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### Abstract

Farming today relies on ever-increasing forms of data gathering, transfer, and analysis. Think of autonomous tractors and weeding robots, chip-implemented animals and underground infrastructures with inbuilt sensors, and drones or satellites offering image analysis from the air. Despite this evolution, however, the social sciences have almost completely overlooked the resulting problematics of power and control. This piece offers an initial review of the main surveillance issues surrounding the problematic of smart farming, with a view to outlining a broader research agenda into the making, functioning, and acting of Big Data in the agricultural sector. For surveillance studies, the objective is also to move beyond the predominant focus on urban space that characterises critical contemporary engagements with Big Data. Smart technologies shape the rural just as much as the urban, and “smart farms” are just as fashionable as “smart cities.”

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### Introduction

Farming is being transformed by smart technologies. Think of autonomous tractors and weeding robots, underground infrastructures with inbuilt sensors, or drones and satellites offering image analysis from the air. What these applications have in common is that they work through the accumulation, transfer, and analysis of data. Estimations talk of an average 4.1 million data points per day and per farm generated in 2050 (Gralla 2018). Thus the smart farm is also a surveillant farm, if we understand surveillance as “focused, systematic and routine practices and techniques of attention, for purposes of influence, management, protection or direction” (Lyon 2007: 14; see also Murakami Wood et al. 2006).

Despite this evolution, existing literature on Big Data remains overwhelmingly urban centred. Likewise, with very few exceptions (Haggerty and Trottier 2015), surveillance is almost exclusively approached in, and related to, urban settings. In this, an important part of the picture is missed. Smart technologies, such is my basic assumption, shape the rural just as much as the urban, albeit in different ways and with different implications. “Smart farms” are just as fashionable as “smart cities.” In some cases, agriculture might even be a particularly relevant field for technology deployment: eighty per cent of the future drone market is expected to relate to agriculture (Association for Unmanned Vehicle Systems International 2013).

I here propose a more systematic programme of research into the problematics of Big Data and

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agriculture. I start with some initial terminological clarifications around the concepts of “precision agriculture” and “smart farming.” Then, I discuss four main issues surrounding smart farming, relating to ecology, politics, society, and economics, before outlining a series of research problems and questions that should be explored in future academic work. These are situated on three analytical levels (Klauser and Pedrozo 2015), referring to

- where, how, and by whom novel smart-farming solutions are being developed and subsequently diffused (the making of smart farming)
- how smart technologies work and how they permeate the farming sector (the functioning of smart farming)
- what social, spatial, political, and economic implications this evolution conveys (the acting of smart farming)

In turn, I argue that from these levels of investigation arises a more general, conceptual task that consists of the critical reconsideration of the concept of “surveillance” itself, beyond the usual focus on risk, on the human and on the urban.

While this discussion is strategically ambitious, aiming to open up a novel research field for surveillance studies, it does not aspire to provide a comprehensive picture of the way ahead. Rather, my argumentation is fundamentally exploratory in scale and scope, inviting future reflection and debate rather than bringing it to a close.

## Smart Farming

From the early 1980s, the term “precision agriculture” was used to talk about the use of sensing technologies to monitor and manage practices and sites of food production (Daberkow and McBride 2001; Sonka and Cheng 2015; Anken 2018). More recent technology advances further increased the computerisation of agriculture, while also spawning a number of novel terms. These range from “data-driven farming” (Bolman 2016) to “digital agriculture” and “big agriculture” (Van Es and Woodard 2017; Carbonell 2016). The most common terms today are “smart farming” (Vate-U-Lan, Quigley, and Masouras 2016; Bertschi 2018) and “big data in agriculture” (Protopop and Shanoyan 2016). Although they suffer a great deal of definitional elasticity (Bolman 2016: 149), these latter two terms add at least two crucial aspects to “precision agriculture” and will be used interchangeably here.

