Ethics of Using AI and Big Data in Agriculture: The Case of a Large Agriculture Multinational

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Abstract: Smart information systems (Big Data and artificial intelligence) are used in the **agricultural industry** to help the planting, seeding, and harvesting of crops, as well as farm management, plant and livestock illness and disease detection. I looked at how a Digital Division at a large agricultural multinational is using smart information systems (SIS), through their SISproject, to provide farmers with local weather predictions, farm efficiency and sustainability metrics, and early detection systems for weed, pests and disease. SIS being used in agriculture, types of data retrieved from the farm, how this data is analysed, and agribusinesses involved in this burgeoning field. Agricultural SIS has the potential to **automate activities** that are typically done by agronomists, allowing for cost reductions, quick and effective crop forecasting, and improved decision-making and efficiency for the farmer. Agricultural SIS also offers agribusinesses an additional revenue, better customer-relations, and reduced costs from hiring additional agronomists and advisors. The world's population will exceed 9 billion by 2050, forcing the agricultural sector to increase its production levels by up to 70%. SIS are being hailed as one possible solution to help plant, seed, harvest, and manage farms better and more effectively. However, the use of agricultural SIS may create a number of ethical concerns. For example, the **accuracy of data and rec-**

ommendations provided by SIS may lead to lost harvests, ill livestock, and loss of earnings. There is also a tension between ensuring an agribusinesses' **intellectual property** and the protection of the farmer's **data ownership**. The use of SIS is relatively expensive, which may create a **digital divide**. Agricultural Big Data is also vulnerable to **privacy and security** threats because it could be used nefariously by corrupt governments, competitors, or even market traders. Sensors, robots and devices may cause harm, distress, and damage to **animal welfare and the environment**.To assess if these ethical issues mirror those experienced in the field, I interviewed three members of this company working on their SIS project. This project combines data retrieved from the farmer with the company's agronomic knowledge to **manage their farm more effectively**. The project was designed to provide farmers with local weather predictions, plant disease in situ detection, and recommendation tools to minimise risk, crop and yield previews, farm efficiency and sustainability metrics, and early detection systems for weed, pests and disease. One of the primary motivations for using SIS technology for the company is the ability to make the farmer's life easier, more productive, and to **save costs**. The aim is to improve farm management, not by increasing fertilizer use, but by more intelligent farming decisions and practices.

The ethical issues faced in the project strongly correlated with those in the literature, with the addition of **employment**. The general public is concerned that SIS will replace human jobs, such as the agronomist, but the team stated that their SIS is intended to complement the human expert, rather than replace them. **Accuracy and availability of data** proved to be an issue because not all farmers had available data and data retrieved from third-parties may not be accurate. The team ensure that their customers' **privacy**is protected by having strong **security** measures to avoid misuse and hacking. **Data ownership** belongs to the farmer and they can move to a different farm management system supplier, with that data, if they choose to. The tool is free to use to avoid the issue of a **digital divide**. The company incorporate a strong **sustainability** agenda into their SIS, developing it from the European PEF (Product Environmental Footprint) and a Life-cycle assessment (LCA) framework. Overall, my report was able to evaluate how ethical issues found within the SIS literature correlate with those identified, and tackled, in practice.

Keywords: Big data, Agricultural, AI, SIS, Technology

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1 Introduction

Approximately 26.5% of the world's population work in agriculture, which accounts for nearly $3 trillion in global trade (The World Bank 2018). Despite this, it is an industry that needs to grow its production levels by 70%to feed the world's growing population by 2050 (Schönfeld, Heil and Bittner 2016; Kamilaris, Kartakoullis, and Prenafeta-Boldú 2017). In addition, our current ecological footprint is twice the level that it should be; leaving the agricultural sector with the colossal challenge of producing more food, while reducing their ecological impact (Popa 2011; Wolfert, Sørensen, and Goense 2014).

The agricultural industry is looking at different solutions to meet these challenges, one of which is data analytics. Big Data analytics is seen as the fourth technological revolution in agriculture and it is hoped that it will provide a solution to our growing food demands (Kumari, Bargavi and Subhashini 2016; Morota et al. 2018; O'Grady and O'Hare 2017).[1]

It is predicted that Big Data analytics will take on a fundamental role in the future of agriculture (Zhang et al 2014; Carolan 2015). Agricultural Big Data, data analytics, and machine-learning algorithms are the catalysts that are expected to underpin the realisation of the world's agricultural goals.

Agricultural Big Data analytics is the analysis of large datasets from a wide range of resources, often using artificial intelligence (AI) techniques. The integration of Big Data and AI (Smart Information Systems - SIS) is expected to be vital for the successful growth of the agricultural sector. Agribusinesses are now shifting their focus towards data-driven agricultural solutions.While these developments are seen as effective ways to achieve the challenging goals ahead, they also raise a number of serious social and ethical concerns that we will analyse in this case study.

The primary research questions are: Which ethical issues arise in the use of SIS in agriculture? And how can they be

The primary research questions that will be addressed in this case study report are: Which ethical issues arise in the use of SIS in agriculture? And how can they be addressed? To answer the questions, the key issues within the literature on the topic will be analysedand interviews with three staff members working for a large multinational agricultural organisationwill be conducted.

The aim of this case study is to identify ethical issues that may appear in practice in an agricultural organisation that are not covered in the literature; whether or not they face

[1] The industrial revolution, the green revolution, and the biotechnology revolution.

the same issues discussed in literature as in practice; and if there are policies and procedures set in place for addressing these concerns.

The case study will be divided into four main sections, with the first two sections focusing on an analysis of the literature in the field, while sections three and four focus on the organisation. Section 1 will analysethe current implementation of agricultural data analytics and establish how SIS technology is used in practice; while section 2 will concentrate on a range of social and ethical issues surrounding SIS use and implementation in the agricultural sector. Section 3 will analyse anorganisation using agricultural SIS technologies: the large agricultural company. Section 4 will critically evaluate ethical issues that arise when using SIS technologies in the company, incorporating the three interviews done at on August 22nd, 2018.

2 The Use of SIS in Agriculture

Before analysing the social and ethical issues that may arise from using SIS technology in the agricultural sector, it is important to understand how and why these technologies are being developed in the first place. In order to effectively understand the societal and ethical implications of using such technologies, it is vital to elaborate on the types of data being retrieved, where they are being retrieved from, and how are they being applied.

