Big Data on a Farm—Smart Farming

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Abstract Digitization has increased in importance for the agricultural sector and is described through concepts like Smart Farming and Precision Agriculture. Due to the growing world population, an efficient use of resources is necessary for their nutrition. Technology like GPS, and, in particular, sensors are being used in field cultivation and livestock farming to undertake automatized agricultural management activities. Stakeholders, such as farmers, seed producers, machinery manufacturers, and agricultural service providers are trying to influence this process. Smart Farming and Precision Agriculture are facilitating long-term improvements in order to achieve effective environmental protection. From a legal perspective, there are issues regarding data protection and IT security. A particularly contentious issue is the question of data ownership.

1 World Nutrition Using Big Data?

According to recent estimations, by 2050, there will be 9.7 billion people living on earth.[1] Already today, on a daily basis, 795 million people go to sleep hungry. Although this number has decreased by 167 million in the last ten years,[2] it remains

[1]United Nations 2015, World Population Prospects: The 2015 Revision—Key Findings and Advance Tables, https://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf.
[2]Food and Agriculture Organization of the United Nations 2015a, The State of Food Insecurity in the World 2015, http://www.fao.org/3/a-i4646e.pdf.

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uncertain whether this decreasing trend will continue. It is estimated that food production would need to increase by around 60% until 2050.[3] Achieving this using only traditional agricultural and livestock farming methods will be difficult. A main reason for this is that the necessary farmland cannot be expanded without limitations, or at least cannot be expanded in an environmentally sustainable manner. Therefore, Big data concepts such as Smart Farming and Precision Agriculture are important. Digital technologies can make food production more efficient by collecting and analyzing data. Besides the increased demand for food, climate change, and the increased food-price-index have influenced the global agricultural yields, as, for example, the global food crisis of 2007/2008 has shown. The UN even crowned 2016 the International Year of Pulses in order to emphasize their significance as a particularly profitable crop for sustainable food production as well as food security.[4]

But what do concepts like Smart Farming or Precision Agriculture really mean? Which technologies are used? What are the consequences for farmers, seed producers, machinery manufacturers, and IT service providers in the area of agriculture? Which legal issues should be discussed? Those consequences and issues will be discussed in the following overview.

2 Smart Farming

Digitization has an important effect on the agricultural sector for quite some time now. This development can be described through the concepts of Precision Agriculture and Smart Farming. Precision Agriculture includes the implementation of automatically controlled agricultural machines, monitoring of the yields and various ways of seed drilling and fertilizer spreading. The right amount of seeds and fertilizers as well as adequate irrigation requirements can be determined based on soil and field data, aerial photography and historical weather and yield data. In addition, Smart Farming integrates agronomy, human resource management, personnel deployment, purchases, risk management, warehousing, logistics, maintenance, marketing and yield calculation into a single system.

The influence of digitization is not limited to traditional areas of agriculture, but also covers the increasing developments in livestock economy through sensor technologies and robots (e.g. milking robots).[5]

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[3]Sanker/van Raemdonck/Maine, Can Agribusiness Reinvent Itself to Capture the Future?, http://www.bain.com/publications/articles/can-agribusiness-reinvent-itself-to-capture-the-future.aspx?utm_source=igands-march-2016&utm_medium=Newsletter&utm_campaign=can-agribusiness-reinvent-itself-to-capture-the-future.

[4]Food and Agriculture Organization of the United Nations 2015b, Action Plan for the International Year of Pulses “Nutritious seeds for a sustainable future”, http://www.fao.org/fileadmin/user_upload/pulses-2016/docs/IYP_SC_ActionPlan.pdf.

[5]Cox, Computer and Electronics in Agriculture 2002 (36), p 104 et seqq.

The concepts described above use data from different sources, which are collected, analyzed, processed, and linked through various technologies.

The linking of this data is a distinguishing feature of big data in Smart Farming. This stands in contrast to the individual collection of so-called raw data, for example, weather data or the nutrient content of soil.[6]

3 Smart Farming Technologies

Fundamental technologies for Smart Farming are tracking systems, such as GPS. They enable data to be allocated to a particular region of the farmland or determine the current position of agricultural machines or animals in the barn.