First, the “smartness” or “Big Data aspect” of farming is set in relation to increased connectivity, as opposed to the management of isolated technological abilities or fields, as in precision agriculture (Bolman 2016). Thus smart farming is related to the multi-scalar combination of various tools, sites, and databases (Protopop and Shanoyan 2016), implying ever-increasing data gathering and ever-wider circuits of data flow (Vate-U-Lan, Quigley, and Masouras 2016). For example, consider John Deere’s online platform [www.myjohndeere.com](http://www.myjohndeere.com), which offers access for farmers to real-time generated data from sensors attached to their own machines and aggregated data from other farmers, as well as external datasets including weather and financial data (Carolan 2018a).

Second, smart farming is associated with data processing and analytics, aiming at the automated and anticipatory management of agriculture (Bertschi 2018; Ribarics 2016; Carolan 2018a). At their core, efforts towards smart farming thus imply a world of ordering and regulation-at-a-distance that relies, fundamentally, on the coding of agricultural processes and practices into software (Hollands 2008; Kitchin and Dodge 2011). In sum, the farm of the future is presented as a software-driven system of connections, processes, and flows based on carefully orchestrated techniques of data gathering, transfer, and analysis.

## Key Issues

Related issues can be structured into four intertwined categories relating to ecology, politics, society, and economics. Discussing these highlights a series of problems and challenges on which future research on smart farming should focus and which might be substantially different to the problematics addressed in urban-centred surveillance research.

### *Smart Farming and Ecology*

Policy discourses on smart farming are channelled heavily through visions of technology-induced precision, reliability, effectiveness, and efficiency, related to environmental protection and sustainability (Bongiovanni and Lowenberg-Debowers 2004; Jullien and Huet 2005; Agri-Trend 2014; Moreira 2017; Wolfert et al. 2017). In contrast, there is also a small line of critical academic work that questions the assumption that current advances in sensing technologies and agricultural software simply pave the way for a “smart, prosperous and sustainable future” (IBM 2010). This work emphasises the ecological vulnerabilities resulting from increased techno-dependency, productivity, and standardisation, especially when connected to the corporate interests of the contemporary “food security complex” (McMurry 2012).

For future research, it will be important to critically deconstruct the “language games” (Söderström, Paasche, and Klauser 2014: 307) around smart farming and to study the performative role of techno-infused “sustainability talk.” Here, there is a lot to be learned from the already existing literatures on the “discursive engineering” dimension of contemporary smart-city initiatives (Bell 2011; Söderström, Paasche, and Klauser 2014). Furthermore, it will be necessary to explore how exactly issues of vulnerability and sustainability are understood and addressed in particular smart-farming projects and indeed how smart technologies change the ways in which farmers themselves relate to their cultivated land and livestock (Fortané and Keck 2015).

### *Smart Farming and Politics*

Agriculture is of central concern in domestic and foreign politics. It interlinks neatly with other policy domains such as food security, energy supply, land management, and national sovereignty and identity. Thus the computerisation of farming naturally raises a range of political issues. One of the most central issues is that the proliferation of smart-farming techniques affects how and by whom farming processes and practices are controlled and managed, both on a national and transnational policy level and in terms of the everyday operation of specific sites. Managing and governing in the world of Big Data means to understand, regulate, and make use of the mediating means and mechanisms involved in associating the masses of data generated and processed and in coding into software the objects, practices, and processes to be regulated (Lyon 2007: 100).

This gives certain forms of techno-scientific expertise and (private) parties more weight and puts traditional modes of governance at stake in challenging decision-making processes that were traditionally placed under the exclusive responsibility of the nation state (Fortané and Keck 2015). Critical issues revolve around fears of increased techno-dependency and loss of “data” and “food sovereignty” (Carolan 2018b; forthcoming).

Future research should approach these issues empirically by focusing on the actors, interests, and sources of authority that come together in consensus and conflict in the field of smart farming and thus shape specific initiatives and solutions, act on the resulting processes of policy imitation and exemplification, and ultimately co-produce the ways in which farming is understood, regulated, and practised.