This section will focus on the use of SIS in the agricultural sector in order to elucidate the different ways these technologies are used in practice and by whom, i.e. who are the companies developing them. An extensive literature review was conducted of the different ways that agricultural SIS technology is used and implemented, and on a number of agribusinesses integrating SIS within their business models in order to demonstrate how they are being incorporated in practice. The review ranged from computer science, agricultural management, and agricultural practice, to agricultural Big Data literature, in order to establish an exhaustive overview of the different stages of agricultural SIS technology's use and application.

To begin with, there are many different components in agricultural SIS integration, from the retrieval, analysis and prescription of data. The *types* of data retrieved range from: animal movement and grazing patterns, soil moisture and nutrient level, irrigation, rainfall and climate, land imagery, crop growth patterns, and market pricing (Bennett 2015; Kamilaris, Kartakoullis, and Prenafeta-Boldú, 2017).

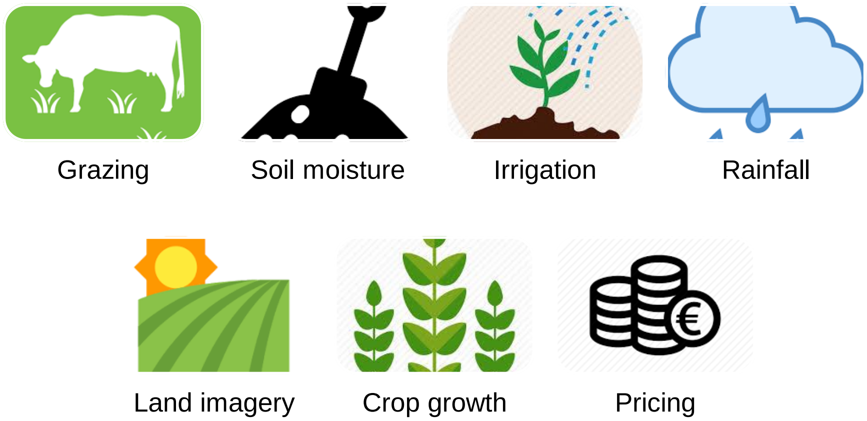

Figure 1: Types of Agricultural Data Retrieved

This data is retrieved from many different *sources*: weather stations, surveys, static historical datasets, geospatial data, satellite imagery, farm sensors, farm equipment sensors, radiation sensors, climate sensors, and GPS-based field maps (Tzounis et al. 2017; and Ribarics 2016). The data is also applied in a number of different contexts: weather and climate, land, animal research, crops, soil, weeds, food availability and security, biodiversity, and farmers' insurance and finance (Kamilaris, Kartakoullis, and Prenafeta-Boldú, 2017).

Despite the potential value of applying agricultural Big Data in all of these contexts, the amount of data that is currently being analysed is still relatively small (Hirafuji 2014). This is set to grow rapidly because of the abundance of *benefits* promised by the effective use of agricultural BigData. These include: improve water and air quality, improved soil health, food quality and security, protection of biodiversity, improvements to quality of life, increase output, cost reductions, crop forecasting, and improved decision-making and efficiency (Castle, Lubben, and Luck 2015, Mintert et al. 2016, O'Grady and O'Hare 2017, Schönfeld, Heil and Bittner 2016, and Sonka and Cheng 2015).

Figure 2: Promised Areas of Improvements of Agriculture by Data[2]

It is argued thatSIS can help during the planting stage to maximise crop yields, or to react to diseases, animal ill-health, or unfavourable climatic conditions. SIS can also assist farmers in managing their farms through effective 'prescriptive farming' (Antle, Capalbo and Houston, 2015). Therefore, many propose that 'good farmers do not follow their gut, they follow data' (Carolan 2015, p. 11).

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Monsanto estimate that data analytics will increase global crop production by $20 billion annually (Bunge 2014). Therefore, traditional agricultural businesses (e.g. machinery, seed or chemical companies) have branched out into data analytics, to become agricultural technology providers (ATPs). They sell prescriptive analytics to farmers: 'The farmer generates (or hires the dealer or a third-party company to generate) data on field-specific attributes such as GPS-coded soil sampling and field maps for selected plots of land' (Sykuta 2016, p. 60). Using different machine-learning algorithms and data analytics software, along with a wide-range of the company's datasets and acquired datasets, the farmer's data is transformed into prescriptive recommendations by ATPs.

There are many different agricultural companies implementing SIS technology in their programs. For example, Monsanto's FieldScripts® program retrieves data from the farmer and combines it with Monsanto's agronomic knowledge and prescribes recommendations to the farmer. 'The dealer and Monsanto's field agents help monitor performance through the season and advise on field management needs. At the end of the season, the farmer submits yield data to help improve future prescriptions for the field, which Monsanto can incorporate to update its basic algorithm as well' (Sykuta 2016, p. 61).

[2] Cost reductions, crop forecasting, and improved decision-making and efficiency are additional promised benefits directly for farmers.

DuPont Pioneer's Field360™ and WinField R7 programs identify hybrid seed selection, provide crop management projections and crop growth estimations, and recommend planting methods (Sykuta 2016, p. 61). Pioneer's Field360™ Select Software 'combines current and historical field data with real-time agronomic and weather information to help growers make informed management decisions' (Antle, Capalbo and Houston, 2015, p. 3).

John Deere attaches sensors to its farming equipment and analyses the data collected from them, then sells recommendations back to farmers (Bronson and Knezevic, 2016). John Deere's analytics service costs farmers $15 per acre of farmland but promises a $100 per acre increase in profits. 'This programme gives users access to algorithms that show historical trends of soil moisture and crop level weather patterns going back 30 years. The product allows farmers to plug in different seeds and receive as output, before planting season has even commenced, what their likely yields will be that fall' (Carolan 2015).

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The integration of data analytics is often intertwined with traditional agricultural business models, for example, the seed business for Monsanto and DuPont Pioneer, and tractor business for John Deere. Many of the most notable agribusinesses are driving towards an adoption of the "smart farm" framework, fully technologised with a constant retention and application of data (Coble et al. 2018).

There are many pressing social and ethical concerns in the literature relating to the implementation of smart information systems within the agricultural domain. It is important to analyse these in order to identify which ethical issues arise in the use of SIS in agriculture and how they can be addressed. It is also important to identify these issues for comparative purposes with the issues highlighted in the interviews with three members of this company, later in this report.

