Digitisation in agriculture - from precision farming to farming 4.0

Automated steering systems, data-driven targeted application of fertilisers and pesticides, field robots and drones, soil analysis sensors, autonomous driving - digitisation is advancing in agriculture as elsewhere. The question asked by farmers and by society in general is whether the increasing adoption of digital technologies in agriculture is a curse or a blessing. One thing is certain: the economic potential is huge - and does not exclude ecological benefits. Digitisation clearly creates the conditions for successful agricultural practices.

Digitisation is gaining momentum at a pace second to none. The figures on digital progress speak for themselves, especially in the field of agriculture: back in 2015, 30 percent of all value created with agricultural machinery worldwide came from software, electronics and sensors, surpassing the value created in the automotive industry three times over. It is essential for farmers and for the environment that processes are adapted to a digital technology concept because innovative processes can potentially lead to efficient and resource-friendly sustainable farming.

Adding value through increased value creation

Tractor with nitrogen sensor and fertiliser spreader. A plant sensor mounted at the front of the tractor measures the wheat's nitrogen requirements and adjusts the fertiliser application rate by the spreader mounted at the rear of the tractor.

Agriculture is a series of complex individual but inter-dependent processes. Agricultural work needs to be organised into efficient stages to ensure a good yield. Therefore, the success of a given product is based on a triangle formed by the farmer, technology and the service- and consulting concept.

Two terms crop up at regular intervals: "precision farming" and "smart farming". What do they mean? “Precision farming” is the targeted management of agricultural land using smart electronics. Examples include electronic devices for sensor-assisted soil assessment, the automated monitoring of free-ranging animals on pastures and the targeted control of agricultural machinery. Modern differentiated farming methods enable the management of spatial and temporal variability within plots of land.

Precision farming:

Precision farming is an agricultural concept involving new production and management methods that make intensive use of data about a specific location and crop. Sensor technologies and application methods are used to optimise production processes and growth conditions. In contrast to conventional agricultural methods, using digital data can increase resource and cost efficiency as well as reduce environmental impact.

Information about the presence of different soil properties and productivity within a particular plot of land can be electronically retrieved from so-called field record files, enabling farmers to respond in real time. Satellite-controlled accurate lane guidance of agricultural machinery and intelligent sensors enables the targeted application of seeds, fertilisers and pesticides. This enables seed quantity as well as fuel consumption to be reduced.

Real time kinematic (RTK) steering systems. RTK steering systems that are used to accurately determine position coordinates by satellite navigation methods, and manage agricultural land more efficiently. They reduce tractor turnaround time as well as lane overlapping.

Future concepts will not just be about size and volume. Attributes such as "smaller", "more intelligent", "more efficient" are also becoming more important, especially for medium-sized agricultural enterprises. Aerial images taken using drones provide valuable information about fields, including for example soil quality, unwanted plants and plant diseases. Data is available relatively quickly and appropriate measures can be taken. Field robots are excellently suited to the gentle treatment of soil and plants because they are so lightweight. They are cloud-controlled and can be used to establish a specific sowing and fertilisation pattern. They are also able to remove individual weeds. However, the legal framework for these future-oriented, emission-free tools has yet to be defined in Germany.

However, drones and robots are only helpful to a limited extent on large acreages due to their limited flight/operating time. Large-scale crop cultivation still requires horsepower, harvesters and large agricultural machinery.

Smart farming:

Smart farming (also known as Farming 4.0 and digital farming) is the application of information and data technologies for optimising complex farming systems. The integration of smart agricultural technologies and modern data technologies enables seed planting to be adapted to a specific field to ensure an efficient production process. The application of information and data technologies supports farmers in making informed decisions based on concrete data.

Smart farming is also based on precise control electronics. This paves the way for enabling agricultural machines to communicate among themselves as they can all access electronic field record files. But how does a farmer process all this information? There are farm management systems, agricultural apps and online platforms to support farmers. "Smart farming", often also referred to as "Farming 4.0", involves not just individual machines but all farm operations. Farmers can access real-time data on mobile devices (mobile phones or tablets). Data about, for example, the condition of soil and plants, terrain, climate, weather, resource usage, manpower, funding applications is collected, processed and evaluated. An agricultural business rarely purchases modern machinery and equipment from a single manufacturer. So choosing equipment providers not only depends on how efficient the equipment is, but also whether devices can be flexibly connected with each other.

Will small farms be left behind?

While precision farming dominates large farms in northern and eastern Germany, many farmers with small-scale agricultural businesses, for example in Baden-Württemberg, are reluctant to use precision farming technologies. However, it is important to embrace the continuous progress made in this field.

The Augustenberg Agricultural Technology Centre (LTZ), a state institute of the Baden-Württemberg Ministry of Rural Affairs and Consumer Protection, has been focusing on the issue of economic efficiency for many years as well as testing precision farming methods in cooperation with project partners. The LTZ has come to the conclusion that precision farming also has economic and ecological benefits for agricultural businesses in Baden-Württemberg. The advantages identified by the LTZ are increased product quality, increased yield per unit area and significantly reduced production costs. Precision farming could help farmers meet environmental requirements and make the documentation of the agricultural management measures and workforce instructions much simpler.