### *Smart Farming and Society*

Big Data in agriculture raises major issues in terms of data quality, access to and ownership of data (Dürr, Kaufmann, and Meier 2004; Carolan forthcoming), and data security (Wolfert et al. 2017), affecting both privacy and accountability (Bronson and Knezevic 2016). Furthermore, as argued previously, smart farming involves manifold techniques of software sorting, used to inform and automate agricultural decisions, practices, and processes (Carolan 2018a; Carbonell 2016) that are—by definition—never neutral, whether aimed at greater efficiency, profitability, convenience, or security (Thrift and French 2002; Graham 2005; Kitchin and Dodge 2011; Gabrys 2014). Computer algorithms constitute not only a tool of analysis but also a “grammar of action” (Galloway 2004; Kitchin and Dodge 2011). As a model and technique of analysis, they simplify reality into a legible order (Budd and Adey 2009: 1369); as a means of automatic response, they perform everyday life through this order. Thus software-based surveillance is both produced by and in turn produces specific classifications and orderings of reality. As Murakami Wood puts it, “we now live in a surveillance society under digital rule” (2008: 95). This also applies to the agricultural world.

Further issues include the vulnerability of such systems and, more generally speaking, the (in-)adequacy of software to orchestrate reality in its internal complexities and dynamics (Budd and Adey 2009: 1370). Consequently, there is a pressing need for more systematic engagements with how, for what purposes, and with what implications software solutions are today being deployed in agriculture. Again, such issues should be approached empirically and from a micro perspective, centred on the organisational settings and situated coalitions of authority underpinning current efforts towards the software-mediated governing of agriculture. Through the study of particular pilot projects and sites, the specific rationales built into smart-farming solutions can be explored and questions can be asked about the way in which these rationales then affect the practices and relationalities managed through code.

### *Smart Farming and Economics*

Economically speaking, the objective of smart farming is to increase agricultural productivity, while also minimising the risks and costs implied (Bongiovanni and Lowenberg-Debowler 2004; Jullien and Huet 2005). Critical concerns, in turn, revolve around the impact of Big Data on agricultural employment rates (Van Es and Woodard 2017) and diversity (Walter et al. 2017), connected also to fears of a growing digital divide between capital intensive farms benefitting from smart technologies and those unable or unwilling to follow suit (Fraser 2018: 9).

In any case, smart farming is likely to change and challenge our very understanding of farming as an economic sector and of the farmer of the future. Yet many farmers today lack specialised training in the use of digital technologies and software, which raises not only important technical and organisational challenges (Kshetri 2014) but also critical issues in terms of identity and subjectivity (Bolman 2016). This underlines the need to institute new educational programmes and modes of collaboration in the agri-food chain (Wolfert et al. 2017: 74) that facilitate the social appropriation of smart technologies and build confidence in the tools concerned and trust in the novel actor networks implied (Fraser 2018: 8). As part of this process, it is important to involve farmers from the very fabrication and programming of novel smart techniques. However, it remains unclear how to do this and what farmers’ specific needs, difficulties, and expectations are. Yet only by taking into account the expectations, hopes, and fears that crystallise around smart-farming techniques and projects, especially by those directly concerned, can we understand when, why, and how novel smart technology solutions succeed or fail.

### **Towards a More Systematic Research Agenda**

The task now ahead is to explore in depth and detail the possibilities, limitations, and problems evoked by novel smart-farming solutions. As seen, there has already been some initial work on this, although it remains frustratingly scarce and unempirical and thus generalist and preliminary in tone and scope.

Furthermore, the few relevant investigations are heavily Anglo-centric, with other linguistic contexts and agricultural systems remaining overlooked.

With this in mind, the paper discusses three main analytical objectives that should be pursued in future research. Together, they are intended to provide a more solid understanding of the origins of and dynamics behind the current proliferation of smart-farming techniques (the making of smart farming), the specific modalities of use (the functioning of smart farming), and the resulting implications of the systems put into action (the acting of smart farming). Calling for detailed fieldwork, the emerging lines of investigation can be read as different levels of engagement with the political, social, economic, and ecological issues connected with the current digitisation of agriculture.

### *The Making of Smart Farming*

The first analytical objective, termed the “making of smart farming,” relates to the questions of how, where, by whom, and for what reasons smart-farming solutions are developed, tested, diffused, and subsequently put into practice. Two complementary lines of investigation are highlighted.