3 Ethical Issues of Using SIS in Agriculture

In the key journals on agricultural and environmental ethics, there was no research published on the ethics of SIS in the agricultural industry. These journals included 'Agriculture and Human Values', 'Journal of Agricultural Ethics', 'Journal of Agricultural and Environmental Ethics'. 'Environmental Values', 'Environmental Ethics', and 'Ethics, Policy, and Environment'.

A broad keyword search, using multiple different variations, was therefore conducted to attract relevant articles, achieved by collating literature from bibliographical databases: Google Scholar, ScienceDirect, Web of Science and Scopus. Using this approach, the following issues were identified: accuracy of data and recommendations provided from algorithms; data ownership; digital divide, privacy and security; and animal welfare and environmental protection.

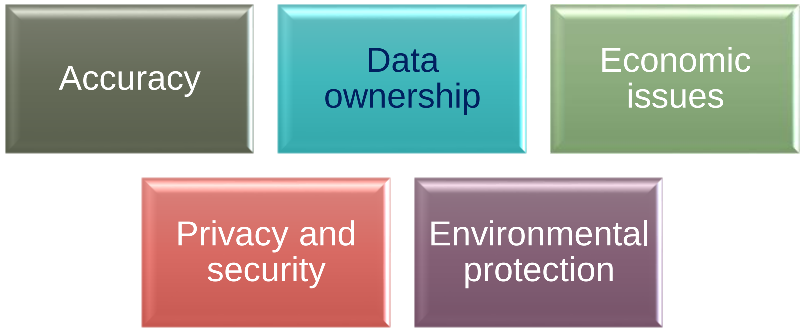

Figure 3: Ethical Issues in the Literature – SIS & Agriculture

3.1 Accuracy of Data and Recommendations

The primary purpose of integrating SIS technologies within the agricultural sector is to enable better decisions, adaptation to circumstances and prescriptions (Talavera et al. 2017). However, some claim that machine learning is not fit for purpose because the algorithms used are only suitable for small datasets (Zhang et al. 2014). These algorithms cannot effectively analyse Big Data or large datasets because of their inability 'to strike a balance between timeliness and accuracy of processing' (Zhang et al., 2014, p. 141). This is a technical limitation that needs to be addressed within the agricultural sector, and more broadly, the SIS industry as a whole. Limited data may also create misleading conclusions. ATPs may provide prescriptive recommendations that cause detrimental outcomes, which are based on incorrect or inaccurate data (Taylor and Broeder 2015, p. 13).

There is also a possibility that the retrieval of data is misleading or inaccurate because of environmental circumstances. For example, animals may interfere with SIS technologies by affecting the radio signals used to communicate by being too close to sensors or interfering with the equipment (O'Grady and O'Hare 2017). Sensors can be shielded against damage, but there are also concerns regarding circumstances that give false readings, such as temperature extremes and humidity (Tzounis et al. 2017). Possible interferences need to be considered to minimise false readings, skewed analytics and misleading prescriptions.

Another potential issue is that data may be difficult to interpret because of local differences or idiosyncrasies (ByarugabaAgaba et at. 2014, p. 21). Therefore, there is a clear need to analyse data contextually to make unbiased decisions (Taylor et al. 2014). If these differences are not factored into the prescriptive analysis, it may lead to lost resources and harm to the farmer's livelihood. ATPs also need to be confident in the accuracy and legitimacy of information provided by farmers in order to provide appropriate recommendations (Lokers et al. 2016). While the accuracy of data and recommendations are not ethical issues in themselves, providing inaccurate data to farmers or giving inaccurate recommendations may lead to lost harvests, ill livestock, and loss of earnings and negative impacts on their business.

3.2 Data Ownership and Intellectual Property

There are concerns about distribution of farm data to third parties (Rosenheim and Gratton 2017, p. 403). Farmers fear that their data may end up in the wrong hands and subsequently be used against them (Ferris 2017). Some farmers worry that if they surrender their data, it will put them in a precarious position in the future (Coble et al. 2018, p. 84). They are concerned about the collection and dissemination of their data to regulatory bodies, agencies and governmental officials (Sykuta 2016). Their data may be used against them in a wide array of different contexts, such as regulatory enforcement, imposition of charges, fees, fines, and restrictions. There is also the concern that their data will be used by commodity traders on the stock market (Ferris 2017). This could be used against farmers by finding out specific information about the farm that would allow traders to purchase it for less, or be used as a bargaining chip against the farmer.

Who owns the data and who can monetize the data?

Therefore, one of the most contentious issues relating to SIS implementation is regarding data ownership (Schönfeld, Heil and Bittner 2016). Essentially, 'who owns the data and who can monetize [the data]' (Kamilaris, Kartakoullis, and Prenafeta-Boldú, 2017, p. 29). The issue of data ownership raises the question 'whether farms should relinquish control of farm data to third parties' (Coble et al. 2018, p. 84). There is the concern that farmers' data will be used to sell unnecessary products back to them (Ferris 2017). 'Big agricultural firms such as Monsanto might influence farmers to buy specific seeds, sprays, and equipment and are likely to profit from the costs of their service and higher seed sales' (Ksetri 2014, p. 13). There appears to be an opacity about who owns the data retrieved from farms and who has control over their use and implementation (Kosier 2017).

Many ATPs insist that farmers own their data, but the ATPs may include a royalty-free license over these data, so they can be used by the ATP regardless of ownership (Darr 2014). If farmers own their data, and they want to change to a different ATP, they may be in breach of contract. For example, Monsanto have tight legislative controls over their intellectual property and data analytics, and if a farmer breaches their contract, this may lead to penalties and/or court-cases against them. Furthermore, if a farmer is looking for a different ATP, it may be difficult or even impossible to find another ATP because of data ownership issues: 'ATPs may have concerns about receiving data from farmers that the farmer herself does not own, giving rise to potential violations of intellectual property or licensing restrictions' (Sykuta 2016, p. 66).

ATPs have tight legislative controls over their intellectual property and data analytics, and if a farmer breaches their contract, this may lead to penalties and/or court-cases against them.