Thanks to GPS, highly precise and efficient self-driving agricultural machines stick to an ideal trajectory within the field tolerating a margin of deviation of only 2 cm. Simultaneously, sensors measure, for example the nitrogen content, the weed abundance and the existing plant mass in specific subareas. Research is currently looking into the development of sensors, which record the disease infestation of plants.[7]

The collected data is submitted to computers in the driver's cabin. These then calculate the best fertilizer composition for a specific area of the field based on a fixed set of rules and regulations and subsequently administer fertilizer to the area. Current research is engaged in developing robots, which could carry out certain field maintenance tasks on their own.[8]

Farmers are even using drones to control their fields and plant growth. Images taken by the drones are being used to collect information about the entire farmland area.[9] This data can be linked to the data collected by the sensors of the agricultural machines in order to create, for example, detailed digital maps of specific field areas. Additional data from other measurements can also flow into this data, such as infrared images, biomass distribution, and weather data.[10]

The administration, management and interpretation of these data are further elements of big data.[11] This data can be combined with plant cultivation rules stored

[6]Whitacre/Mark/Griffin, Choices 2014 (29), p 3.

[7]Weltzien/Gebbers 2016, Aktueller Stand der Technik im Bereich der Sensoren für Precision Agriculture in: Ruckelshausen et al., Intelligente Systeme Stand der Technik und neue Möglichkeiten, pp. 16 et seqq.

[8]Sentker 2015, Mist an Bauer: Muss aufs Feld!, DIE ZEIT, http://www.zeit.de/2015/44/landwirtschaft-bauern-digitalisierung-daten.

[9]Balzter 2015, Big Data auf dem Bauernhof, FAZ Online, http://www.faz.net/aktuell/wirtschaft/smart-farming-big-data-auf-dem-bauernhof-13874211.html.

[10]Ibid.

[11]Whitacre/Mark/Griffin, Choices 2014 (29), p 1 et seqq.; Rösch/Dusseldorp/Meyer, Precision Agriculture: 2. Bericht zum TA-Projekt Moderne Agrartechniken und Produktionsmethoden—Ökonomische und ökologische Potenziale, p 44 et seqq.

in the system and used as decision-making algorithms in order to automatically determine management measures. An increasingly higher degree of automation is expected for the future.[12]

Online systems that independently collect and analyze data and immediately convert it into management measures carried out by agricultural machines, allow for a high level of spatial and seasonal dynamic. In contrast, the decision processes in offline systems are based on static data, and the resulting instructions have to be transferred to the agricultural machines via storage mediums such as USB flash drives.[13] Presently offline systems are more widespread, but real-time data systems are catching up. Real-time data systems are distinguished by their use of clouds.[14] Through this process, all data connected with a specific product in one way or another, is merged on one platform, although those platforms are still in development.

In addition to precision and efficiency, the optimization of processes and anticipatory planning are key aspects of Smart Farming. A very good example is livestock farming, where microchips and sensors in collars measure the body temperature, vital data, and movement patterns of cows or other animals. Analyzing this data does not only allow to continuously monitor the health of the cows, but also to determine the appropriate time for insemination.[15] Farmers and veterinarians are notified by a software controlled app.[16] The milking of cows is already entirely carried out through robots, which also control the amount of milk and care for the udders of the cow.[17] In the long run, the effective and useful implementation of big data for Smart Farming in the future requires the development of a nationwide digital infrastructure, especially in rural areas.

4 Social Implications

The evolution in agricultural engineering and management organization has many facets: self-driving agricultural machines, extensively automatized sowing, harvesting, and animal breeding, and also storage, analysis, and data evaluation through software and the use of decision-making algorithms. All those developments facilitate—at least in theory—a more accurate, efficient and ultimately more

[12]Poppe/Wolfert/Verdouw, Farm Policy Journal 2015(12), p 11.

[13]Rösch/Dusseldorp/Meyer (2006), Precision Agriculture: 2. Bericht zum TA-Projekt Moderne Agrartechniken und Produktionsmethoden—Ökonomische und ökologische Potenziale, p. 6.