Drones are used to help farmers gain a fuller picture of specific agricultural area. This image shows unevenly growing rapeseed stands.

As far as investment costs are concerned, external partnerships are becoming increasingly important. The Baden-Württemberg Machinery Rings Association represents machinery rings in Baden-Württemberg, which offer shared use of machinery and other services. Some service providers offer tailor-made solutions for individual farms and provide advice to help farmers navigate the big data jungle: what is really efficient, sustainable and economic for a specific customer? Service providers collect, analyse and automate all data. The farmer can intervene at any time and correct agricultural management measures. Individual solutions are available, for example those that optimise a single customer-specific work step such as machine-to-machine communication within a harvest and transport concept.

Digital technologies can be particularly beneficial for small farms that cannot afford staff. Using digital field records and the

information stored therein, farmers can cut out some of the steps during the planting and harvesting processes, transportation of produce from plot to barn, or documentation, operational analysis and funding applications. Drones and field robots can also be used for mapping and collecting data from farmland.

Which markets are opening up?

The advanced use of digital technologies in agriculture has the potential to meet growing global demand for food while ensuring the sustainability of primary production. The EU's Horizon 2020 Programme for Research and Innovation funds projects in the "smart agriculture" sector.

The increased use of digital technologies in agriculture opens up many new markets. For more demanding and sensitised end consumers, farmers are able to create their own production chain for their produce. This is where start-up companies that create innovative products with intelligent systems come into their own. These systems document everything from crop cultivation, fields, mills, and processing plants in a way that customers can understand and trace.

The development of novel products also continues in the agricultural engineering sector. There is the expectation that innovative solutions will continue providing farmers with opportunities to feed the world whilst operating a profitable business. For example, agricultural GPS systems (e.g. AGCO, Claas, CNH, John Deere, Krone, Lemken, Rauch, etc.) can contribute to further reductions in the quantity of fertilisers and pesticides used. The farmers can use their own electricity to power new, fully battery-powered, emission-free and virtually noise-free tractors. Other models offer system-based ballasting and tyre pressure adjustment for resource and soil conservation. Modern agricultural engineering products mean that agriculture leads the way in the areas of sensors, digital positioning, optical recognition systems or data visualisation. Autonomously controlled harvesting machines have already become reality in agriculture: the machine processes information independently and makes at least partially autonomous decisions, while the farmer predominantly takes on a monitoring role. In Germany, the legal framework conditions, including safety and liability regulations have not yet been defined.

The cornerstones of digitisation

Many German farmers understand the advantages of using digital technologies in agriculture. According to representative surveys carried out by the industry association Bitkom, Berlin, almost 90 percent of all agricultural businesses associate digitisation with more efficient use of resources. More than half of the companies surveyed are already using digital applications, especially smart agricultural machinery and farm management software. The worldwide market potential for digital products and business models is huge. The tendency to shift to high-tech systems is growing rapidly.

The basic prerequisite for a shift to high-tech systems is the expansion of the broadband network as well as access to the internet, especially in rural areas like Baden-Württemberg. The digital field record system is a database of several gigabytes that needs to be accessible in real time, not just because of operational efficiency, but also with regard to critical factors such as driving an agricultural machine on the road or field. It is crucial that obstacles such as wild animals are immediately identified.

Digitisation is not just for farms. Digital technologies should be part of the curriculum in schools, universities and research institutions. In Baden-Württemberg, for example, the Institute of Agricultural Engineering at the University of Hohenheim is active in the core competence area of modern agriculture. Some of the projects carried out by researchers led by Prof. Hans W. Griepentrog in the Department of Process Engineering in Plant Production focus on the development of precision farming and smart farming. The Fraunhofer Institute for Manufacturing Engineering and Automation IPA in Stuttgart develops automated robotic solutions.

Innovative economic policies at the regional, federal and EU level need to create optimal conditions for further exploiting agricultural potential. Interdisciplinary research projects (e.g. from the computer sciences, electrical engineering, mechanical engineering, economics, law and agricultural sciences, process engineering) as well as the establishment of agricultural clusters such as the one in North Rhine-Westphalia are promising approaches. The Baden-Württemberg Ministry for Rural Areas and Consumer Protection has launched an interesting funding programme called "Components of Precision Farming – FAKT (funding programme for agricultural environment, climate protection and animal welfare) measure F3". This programme focuses, amongst other things, on soil analyses and phosphate fertilisation using optical sensors for nitrogen fertilisation and geographic information system (GIS) applications. The programme aims at finding ways to reduce nitrate input into the groundwater and phosphate input into surface waters. As part of its digitisation strategy, the Baden-Württemberg government's "Landwirtschaft 4.0 nachhaltig.digital" (Agriculture 4.0 sustainable.digitable) package of measures supports small- and medium-sized agricultural enterprises and farms in the development and introduction of digital production processes as well as in knowledge management.