Fundamentally, ATPs need to protect their intellectual property rights and investments in SIS. One way to ensure this is through contractual agreements with farmers. However, in the United States 'fewer than seven percent of small-scale and medium-scale farms used contracts while over 50 percent of very large farms used contracts' (Sykuta 2013, p. 19). The use of SIS technologies may force smaller farmers into contractual obligations with ATPs. Many of these farmers have no experience with legal documents and contractual terminology, so there is the possibility that farmers will not understand what they are consenting to when using SIS, raising ethical issues around sufficient informed consent to enter into these agreements. In addition to this lack of knowledge about legal descriptions, there is also the concern that the technologies themselves are beyond the average farmer's capacity.

Data retrieved from farms is often inaccessible to farmers themselves, with many fearing that they do not have the technological capacity to use SIS (Sykuta 2016, p. 60). Technical knowledge is required to interpret this data, and farmers may not be able to get this knowledge for free, and so become dependent on ATPs (Schönfeld, Heil and Bittner 2016). There is also the possibility that the role of farmers will be reduced, and a lot of associated freedoms curtailed, because of data analytics (Wolfert et al. 2017). Farmers have already started to see restrictions imposed on their land and farm machinery. Companies such as John Deere have implemented policies that disallow farmers repairing or fixing their own machinery, as this may infringe upon copyright and intellectual property given that the company's hardware is contained on/within the vehicle. Any tampering with these devices is hence a breach of contract, and subjugated to economic penalties (Carolan 2015).

3.3 Economic Issues and the Digital Divide

Small farms far exceed the number of large farms globally. In the United States alone, 66% of all farms do not exceed $1 million in annual sales (USDA NASS, 2014). In LMICs (low-to-middle-income countries), most agriculture occurs on small farms with very little technology. However, most agricultural data analytics is only being done on large monoculture industrial farms (Carbonell 2016). This may cause an issue of disproportionate growth of larger farms and the potential dissolution of smaller farms. The use of SIS technologies is relatively expensive, which may also prevent poorer farmers from adopting them (Kosier 2017, p. 11, Schönfeld, Heil and Bittner 2016). This leads to a 'digital divide' between those who can implement SIS and those who cannot (Kamilaris, Kartakoullis, and Prenafeta-Boldú, 2017, p. 29). Rural remote locations may also suffer from data transmission limitations, which could prevent farmers from using these technologies. SIS technologies hence have the potential to create or exacerbate inequalities between those who can use them and those who cannot (Poppe, Wolfert and Verdouw 2014).

The agricultural sector is the largest employer in LMICs and requires substantial growth in the coming years to meet increasing food demands. In these countries, yields are often reduced by up to 40% because of poor farming techniques, lack of information and incorrect planting, weeding and harvesting times (Ksetri 2014, p. 10). Therefore, one of the biggest areas of potential for SIS is in LMIC countries (Ksetri 2014). There is hence a push towards transforming unstructured data into implementable goals for LMIC development (Global Pulse 2012, Panicker 2013) and the UN has proposed that significant development in LMICs will be the result of effective data analytics and the implementation of their results (Micheni 2015). However, there are many obstacles impeding SIS adoption in LMICs, such as the lack of technical capabilities to analyse and formulate this data in lower tech countries, lack of investment, poor technological infrastructure, and political and economic instability (Micheni 2015). Furthermore, privacy and data protection laws are quite scarce or non-existent in many LMICs, so the collection and processing of data remain essentially unregulated (Taylor and Broeder 2015, p. 15).

3.4 Privacy and Security

Even though information about individuals could potentially be anonymised, Big Data in agriculture may still lead to negative repercussions for groups of people. Authorities and corporations can draw conclusions and implement courses of action at a group level, for instance, which may be undesirable for farmers. Essentially, 'it is precisely being identified as part of a group which may make individuals most vulnerable, since a broad sweep is harder to avoid than individual targeting' (Taylor 2017). This is particularly pertinent in LMICs, where there is less data protection regulation. For example, in sub-Saharan Africa, only 8 out of the 55 countries have data protection legislation (Taylor 2017). In the agricultural sector, this data could be used nefariously by corrupt governments, competitors, or even market traders.

At present, there is very little regulation on agricultural data (Ferris 2017). It is claimed that Big Data in the agricultural sector is not as vulnerable to privacy and security concerns as other sectors (Zhang et al. 2014). This is because ATPs do not collect obviously sensitive data, such as information about children, banking data, or healthcare records (Ferris 2017). Despite this, farmers still provide a wide range of details about their farm. Personal information relating to names, locations, property types, income levels and valuations are retrieved for processing (Ferris 2017). These are all personal data, some highly sensitive, e.g. income. There is also a concern that drones, and other data-retrieving technologies, will monitor third-party individuals, infringing upon their personal privacy (Schönfeld, Heil and Bittner 2016).

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Big Data is retrieved from many different sources, such as radio equipment, agricultural information websites and mobile terminals (Zhang et al. 2014). As a result, there are a multitude of potentially sensitive data types that need to be stored and transferred, so data security is a very important concern for farmers (Tzounis et al. 2017). Farmers need to be assured that their data are safe, used appropriately and interpreted in the correct manner (Lokers et al., 2016). However, this is difficult to universalise because the 'nature of data security issues also differ by vendor given their services and platforms' (Sykuta 2016, p. 60). Also, the type of data that is retrieved varies in terms of security needs, for example, securing data about a farmer's sales and yields may be far more sensitive than data about rainfall levels on the farm.

3.5 Animal Welfare and Environmental Protection

The implementation of sensors, robots and other devices on farms may cause undue stress or harm to farm animals and external wildlife. These electronic devices and sensors may upset, injure or even kill livestock and/or local wildlife. Robots, sensors and unmanned aerial vehicles (UAVs) also have the potential to emit toxic material, fumes and waste into their surrounding environment. An additional concern is that the algorithmic prescriptions used by such devices may cause detrimental effects because they do not consider land external to the farm (Antle, Capalbo and Houston, 2015). For example, some potential effects could be surface water run-off, encroachment on habitats, or general pollution to the surrounding area. Therefore, the ecological and social effects of implementing and deploying SIS technologies to the wider environment are significant factors (Kosier 2017).

After discussion the many ethical issues covered in the literature that are related to the use of SIS in the agricultural industry, it is evident that these concerns cover a broad spectrum of issues. In order to better understand the ways in which these issues arise in practice, the following section will describe a specific case of agricultural SIS.