On one hand, this objective invites a micro approach that focuses on a range of specific initiatives, anchored in specific sites of experimentation, that contribute to the development of novel solutions in the field and that help assemble the actor networks that carry forward the current and future evolutions. For example, consider the *Swiss Future Farm*, a pilot project launched in Tänikon in the canton of Thurgau on September 21, 2018, with the intention of providing a space for experimentation for the development of novel smart-farming solutions (Federal Office for Agriculture 2017; see also Swiss Future Farm 2018). Such sites and projects should be studied in empirical detail, drawing on the Latourian vocabulary of “centres of calculation” and “cycles of accumulation” (Latour 1987), to better understand how knowledge about smart farming circulates between and builds on specific sites of differing functionality and how it accumulates, stabilises, and becomes manageable through these sites.

On the other hand, it is important to explore the transnational dimensions of the circulation and sharing of previously tested and subsequently exemplified smart-farming solutions. Focusing on the mechanisms and actor networks through which these travel from place to place, this strand of investigation is meant to address issues of policy coordination, learning, and imitation in the digitised agricultural sector on a macro scale. In particular, this asks for critical exploration of the role of global commercial players, such as Monsanto and John Deere, which are today aiming to become “obligatory passage points” (Callon 1986; Latour 1987) in the organisational settings and coalitions of authority underpinning and shaping the smart-farming field, boosted by their technical expertise and marketing and selling campaigns.

Taken together, the two lines of work invite a multi-scalar analysis of the processes, relationships, and interests through which current efforts towards smart farming are conditioned and co-produced, bringing together various technological and discursive, public and private, local, national, and transnational realms.

### *The Functioning of Smart Farming*

The second analytical objective consists of the exploration of the socio-technical mediations that underpin and condition the functioning of novel techniques of smart farming in operation. This analytical strand incorporates questions of how and for what reasons such techniques are used in different institutional settings and sites and how issues of power and control are effectively actualised within everyday smart-farming processes and practices. What matters here is to study the organisational settings, the interacting forms of expertise, and thus the situated coalitions of authority that shape differing smart-farming systems in their everyday use. Again, there are two main sub-themes to be highlighted.

The first sub-theme relates to the distancing effects implied by smart-farming techniques, from the perspective of the users of the deployed technologies (Marx 1991; Ruegg, Klauser, and November 2007).

Whether we are talking about self-driving tractors or hacking robots, autonomous drones for spraying pesticides, satellite-enabled image analysis, or sensors inbuilt in water pipes or other infrastructure, the key point is that information is being recorded somewhere and subsequently transferred, accumulated, and analysed elsewhere. This differs from traditional forms of farming, based on the multisensory interaction between the farmer and field, crop, or cattle. For future research, it is important to study how the novel forms and degrees of remoteness hence implied are perceived and lived by those who use the systems and are exposed to them and to question critically what it means to enhance if not replace the farmer's direct sensory contact in and with the field with additional elements of "artificial multisensory surveillance," such as weather gauges or sensors for the automated detection of parasites, snow, and so on.

The second sub-theme to highlight relates to the aforementioned role of software in the monitoring and management-at-a-distance of agriculture. What difference does it make if farming is governed through software, that is, in ever more automated but also pre-fixed and thus standardised ways? What are the power issues and (spatial and temporal) logics of regulation implied? How efficient and indeed how adequate is the use of software in the agricultural sector, given the internal complexities and dynamics of the governed realities?

### *The Acting of Smart Farming*

The third analytical objective relates to the "acting" of novel smart-farming solutions. How do smart-farming techniques intervene in the governing of the agricultural everyday? What do they produce? And what does this then tell us about the benefits and problems associated with their evolution? This problematic implies a focus on the specific "rationalities of power" inherent in the software-mediated techniques of control and regulation that now proliferate in the farming sector. Only if we understand how—that is, through what specific techniques and logics of power—smart farming acts can we understand its socio-spatial implications.

