made by Goodman et al. (1987) on the relationship between mechanization and labour. As technology becomes more sophisticated, it is able to perform tasks currently undertaken by humans, usually more efficiently and at less cost. Feasibly, as decision support tool technology develops, it could replace the need for professional advice. Although it is difficult to envisage that the place-based, personal knowledge of a professional advisor could be replaced without losing something unique, it is certainly possible to foresee a diminishing reliance on this advice if farmers are able to use a tool instead.[2] Again, the question of efficiency at what cost is pertinent. Many farmers greatly valued having "real people coming out on to form…[rather than] an online system [that] makes us all the same, the same number" (arable farmer, focus group). Although one arable farmer (focus group) did say that an online tool was more useful than an adviser "if you wanted to work at 5.30am in the morning [when] my agronomist wouldn't appreciate me ringing them up", the further erosion of human-human contact on-farm was worrying to many respondents. This is a further theme that is worthy of consideration in further research.

8. Concluding remarks

A significant number of decision support tools have already been designed for use on-farm, and the development of such tools, alongside other technologies, is likely to increase further in the next few years (Rose et al., 2016). While some research has suggested that decision support tools have a bright future in agriculture (Yost et al., 2011), offering the opportunity to increase productivity at no extra environmental cost, there has been insufficient research attention on how, where, and when tools are used on individual farms, and on their potential impacts.

In many ways, our findings reinforce the well-rehearsed critiques of the transfer of technology approach which dominated scholarship before a spatial turn. Our findings support the notion that technology, or in this case the relatively unexplored area of decision support tools, are altered by farmers once they are interpreted and used on-farm. This is in line with the broad thrust of scholarship which has illustrated that technology can be socially constructed. We suggest that different characteristics of farms (e.g. enterprise type) and farmers (e.g. age) may affect the extent of this social construction, affecting how far tools are re-scripted.

Our findings also re-inforce previous work that has looked at how agricultural societies may be re-scripted by technologies, although we have explored this on an individual farm basis, a scale which is relatively under-explored in this context. In light of our findings, we suggest that more research is needed to theorise how technologies and users are spatially re-scripted on-farm, further exploring the consequences of re-scripting. It is not possible to form this theory on the basis of one empirical study, but our findings strongly suggest that it is worth working towards doing so. The results suggest that the introduction of decision support tools is changing the spaces of decision-making on individual farms. This is consequently affecting how a farmer interacts with their land, and maybe even how they imagine the industry of agriculture. Since farming is a social enterprise, the impacts of decision support tools need to be explored with a greater social and spatial sensitivity. It may be possible to theorise how both the re-scripting of tools and the user might vary on different farms, and it is worth noting that the two elements of re-scripting may be linked. Those farmers who resent the changing spatialities of farm decision-making under a decision support tool regime are most likely to resist their introduction. Such farmers are, therefore, likely to change the technology more to suit their desired workflow, re-scripting the technology, instead of allowing their lives to be re-scripted. In our study, we noted that older farmers were more likely to resist the introduction of decision support tools and the spatial workflows (e.g. office-based, technical) associated with them. Learning from the 'university of life', older farmers may be more likely to make decisions in the field based on situated knowledge, and thus resist a more office-based decision process. Furthermore, we found evidence that arable farms, particularly larger ones, have more office-based environments suited to the use of decision support tools (Rose et al., 2016). This may mean that the spaces of decision-making change more on non-arable farms, which might increase the impacts of such change. We note, however, that some decision support tools do not require an office-based environment, and may fit into flexible workflows. It is clear, however, that much more work is needed to investigate how decision support tools affect life on individual farms, also addressing the potential consequences of this.

There are also important considerations for developers of decision support tools, and the policy and other funding organisations who support them. If users are actively shaping the technologies they encounter, re-scripting them through the use of situated knowledges, it is insufficient for developers to ask simply whether their tool is being used: rather, if they are interested in monitoring uptake, they also need to ask how it is being used. Furthermore, it is clear that tools should be designed with flexibility in mind, allowing individual users to configure it to their farm to increase relevance. When designing tools, it is important to keep the intended user firmly in mind (Rose et al., in press), and target it more carefully, rather than creating something too broad and generic which simply provides a view from nowhere.

Developers and funders should also begin to explore the social impacts of decision support tools, and other new technologies, with as much weight as efforts looking at productivity and environmental impacts. As part of the farming community, developers need to ask how their technology might influence how farmers interact with their farm, and the potential consequences of this, including for example limiting enjoyment, or indeed replacing trusted, valued advisors. Farmers, advisors, and other industry representatives should be involved in future discussions about the direction of travel for decision support tool use on-farm, and a process of knowledge exchange should also be facilitated to ensure that the views of these stakeholders are taken into account.

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[2] In light of the findings however about the importance of human-based advice and the value of situated knowledge, it is unlikely that this scenario will become commonplace.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.geoforum.2017.12.006.

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