4 The Case of a Large Multinational Company Using SIS in Agriculture

This multinational agricultural company implements and uses SIS technology within the agricultural sector. Three interviews were conductedwith the company's staff members. During these interviews, their interactions with SIS and what they view as some of the most fundamental issues pertaining to this technologywere discussed. The interviews were conducted on August 22nd, 2018 at their headquarters.

The three interviewees were Interviewee 1, Interviewee 2, and Interviewee 3working in the company. The interviews were transcribed a month later and evaluated in early October. A qualitative analytics software tool (NVIVO) was usedin order to categorise, define, and evaluate the content of the three interviews. Topics were split into different nodes during a two-day SHERPA consortium workshop to evaluate 11 SHERPA case studies. A range of sections pertinent to SIS technology was established. The interviews conducted at the companywere then segmented and categorised within these nodes, which were analysed to produce this report.

Interviewees Working on the SIS Project			
Interviewee	Interviewee 1	Interviewee 2	Interviewee 3
Role in Organisation	Global Governmental Affairs & Management	Sustainability	Foundation Division

Length of Interview	40 minutes	35 minutes	55 minutes

Table 1:*Interviewees Working on SIS Technology*

4.1 The Interviewees

The interviewees from were Interviewee 1, who works in Global Governmental Affairs and Issue Management; Interviewee 2, who works on the sustainability component of the SIS project; and Interviewee 3 working on the backend running of it. Interviewee 1's role focuses on the advocacy of digital initiatives in the company and ensuring communication with different stakeholders, such as policymakers and governmental bodies. Interviewee 2 is

> *'the architect of algorithms which translate farming practices into sustainability language, and then back into, hopefully, improving farming practices' (Interviewee 2).*

The Interviewee 3who was interviewedworks in the Foundation division of the company, ensuring the functionality and usability of the backend systems of the project, such as user management systems, managing users.

4.2 SIS Technologies atthe Company

The project was launched a few years ago to provide farmers with a range of crop management options within one comprehensive platform. It is intended to complement the company's otherprogrammes, by personalising the exact purchase needs of farmers. They are collaborating with the tech companies that can retrieve weather conditions, wind speeds, crop protection, and pest and agronomic data.The company then analyses these data to produce effective agricultural solutions for farmers. By combining these data with the company's agronomic knowledge and individual farmer data, it aims to provide solutions to allow farmers use their land more effectively.

The project consists of three fundamental components: Component 1 provides farmers with local weather predictions, plant disease *in situ* detection, and recommendation of tools to minimise risk. Component 2 provides farmers with crop and yield previews, farm efficiency and sustainability metrics, and early detection systems for weed, pests and disease. It is used by the farmer to manage the agronomic activities of their field, by inputting when particular crops were sown, what kind of crops, so thatitcan provide outlines of how that crop should grow. This tool has large modelling potential and image recognition, which allows the farmer to see the growth cycle of crops and to detect potential threats to the crops. Component 3 is a support system for farming consultants who are working with farmers to find ideal agricultural planning solutions. It is a Windows tablet application and is used by the company's advisers to engage with the farmers and to make recommendations about what products might help them. The software can be tailor-made for each farmer, by factoring in a multitude of data from their location, soil types, crops grown, weather predictions, and farm size.

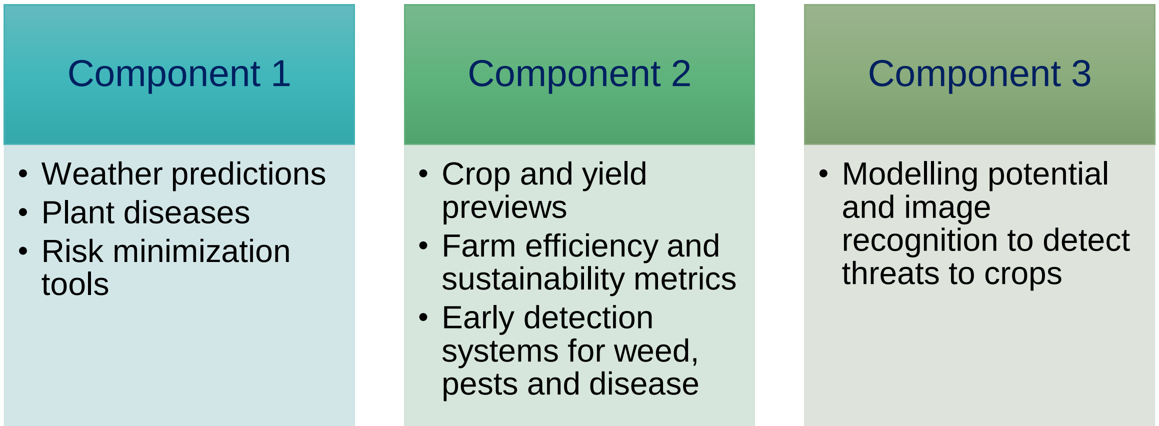

Figure 4: Components of the company's SIS

The company uses image-recognition software that receives images from the farmer, identifies particular crops, and recognises spots or abnormalities on the leaves for early disease detection. This software uses machine-learning techniques to analyse weather data to detect potential crop threats and disease. Interviewee 3noted that the project team are using a wide array of different Big Data and machine-learning tools, such as Hadoop Stack, SAP HANA, and cloud-based systems.

The company have been providing technological solutions to farmers for a long time, and they view the data analytics service as the next logical step to help farmers achieve the best possible yield on their farms in a sustainable and effective manner. They view the integration of their SIS project as a way of reinforcing their goal of providing effective crop protection solutions. One of the aims of the company is to provide farmers with answers far quicker than previously. They stated that if they are unable to get to a customer's farm to provide guidance, they could do it with remotely-accessible tools such as this SIS project, before incidents occur.

One of the primary motivations for using SIS technology for the company is the ability to make the farmer's life easier, more productive, and to save costs (Interviewee 2). They want to incorporate its sustainability paradigm through the use ofSIS. It allows farmers to identify their carbon footprint, their impact on biodiversity, and the environmental impact of their activities. Essentially, through this SIS, the company hopes to improve farming, not by increasing fertilizer use, but by more intelligent farming decisions and practices (Interviewee 1). There needs to be an investment in knowledge and the use of farm management software is one way that this can be optimized (Interviewee 1).