[14]Poppe/Wolfert/Verdouw, Farm Policy Journal 2015(12), p 13 et seqq.

[15]Poppe/Wolfert/Verdouw, Farm Policy Journal 2015(12), p 13.

[16]Hemmerling/Pascher (2015), Situationsbericht 2015/16, p 96, http://media.repro-mayr.de/98/648798.pdf.

[17]Cox, Computer and Electronics in Agriculture 2002(36), p 104 et seqq.

economical agriculture. But what are the consequences for stakeholders in the agricultural sector and for society as a whole? How does Smart Farming impact the environment?

The most obvious effects are the consequences for the farmers themselves. The machines connected to GPS significantly relieve the driver, allowing him/her to focus on the collected data. The monitoring of animals using sensors and computers reduces the need for presence in the stable to a minimum.[18] It is doubtful though whether automatic rules can replace the experience and knowledge of farmers, and if this trend development really is an improvement. Also, the use of new technology is challenging and requires intensive periods of training for the farmers.[19] Last but not least, there are costs for purchasing and installing the new technology. They can be quite substantial, thus favoring bigger companies, as the new technology is only profitable for companies of a certain size. The ever-increasing automation of procedures contributes to a continuing, decade-long structural change in Germany and the EU that results in the formation of even bigger companies and a simultaneous reduction of jobs.[20]

Along with IT companies that collect and analyze data, new and old players enter the sector. Companies such as Monsanto collect and analyze data and make predictions concerning particular questions, such as predicting the best use of fertilizers. They are even able to predict the expected yield for the year by merging the data. Through these precise predictions, they gain advantages in futures exchanges and business negotiations. Apart from the dependence on seed companies, farmers could also become increasingly dependent on companies collecting and analyzing data. This dependence could be prevented—at least in part—by supporting "Open-Source Data Analytics".[21]

Customers could potentially profit from the collection of data. The extensive recording of the production process allows customers to reconstruct for example where the wheat for their bread comes from and whether or not it has been chemically treated. It is also possible to coordinate supply and demand more efficiently by analyzing data of intermediaries and sellers.[22] The exact amount of chemical and organic fertilizers used can be documented and the environmental impact then be analyzed.[23] Digitalization simplifies the documentation of those

[18]Balzter (2015), Big Data auf dem Bauernhof, FAZ Online, http://www.faz.net/aktuell/wirtschaft/smart-farming-big-data-auf-dem-bauernhof-13874211.html.

[19]Wiener/Winge/Hägele (2015), in: Schlick, Arbeit in der digitalisierten Welt: Beiträge der Fachtagung des BMBF 2015, p 179 et seqq.

[20]European Commission (2013), Structure and dynamics of EU farms: changes, trends and policy relevance, p 7.

[21]Carbonell, Internet Policy Review 2016(5), p 7 et seq.

[22]Poppe/Wolfert/Verdouw, Farm Policy Journal 2015(12), p 15.

[23]Whitacre/Mark/Griffin, Choices 2014(29), p 1 et seqq.

procedures, as well as the detailed documentation of the entire production process from the purchase of the raw materials all the way through to the sale of the finished product, as required by EU regulations.[24]

Environment impacts are also to be expected. On one hand, precise measuring should reduce the amount of pesticides and fertilizers used. This would result in less pollution of soil, groundwater and air. Also, better assessment of data, should reduce the use of antibiotics in livestock farming.[25] On the other hand, those developments reinforce the current trend towards bigger companies and even bigger fields.[26] This would have negative impacts on biodiversity and boost the use of monocultures. However, the use of Big Data in agriculture would also allow for a better assessment of the negative impacts of pesticides, for example neonicotinoids.[27] Yet, at the moment, this data in most cases still is not made available for researchers.

Smart Farming is still in the developmental phase of an input- and capital-intensive agriculture and competes with alternative approaches such as ecological farming, which follows a holistic approach. In any case, the problem of world nutrition needs to be resolved by the small-scale agricultural farmers in developing countries. The focus on technical solutions might lead to disregard for alternative approaches.