The farmer retains data sovereignty

Information processing is increasingly taking place via cloud systems where data is automatically collected, analysed and stored. This data can be retrieved using any mobile device. The advantage of cloud systems is that the data sources can be

used by service providers. Thus, the farmer receives extensive information and recommendations for action. It is important to highlight that the data belongs to the farmer, only he or she can decide with whom and to what extent to share such data.

The paradigm shift in agriculture has long since taken place. Opportunities for the efficient and in many aspects even sustainable management of farms are opening up. In spite of all this progression, one aspect that should not be forgotten is that the natural soil biology must not be destroyed and soil compaction and erosion must never result from the proper use of technology, especially on large agricultural areas (in northern and eastern Germany, for example).

References:

Agrarkoordination & Forum für Internationale Agrarpolitik e.V. (Ed.) (2013). Weltagrarhandel und EU-Agrarpolitik. Globale Agrarmärkte oder lokale Ernährungssouveränität. http://www.globaleslernen.de/sites/default/files/files/education-material/ak_biopoli_weltagrarhandeleu-politik_final.pdf , last accessed on 22nd January 2018

Bleisteiner, Norbert: Der Himmel lenkt mit (2016). In: BWagrar, https://www.bwagrar.de/Markt-Management/Betriebsfuehrung/Der-Himmel-lenkt-mit,QUIEPTQ2MTcwMjQmTUIEPTE2Mjk0NQ.html?UID=49EEC9D8738CC4C2D152D88CFC5ACC19C2D9BD45B9E1D32C68, last accessed on 22nd January 2018

German Federal Ministry of Nutrition and Agriculture. Statistik und Berichte des BMEL. https://www.bmel-statistik.de/landwirtschaft/ und https://www.bmel-statistik.de/landwirtschaft/tabellen-kapitel-c-hii-und-hiii-des-statistischen-jahrbuchs/, last accessed on 22nd January 2018.

Digitalisierung der Wirtschaft nimmt Fahrt auf (2016), Bitkom e. V. Online available at https://www.bitkom.org/Presse/Presseinformation/Digitalisierung-der-Wirtschaft-nimmt-Fahrt-auf.html, last accessed on 22nd January 2018.

Digitalisierung industrieller Wertschöpfung (2017) – Transformationsansätze für KMU Begleitforschung AUTONOMIK für Industrie 4.0, iit - Institut für Innovation und Technik in der VDI/VDE Innovation + Technik GmbH

Göggerle, Thomas: Praktiker-Tagebuch zu Farming 4.0: Digital ackern (2019). In: agrarheute, https://www.agrarheute.com/technik/traktoren/praktiker-tagebuch-farming-40-digital-ackern-534060

Griepentrog Hans W.: Der Landwirt bleibt unverzichtbar (2017). In: agrarzeitung

Griepentrog Hans W.: "Green Future – Smart Technology": Chancen und Herausforderungen der Digitalisierung in der Landwirtschaft (2017). DLG Media Service

Gurr-Hirsch, Friedlinde: Landwirtschaft 4.0 – geht das? (2016). In: BWagrar, https://www.bwagrar.de/Markt-Management/Betriebsfuehrung/Landwirtschaft-4-0-geht-das,QUIEPTQ5NTUxMjkmTUIEPTE2Mjk0NQ.html, last accessed on 22nd January 2018

Landtechnik - Entwicklungstrends und Herausforderungen, Branchenreport 2017; IG Metall, https://www.igmetall.de/docs_20171107_Branchenreport_Landtechnik_30_10_f725f829fa8732776898603560d118904ec8478c.pdf

Maßnahmen- und Entwicklungsplan Ländlicher Raum 2014-2020 (MEPL III); Agrarpolitik & Förderung, Infodienst Landwirtschaft – Ernährung – ländlicher Raum; Baden-Württemberg Ministry of Rural Affairs and Consumer Protection; http://www.landwirtschaft-bw.info/pb/MLR.Foerderung,Len/Startseite/Agrarpolitik/Foerderprogramme; last accessed on 31st January 2018

Mitten in der Revolution – Chancen suchen für die Wertschöpfung von morgen, Press release on Farm & Food 4.0 Kongress – Berlin, 22nd January 2018, Deutscher Bauernverlag GmbH

Precision Farming in FAKT, Information and funding programme launched by the Baden-Württemberg Ministry of Rural Affairs and Consumer Protection; http://www.landwirtschaft-mlr.baden-wuerttemberg.de/pb/site/lel/node/1826145/Lde/index.html; last accessed on 22nd January 2018

Smart Farming – Tagungsberichte Precision Farming in Rheinstetten-Forchheim; Landwirtschaftliches Technologiezentrum Augustenberg (LTZ), Baden-Württemberg Ministry of Rural Affairs and Consumer Protection; http://www.landwirtschaft-mlr.baden-wuerttemberg.de/pb/site/lel/node/1826145/Lde/index.html; last accessed on 31st January2018

https://www.baden-wuerttemberg.de/de/service/presse/pressemitteilung/pid/landesweite-digitalisierungsstrategie-startet-mit-67-leuchtturmprojekten/

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