Component 2 of their SIS is available on the web and can be used with most modern internet browsers and is available on Android and iOS tablet applications. However, there are no MAC versions available at present. It is available free-of-charge and anyone with an internet connection can download the software. Hence, it could potentially offer valuable services to farmers around the world, something too costly if done by sending trainers to these locations. However, it is hoped that the service can be charged for in the future.

4.3 Potential Technical Challenges of Using SIS for the Company

All three interviewees emphasized that the project is still in its very early stages of development. Their goal is to effectively communicate a wide range of recommendations to farmers. The sustainability component of the project was envisioned through a wish-list of what they would like the system to do and requirements that should be programmed into it. There is the hope that by mid-2019 users in Europe and Canada will be able to see:

> *'the fully-fledged indicator systems for sustainability, presented in a nice way' (Interviewee 2).*

The SIS are supervised by human beings, carrying out regular analysis of the recommendations that it proposes. All three interviewees stated that they were aware that algorithms may be fallible. There is a wide array of disparities with variables that measure weather, soil and plant disease. These variants can cause a lot of difficulties for artificial intelligence algorithms.

The image recognition software to detect plant disease has to be effectively trained on a very large and growing repository of images. The company have created an algorithm that can be very helpful, if the data repository is sufficient. So far, they have hundreds of thousands of plant images in the repository. Furthermore, the system is only as effective as the datasets that it is being trained on. If the system is not trained on a particular dataset, i.e. a banana leaf, then the system will not be able to effectively identify what that image is. However, if you ask an agronomist, they will be able to tell you straight away that it is a banana leaf. Therefore, their SIS will not replace agronomists anytime soon, as there will always be exceptions where the farmer needs human expertise as a result of the lack of intelligence of machine-learning tools. The Interviewee 3 stated that when there are issues with their SIS, it is the result of data quality issues or lack of data, and not necessarily the algorithms. The algorithms work effectively with the training data that they are provided with, if there is poor or lacking data, then you get poor results.

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Also, there are natural variations from country-to-country and region-to-region, such as differences in pest management, climatic conditions, and crop types. The company is aware that the SIS cannot establish a one-size-fits-all approach for their project and changes their algorithms for different regions. Another constraint lies in the actual labourpower required to maintain many farm management systems, requiring a large department to work on it. Particularly, when it comes to ensuring the safety and security of the farmer's data.

Interviewee 1 said that recommendations to improve sustainability are dependent upon data availability and the ability to extract useful and meaningful information from this data. While there are interesting questions that would help their algorithms, farmers did not want to disclose certain pieces of information; for example:

> *'How much land do you dedicate to agri-environment schemes?'* (Interviewee 2).

The focus of national sustainability discussions has also proved to make developing universal algorithms for all countries challenging because of their varying needs. For example, some countries like to talk about biodiversity, so it is incorporated into the SIS' algorithms, whereas in other countries different sustainability parameters take precedence.

4.4 Feedback from Stakeholders

The team received some negative feedback about particular aspects of the SIS and changed those features accordingly. One of the main challenges was creating simple and effective user interfaces, and external companies and consultantswere employed to assist. Traditionally, the company has been a b-to-b company[3], but this project differs in this approach because it can also be used by the end-user. The project pays close attention to user needs and incorporates feedback and input from farmers into the dashboard's functionality.

Feedback on the project was obtained through focus groups and farmer associations. It was not a 'co-creation', according to Interviewee 1; but farmers were heavily involved in improving the tool. He stated that one of the main objectives of the project was to be able to make the information provided to farmers accessible and understandable. Whether or not it would be successfully adopted and used depended on how effectively message were translated:

> *'We are nerds, we are geeks sitting here in an ivory tower and we like everyone to know all this stuff, but the real world is the world of the farmers, and we have to translate information in a way that farmers find this understandable and, to maybe [to] some extent, appealing'* (Interviewee 2).

Because the platform is still in its infancy, the company is still working to identify how it has improved the lives of farmers and ways to improve it going forward.

> *'We start a pilot with a dedicated number of farmers, let's say 20, 50, 100. With these farmers, we have intense interaction. ... We repeat that for every country. You could say, "We've done it in the United Kingdom, so we can start it in Germany directly." No, we don't do that'* (Interviewee 3).

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[3] Business to business company.

The company are aware of the different needs and effects of their SIS on stakeholders, so they need to carefully design it for each region. The team have worked with many different weather companies, dashboard design consultants, and advisory boards to develop their SIS. The SIS is sent for external review to ensure that it is fit for purpose and functions according to their intent.

Figure 5: Ethical issues identified from using SIS at the company

5Ethical Issues from SIS Technology

Throughout the three interviews conducted at the company, and through desktop research conducted from the company's website and a number of other sources, certain ethical issues were highlighted as a result of using SIS technology in the company. These issues largely reflect those found in the literature, as above, highlighting a great deal of correlation between academic understanding of the issues with those working in industry as below.

5.1 Accuracy of Data and Recommendations

One of the problems that the company encountered initially was that not all farmers had data available to be evaluated because of poor record-keeping. An issue related to the plant recognition technology used to identify plant disease was the inability of some farmers to take clear pictures of the plants. If the image data is unclear, it is extremely challenging for the image recognition algorithms to determine what plant it is.

Data retrieved from third-party weather companies may not be accurate, and micro-climatic conditions may occur in certain fields that are not represented in the algorithms. So, for instance, if the weather data being put into the plant growth algorithm is inaccurate, there may be discrepancies with the growth predictions. Interviewee 3 stated that the problem usually lies with the accuracy of the data being inputted into the system, rather than the algorithms, if there are issues or discrepancies with the system.

If the weather data retrieved from weather APIs is inaccurate, then it may lead to inaccurate growth projections in their crop growth stage predictor. However, if these growth predictions are inaccurate because of misleading weather data, the farmer still has the ability to update the projections with what is happening in reality. For instance, if the SIS tells the farmer that his crop is at BBCH[4] stage 32, but it is at stage 36, they can reset and recalibrate the system. The Interviewee 3 mentioned that they are aware that the SIS will not be perfect every time and they have considered methods to counteract these errors.