5 Legal Implications

Smart Farming raises diverse legal issues, which, in their depth, still remain entirely unanswered. The amount that Smart Farming gains in economical, technical and social importance, the more pressing the legal issues will become in the future. So, where does a legal potential for conflict exist that needs to be addressed? New technologies are already valuable for farmers. Manufacturers of machines, seed producers and agricultural service providers are depending on the digital development in agriculture and expect to henceforth have an increased influence on the production methods.

[24] Rösch/Dusseldorp/Meyer (2006), Precision Agriculture: 2. Bericht zum TA-Projekt Moderne Agrartechniken und Produktionsmethoden—Ökonomische und ökologische Potenziale, p 75 et seqq.

[25] Voß/Dürand/Rees (2016), Wie die Digitalisierung die Landwirtschaft revolutioniert, Wirtschaftswoche Online, http://www.wiwo.de/technologie/digitale-welt/smart-farming-wie-die-digitalisierung-die-landwirtschaft-revolutioniert/12828942.html.

[26] European Commission (2013), Structure and dynamics of EU farms: changes, trends and policy relevance, p 7.

[27] Carbonell, Internet Policy Review 2016(5), p 3.

In the USA, it is status quo that farmers submit data to service providers who professionally and individually prepare and analyze it to meet the needs and demands of the specific farmer. As a consequence, projects have been founded, that try to regulate publicity and privacy of the agricultural data of the parties involved. A popular example is the *Open Ag Data Alliance*.[28]

The farmers' main fear is that the data could end up in the wrong hands.[29] As newspapers report about disclosed security loopholes of technical systems on a daily basis, farmers fear not only data misuse by competitors or conservationists, but also misuse through commodity traders and data collecting service providers themselves.[30] In this respect, IT safety is particularly crucial prerequisite.

In addition, state sanctioning and monitoring of farmers is being simplified, for example responsible environmental authorities can explicitly prove environmental law infringements.[31] Whether this could in fact be a disadvantage to environmental protection, as a state objective according to article 20 (a) of the German constitution, remains to be seen.

It is certain that in digitalized agriculture, there is also a necessity to protect and safeguard data sets. This concern can only be guaranteed through interplay of technical data protection and legal protection. This is the only interaction which ensures that the farmers' data sovereignty is protected and potential misuse of the data inhibited. In Germany, Klaus Josef Lutz, the CEO of Europe's largest agricultural trader BayWa, claims that "data protection must have the highest priority".[32]

6 Which Areas of Law Are Affected?

From a legal point of view, issues mainly arise in areas of data protection law and intellectual property law. Moreover, superordinate research challenges like the legal assignment of data and the related rights of data are an issue not only for Smart Farming, but for the entire Industry 4.0.[33]

[28]Visit http://openag.io/about-us/.

[29]Manning, Food Law and Policy 2015 (113), p 130 et seq.

[30]Rasmussen, Minnesota Journal of Law, Science and Technology 2016 (17), p 499.

[31]Gilpin 2014, How Big Data is going to help feed nine Billion People by 2050, TechRepublic, http://www.techrepublic.com/article/how-big-data-is-going-to-help-feed-9-billion-people-by-2050/.

[32]Cited in Dierig, Wir sind besser als Google, Die Welt, http://www.welt.de/wirtschaft/article148584763/Wir-sind-besser-als-Google.html.

[33]European Commission 2015, Strategie für einen digitalen Binnenmarkt für Europa, COM 2015 (192) final, p 16 et seq.

6.1 Data Protection Law

Data protection as an area of law is—in contrast to the decade long traditionally and conservatively influenced German agriculture—a comparatively new phenomenon. Besides the applicable special-law provisions in the German Telecommunications Act (TKG) or the German Telemedia Act (TMG), the German Federal Data Protection Act (BDSG) is, in particular, applicable regarding content data. The latter is applicable, if so called personal data is collected or processed. According to section 3 (1) BDSG data about the personal or objective circumstances of an identified or identifiable natural person is included.

The assignment of the data to a person is possible in a number of different ways. For example, data of animals can be assigned to the livestock owner. The same applies for data of agricultural products and especially for data of the farm field, which can be assigned to the owner, holder, tenant, or farmer. This is determined by using—for example—connected data of satellite monitoring, photos and landowner data from the Real Estate Register.[34]

Further legal issues arise if modern machines, such as remote-controlled drones, have the ability to record other people and theoretically identify them. This is particularly relevant in densely populated areas.