For this investigation, a fruitful framework and toolbox can be found in Michel Foucault's (1982) conception of power and governmentality. In differentiating, for example, between juridico-legal, pastoral, disciplinary, and security types of power, Foucault (2007) offers a meta-level analysis that focuses on the crosscutting rationalities characterising differing apparatuses of power, for example in their relation to the governed reality, to normalisation, and to space (Klauser, Paasche, and Söderström 2014). This carves out a vocabulary and analytical framework that can be mobilised to explore the power dynamics conveyed by smart-farming techniques in their acting on the monitored and managed reality. Moreover, Foucault's conception of power is of interest in that it conveys the idea that techniques of power can be resisted, socially redistributed, rearticulated, renegotiated, and hence inverted (Foucault 1982: 793), which leads to the question of how farmers react to, resist, but also appropriate and redefine smart-farming techniques, and how this in turn shapes the farming sector.

Thus again, this third analytical objective asks for detailed field research to study how smart-farming solutions affect farming as it is lived, perceived, and conceived (Lefebvre 1991) and thus ultimately to understand how Big Data today shapes the agricultural everyday (Lefebvre 2002: 11). This focus on the everyday invites a focus not only on the rationalities of governing through techniques of systematic attention but also on the cracks, chinks, and gaps left open and produced by these techniques, in which opportunities for escape, creativity, and "interstitial freedom" arise (Lefebvre 2005: 127).

### *Redefining Surveillance*

From the preceding analytical objectives arises a fourth, theoretical aspiration relating to the concept of surveillance itself. I suggest using the smart-farming problematic as a prism through which to advance new conceptual understandings of governing through data accumulation and analysis. The topic is of interest for several reasons.

First, it allows the study of surveillance beyond the usual risk focus, thus inviting a more sustained reflection on systematic data accumulation, management, and analysis in relation to sustainability, efficiency, and productivity (Klauser and Albrechtslund 2014). For example, agricultural applications to consider range from crop management to field robotics and from automated fertilization applications to real-time assistance through weather and disease alerts. This will allow the investigation of how differing aims and modalities of smart farming inform each other, support each other, modify and shape each other, but also conflict with each other in ceaseless reciprocity.

Second, the field of smart farming reiterates the need to investigate in more depth how the disparate aims and modalities of surveillance coalesce into apparent “whole” architectures and systems. There are many authors underscoring the normality and depth of governing through code in all aspects of present-day life, including agriculture. Yet little attention has been paid to how the disparate aims and modalities of technological mediation of the everyday are combined within an explicitly holistic approach and thus converge, in congruent and conflicting ways, into larger “surveillant assemblages” (Haggerty and Ericson 2000), bringing together heterogeneous driving forces, actors, and means. This is exactly what the Swiss Future Farm is all about.

Third, the smart-farming field offers an opportunity to explore how surveillance incorporates parameters relating to both human and non-human phenomena, from micro-climate modelling to the monitoring of water pipes and cattle movement. So far, surveillance studies are concerned almost exclusively with the collection of personal data relating to individuals and social groups. Yet data that takes into account both human and non-human phenomena may present important parallels and interconnections which on examination shed light on the broader mechanisms and relationships lying behind the current recalibrations of surveillance.

Fourth, the example of smart farming invites a consideration of novel “spaces of surveillance” that are dramatically underexplored in scholarly research. In saying this, I think not only of the field’s move beyond the usual urban focus in surveillance studies, but also of its “volumetric component,” which naturally extends the existing focus beyond ground-level surveillance (such as public space monitored by CCTV cameras, for example). By way of example, think of drones for crop management from the air and underground sensors in water pipes: smart farming is fundamentally volumetric in its spatial logics and implications. This then pushes surveillance studies towards a more systematic theorisation of both the horizontal and vertical dimensions in the exercise and projection of power through systematic attention across and within space and invites a reflection on the possibility of a properly three-dimensional or volumetric type of surveillance studies.

In sum, in moving beyond traditional research foci on the surveillance of humans, on single control technologies, on the risk problematic, and on surveillance on the ground, the field of smart farming offers a fascinating terrain for investigating the agents, practices, and spatialities of surveillance in the present-day world of “governing through code.” Hereby, we should never forget how fundamental agriculture is from both a societal and individual perspective and how immensely important research on its digitisation therefore remains. This makes the actual absence of relevant research in surveillance studies all the more inexcusable and underlines how much deeper we have yet to go.

### **Acknowledgments**

My discussion, in the second part of this piece, of the making, functioning, and acting of smart farming draws upon Klauser and Pedrozo (2015) and Klauser (2017).

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