The SIS gives prescriptive recommendations to the farmer, but if it gives inaccurate recommendations, who is held responsible or how is this problem resolved, is an important question for the project. When discussing potential issues with AI, Interviewee 1 gave the example of another project that the company are working on, a robot that weeds and plants crops, theirrobotics project.In this example, Interviewee 1 stated that the worst thing that could happen is that crops are destroyed, but that because of the procedures set in place, error detection would either be straight away or within a day or two. Therefore,

> *'damage that such a robot can do in one day is nearly negligible' (Interviewee 1).*

While most of these SIS are in their early development stage, and their impact and effect is quite small, it is still an important concern for the company and they stated that they are taking these factors on board.

5.2 Data Ownership and Intellectual Property

Issues surrounding data ownership and intellectual property are very important within the use and implementation of SIS technology and the data retrieved to make these processes work. Therefore, the types of data retrieved is an important factor to identify. After discussing this with the Interviewee 3, he mentioned that there are a number of different types of personal data retrieved from the farmer:

> *'we have his name, we have his email address, we have his phone number, mobile phone number if he gives it, we have his postal address if he gives it. The farmer is creating his farm, at a certain location, so we have geo coordinates. The farmer is growing his fields, so we have – even – field locations' (Interviewee 3).*

The Interviewee 3 also mentioned that it is a top priority for the company to securely protect this data from misuse, hacking, and the misappropriation for economic or marketing purposes. He stated that the company does not use the individual farmer's data to make comparisons between farms, and if this is done in the future, it would not be done without explicit informed consent from the farmers involved. The data are used for the benefit of the farmers, the improvement of their algorithms, and the development of the SIS technology.

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All three interviewees made it explicit that the farmer owns their own data and they can move to a different farm management system supplier, with that data, if they choose to.

[4] BBCH is a scale used to identify the phenological development stages of plants.

During the interviews, it became clear that there needs to be a symbiotic mutually beneficial relationship between the farmer and the agribusiness in order to procure data to improve SIS:

> *'we are convinced that people are willing to share data if they have a benefit from that' (Interviewee 1).*

It is aimed to help improve the farmer's yield, help sustain their business, and remove some of the costs from hiring agronomists. Using agronomists can be expensive, but the company is aware that their SIS would not replace the effectiveness of human input provided by agronomists.

5.3 Economic Issues and the Digital Divide

One of the key constraints in agriculture is the pressure being placed on farmers to produce more for less. There are great strains being placed on the farmer by large supermarket and food production companies to supply cheaper, more diverse, and quicker produce. Interviewee 1 noted that, the farmer does not have a great deal of bargaining power in this relationship. The hope is that tools like this will enable the farmer to farm more effectively, thus alleviating some of the strains placed upon them. One key factor in the creation of this project was ensuring that it was affordable and easy to use for farmers, otherwise it would have been rejected in its implementation phase.

As noted earlier, their SIS is available free-of-charge and anyone with an internet connection can download the software. One of the beneficial and essential components of the project is that it opens up the possibility of providing free advice to many poorer nations unable to afford agronomic advice, helping sustainable agricultural development in LMICs.

At the same time, if there were no economic incentive for the farmer, the software would be rejected. Therefore, there was a strong need to make the use of the SIS viable for the farmer. All three interviewees expressed the economic strains placed on farmers underpinned the success or failure of the SIS. If the system helps cope with the strain, it is more likely to be accepted.

5.4 Privacy and Security

The relationship between privacy and data security is a key concern for the company and it was clear that the two were very closely related, with the customer's privacy being ensured by strong security measures. Interviewee 3noted that data security was a very high priority for the company and that they develop the latest methods to ensure their system is secure:

> *'Inside the system, passwords … are encrypted. For storing the data, the general mechanisms of SQL[5] databases are used - also, for encrypting. The data is as se-*

[5] Structured Query Language.

> *cure as our system is, to prevent it being compromised by having an intruder there that can get his hands on the farmer's data' (Interviewee 3).*

In order to ensure that this data security is maximized, the company hires third-party organisations to test their systems and to coordinate attacks to find issues or problems. The SIS team are aware of issues surrounding reverse engineering to access their algorithms, so they put great emphasis into securing all of their platforms. If their servers are secure and their software is fully encrypted and secured, then there is little chance that farmers' data will be breached, according to the interviewees. The project works within the company's code of ethics, so abides by their use of customer data and other regulations. Interviewee 1 emphasized that they aim to promote transparency and legitimacy within the project,

> *'to make sure that what we defend in public is what we want to see also within the company' (Interviewee 1).*

One of these goals is the strong emphasis within the company on sustainability, putting a dedicated focus into ensuring that sustainability goals and parameters are implemented into the SIS.

5.5 Environmental Protection

There were no customer requests to have a sustainability component put into the SIS, but the company viewed it as an important factor to integrate within the SIS. Interviewee 1 pointed out that when the usefulness of the SIS was explained to farmers, and that it can be used to comply with different regulatory procedures, it was more widely accepted. Interviewee 1 said that the project is aligning sustainability certification schemes within it in order to help farmers meet these certifications. The sustainability criteria were developed from the European PEF (Product Environmental Footprint) and the company's Lifecycle assessment (LCA) frameworks (European Commission 2018). However, Interviewee 1 is aware that countries will have different sustainability standards, so their SIS needs to account for these differences.

The project was launched in North America and focused on providing advice within this context. They were aware that the algorithms used for these farmers could not be universally used for farmers everywhere. Different algorithms are required because of the varying climatic conditions, crop types, and needs of farmers worldwide. Interviewee 1 stated that sustainability needs are local and require different sustainability parameters and there was a trial-and-error process in the beginning to fix bugs, as this project was a prototype. All three interviewees emphasized that this SIS was still in its early stages of development, but the company is working hard on resolving any issues that may arise. They are taking a fresh perspective in the industry by incorporating a sustainability component within their farm management system to anticipate future constraints placed on farmers, the environment, and society as a whole, in the future.

5.6 Employment

One element that emerged through the interviewees and less so through the literature research was employment. During the interviews, it became clear that farm management systems, like this SIS project, would not replace the role of agronomists because the SIS technology is not advanced enough to account for a wide range of different variables and there are limitations within the technology itself. The SIS technology is intended to *complement* the human expert, rather than replace them. Farmers may also prefer receiving advice from human beings, rather than receiving it from an impersonal SIS technology. Some farmers enjoy and benefit from the discussion and articulation of farming needs and prefer using a human advisor to using a software tool. Furthermore, SIS technology is fallible and very often farmers trust the advice of a human agronomist over artificially-intelligent created prescriptions. Farmers still do not fully trust the recommendations given by AI tools, such as this SIS project, so still rely on the input from agronomists.