Incidentally, in agriculture the basic principles of data collection apply, such as necessity, purpose, and data minimization in accordance with sections 3 (a), 31 BDSG. These principles are not only predestined to potentially conflict with Smart Farming and Precision Agriculture, but also with the general field of big data applications.

Conclusively, as of 2018, the European General Data Protection Regulation (GDPR) becomes relevant for the legal classification of content data. Its legal requirements for big data are still open for discussion.

6.2 Intellectual Property Rights Protection Shown by the Example of Database Manufacturers

The question that the farmer asks himself is how he/her can protect "his/her" data. Data protection law cannot solve this, as it only protects the right of personality of the person behind the data. This is where, in particular, the intellectual property rights come into play: It protects exclusive rights on intangible assets and regulates the granting of rights of use. Data itself cannot be—at least not yet—protected. Therefore, the copyright protection of databases will be discussed using the protection of data collections as an example.

[34]Weichert (2008), Vortrag—Der gläserne Landwirt, https://www.datenschutzzentrum.de/vortraege/20080309-weichert-glaeserner-landwirt.pdf.

Farmers can hereby arrange data—for example data of a specific field or crop—in a systematical and methodical way. If the data is individually accessible and the database shows that a substantial investment in either the acquisition, verification, or presentation of the content is required, a "database" within the meaning of the sui generis right, section 87a (1) German Copyright Act (UrhG), exists. The creator of the database would in most cases be the farmer himself according to section 87a(2) UrhG. If a substantial investment exists, depends on the individual circumstances. By using modern, high-quality sensors, or similar technologies, this threshold should be quickly reached. In the past, case law has not demanded high requirements.[35] If all the requirements are met, the database maker is protected against the reproduction, distribution, and public communication of the whole database, or a substantial part under section bob UrhG.

6.3 Overarching Questions for Industry 4.0

The issue of an abstract legal assignment of data is not only important for "intelligent" agriculture, but is of crucial importance for all big data industry sectors. In the smart farming sector, besides farmers, the data processing service providers and perhaps even the companies producing the machines and technologies will stake out a claim.[36] Equally, liability issues—as in the case of insufficient data quality—are also of interest.[37] The solution for all these problems is not only important for the agricultural sector, but also for all digital industries and in general for Industry 4.0.[38] It will now be a matter of waiting to see what the global developments in research and practice will bring.

7 Conclusion and Forecast

Big data and agriculture in Germany is virtually a blank canvas, in particular, from the legal point of view. Issues regarding Smart Farming and related matters are still new items on the agenda, in contrast to discussions concerning self-driving or Connected Cars.

Therefore, the legislators have the opportunity to effectively regulate a new phenomenon from the very start to provide a safe environment for innovation and

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[35]Cf. Dreier 2015, in: Dreier/Schulze, Kommentar zum Urheberrechtsgesetz, section 87a Ref. 14 et seq.

[36]For the American legal sphere Strobel, Drake Journal of Agricultural Law 2014 (19), p 239.

[37]In detail Hoeren, MMR 2016 (19), p 8 et seqq.

[38]In detail Zech, GRUR 2015 (117), p 1151 seqq.

investments as efficiently as possible. To what extent this will be done remains to be seen.[39] The factor of time should not be underestimated. Who would have thought a few years ago that German farmers will be needing legal advice from IT lawyers in the future?[40]

It should be ensured, that the technical developments do not take the agricultural sector by surprise and that the farmers lose their power and influence.

Data collection and analysis can be important in the future, not only for more transparent production processes and a more efficient use of resources, but through facilitating an even better control and enforcement of environmental protection requirements. After all, successful environmental protection should also be an aim of the agriculture sector, as it creates a stable foundation for regeneration and use of fields.

One thing is certain; digitalization will substantially influence and change the work in farming, as it is known today. Although the use of big data applications in agriculture is not as advanced as other sectors yet, the developments in agriculture are of paramount importance for population and society; it is ultimately all about their own nutrition.

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