6 Conclusion

Despite the SIS applications in the agricultural sector, there are still many social and ethical issues during the integration and use of SIS technologies on farms. This case study demonstrated how SIS is being used in the agricultural sector and the relationship between farmer and ATPs. The three interviews offered perspectives into the real-world application of farm management systems and touchedupon a number of practical, economic, and ethical issues in the use of SIS.

The ethical issues in the use of SIS in agriculture mapped onto those identified through the interviewees, with the exception of employment concerns. Issues of employment were not raised in the literature, despite being a widely discussed topic in the field of SIS. The company state that their SIS will not hinder employment, as they are seen as compliments to agronomists, rather than replacing them. However, on the other hand, it is offered free-of-charge, which reduces the costs farmers have to pay for agronomic consultancy, thus questioning the agronomist's purpose if the technology improves in the future.

The company also protects personal data stored about the farmer and acknowledges privacy concerns during the use and implementation of their SIS technology. In the case of this SIS project, the farmer also retains ownership of their own data, which has been a huge concern in the literature.

While great efforts are being placed into the development of SIS, there are still restrictions and limitations to its effectiveness for implementation, as a result of the changing requirements for different countries. The company's SIS team are aware of this and do not intend to roll out a universal SIS, stating that it needs to be tailored to specific needs of each region it is developed. The integration of stakeholders throughout the process was commendable, but going forward, the incorporation of stakeholder input prior to the use of this SIS may be valuable for the company.

They are aware of the limitations of SIS and expressed the need to constantly develop their SIS modelling and improving their data quality. For instance, the plant image verification software will be trained more efficiently with larger image repositories, while the accuracy will be improved through training farmers to take better pictures. The company is also taking a very proactive approach towards sustainability agendas and issues, implementing sustainability parameters and advice to the farmer through their SIS.

6.1 Limitations

One of the main limitations of this report is that there were only three people interviewed from the company. If it were possible to interview more people, from a wider diversity of roles on the project, it would have enriched the case study. Only one of the interviewees had hands-on experience with the technical side of the project (interviewee 2), the first interviewee's sole focus was on the sustainability aspects, whereas, the third interviewee had a more managerial role, and was a little more guarded about some of the answers that he gave about the project.

The project has only been effectively implemented in one country, and while it is being rolled out in a number of European countries, it is still in its very early stages of development. The team are still in the process of evaluating the effectiveness of SIS, so this proved to be a limiting factor in understanding its societal impact. Therefore, while we were able to discuss and address many of the issues that the company face in their implementation of SIS, the case study could have been enriched if there were evaluations by the company to determine how it affected the North American farmers using it in a more empirical manner.

In addition, the case study was limited by only analysing one agribusiness. While efforts were made to incorporate more organisations into the case study, the larger companies using SIS either did not reply or pulled out of the case study with no explanation. Smaller agricultural companies were identified, but upon discussions with different members from their companies, it was discovered that their technologies are quite primitive, and certainly could not classify as SIS. Therefore, it was concluded that they would be invalid to participate in a case study on this topic.

6.2 Contribution to Knowledge

There has been very little written about the company's use of SIS. This report provides valuable insights into their latest project and ethical considerations around its use. The analysis of this project contributes an empirical evaluation of agricultural SIS and how an agribusiness is responding to the ethical implementations of such technologies, such as concerns around privacy, security, accuracy of algorithms, accuracy of data, and employment.

Overall, the project is in its early stages of development, but there werestill strong correlations between academic and practical issues regarding agricultural SIS, with many of the most pressing issues being identifiedin the interviews. While many of the ethical issues discussed have been analysed within academia in other applications of SIS, they have rarely been discussed in an agricultural context.

This report provides an effective literature review of the area and an original empirical evaluation of a large agribusiness using and implementing agricultural SIS. It provides a valuable contribution of knowledge to the discipline of Big Data/AI ethics, while also contributing to empirical research on the implementation of SIS technologies within the agricultural sector. It offers the areas of agricultural ethics, SIS theory, and the burgeoning topic of agricultural SIS, insights into ethical issues related to the use and implementation of SIS in the agricultural industry.

6.3 Implications of this Report

This report will offer insights to agribusinesses on the ethical issues found in the use and implementation of SIS. Some issues that need to be addressed when integrating agricultural SIS are: how willit develop and what types of data will be required and will the farmer will have to pay for this service in the future. These issues needs tobe addressed and made explicit to the end-userfor its successful ethical implementation.

Another implication of this report is reinforcing the importance of identifying responsibility when SIS does not work as intended, or causes adverse effects as a result of its use. It was unclear if there was an onus of responsibility on the company if negative effects occurred from using the technology. ATPs should clarify in their terms of service and providing adequate informed consent to the farmer about this, and this should also be a prime concern for all agribusinesses implementing SIS on farms. This advice should apply to all agribusinesses working with SIS.

There has only been a handful of policy documents created to tackle issues relating to agricultural data and the integration of SIS technology in this domain. There are very few policy guidelines and frameworks for the ethical use of SIS in agriculture, so this case study offers policymakers some insights into how agribusinesses tackle these issues in practice, namely, who owns farm data – the farmer or the agribusiness? This company instil that the farmer is the owner of the data, which is in distinction from many other companies using SIS.

6.4 Further Research

While this report offers an extensive literature review of the most pertinent ethical, social and legal issues of agricultural SIS, there may be additional matters that need to be evaluated in the future. This report evaluated a number of empirical studies conducted with farmers, the use of SIS technology, and their relationships with ATPs, but further empirical research in these areas would provide valuable insights and contributions to the domain. Furthermore, the field would also greatly benefit from additional case studies with other ATPs in this area.

While this case study covered the company's integration of SIS technology, the ethical issues pertinent within the other three ATPs may be quite different from those found in this report. It would be interesting to have these additional case studies available at some stage in the future to cross-examine the varying styles, implementations, and usages of SIS technology by different ATPs. Additional case studies are required to evaluate the differences between the use and implementation of agricultural SIS in North American, contrasted with European implementation of SIS would also offer some great insights into the field. It would also be highly interesting to see what agricultural ethicists and those working in lobbies opposing unethical actions of large agribusinesses, would say about the development of agricultural data analytics.

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