# SMART FARMING

## IoT and robotics are driving farming forwards

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Image provided courtesy of John Deere

- Sensors
- Connectivity
- Reliability

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## IoT and robotics driving farming forwards

It’s 7am Klaus Weber enters the control centre. First, he sets up a satellite link. This will help him check growth in his fruit field and plan for fertilising. He then starts up a driverless tractor – which he parked in the field the day before – to have it plough automatically and autonomously. Next, he sends an automated cultivator into the beet field to remove weeds using AI technology. After that, he has to briefly leave his command post to launch a drone. This will scan his cornfield for problem weeds and tackle them with pin-point accuracy.
The big question is, is Klaus Weber a) a drone pilot b) a robotics administrator or c) a farmer?

By 2050, the world’s population is expected to grow to about 10 billion, resulting in a 50% increase on today’s food demands. The demand for animal products can only be met if there is a 70% increase in the plant-based foods we need to sustain livestock.[1] It’s down to agriculture to meet these demands while making very careful use of our soil, water and energy resources. In Germany alone, potential farmland the size of about 73 football pitches is lost to cultivation every day.

Digital technology is seen as the solution to these challenges. ’Smart farming’ solutions are intended to allow for a more sustainable, efficient and resistant way of farming. Many smart farming solutions are based on common developments in automation technology, mechanical engineering and automotive technology. Farming IoT is enabling the mass use of sensors and the resulting services and interoperability. Autonomous machines and vehicles are already a reality in agriculture and are starting to overtake their counterparts in road use and in industrial settings.

This article describes how far this technology has come, using examples from two smart farming areas.

- Sensors
- Autonomous agricultural machinery and robotics

1. Stefan Stahlmecke, Regional Director Intelligent Solutions Group at John Deere, at the Digital Farming Konferenz, Berlin in May 2022 in his speech on the topic of Precision Farming.

## SENSORS AS WEARABLES FOR PLANTS

*The availability of drinking water is expected to become one of the world's biggest problems. Today, farming consumes about 70% of the world's drinking water. If we fail to use water more efficiently, more will be needed for agriculture alone than will be sustainably available by 2030. According to a conservative estimate, the use of sensor technology in water management reduces water consumption by 20%. (Source: Yara Press Release).*

Back in 2011, a new sensor designed for the smart-irrigation of orchards received the Sensor Innovation Award from the AMA Association for Sensors and Measurement. This non-invasive ZIM-probe (now Yara ZIM Plant Technology) continuously measures the water supply of plants with a high level of accuracy. The sensor system is applied to a leaf with two magnets and measures the cell turgor pressure (the pressure of the cell fluid on the cell wall); the blood pressure of the plant. Telemetric systems send the data to a base station and from there to a control unit. This system is used to monitor and regulate the water demand of plants worldwide to a high degree of granularity.

Fig. 1. The non-invasive ZIM-probe (now Yara ZIM Plant Technology) continuously measures the water supply of plants. The sensor system is applied to a leaf with two magnets and measures the cell turgor pressure. (Image: Yara Press Images)

A promising research project is underway at the University of Sao Paulo in Brazil, on the study of impedimetric sensors.

Their use will be an exciting move in determining the loss of water content (LWC) from leaves, as they allow the non-destructive, local quantification of cell fluid from a single measurement. As water content is a key indicator of the health of a leaf, LWC monitoring can provide important insights into the everyday practice of precision farming and the development of agricultural tools.

The constant challenges of this type of monitoring are leaf adhesion, compatibility, scalability and reproducibility of the electrodes, especially for long-term measurements. The technology uses electrodes consisting of individual Ni membranes produced by established microfabrication methods. Suitable for mass production, these electrodes are the key to enabling researchers to reproducibly determine the LWC. The electrodes work by directly transferring the conductive materials to downy soy leaves using regular adhesive tape.

Fig. 2. The technology uses electrodes consisting of individual Ni membranes produced by established microfabrication methods. Suitable for mass production, these electrodes are the key to enabling researchers to reproducibly determine the LWC. The electrodes work by directly transferring the conductive materials to downy soy leaves using regular adhesive tape. (Images: American Chemical Society)

The research scientists used a potentiostat with a wireless connection to a smartphone to determine the LWC over 24 hours. An automated learning model was able to convert the perceptual responses into a simple mathematical equation that measures the loss of water content at two temperatures (30°C and 20°C) with an improved effective error margin (0.3%).

Overall, the results of the research can help pave the way for implementing Sense/Act technology so we can study the drought tolerance of plants, both locally and remotely. These platforms can provide key information to support efficient data-driven management and help with decision-making processes.

## AUTONOMOUS AGRICULTURAL MACHINERY AND ROBOTICS

A study by the Fraunhofer Institute for Experimental Software Engineering IESE concludes that by 2035, we will see fully autonomous and driverless machines in agricultural use. However, one prerequisite is that the machines must be brought to the field by a driver.

In fields, autonomous vehicles face different challenges compared to cars on the road. Cars move on pre-programmed, marked paths to find their way, while agricultural machinery travels on open, unmarked terrain, which makes it a challenge for the sensor systems. With dust and mud obstructing optical sensors, the new technology uses infrared, microwave (radar) and other sensor solutions to detect obstacles behind tall crops.

Agricultural machines offer plenty of potential for artificial intelligence applications, including being able to distinguish plants and determine their degree of maturity.

## AUTONOMOUS PLOUGHING

Fig. 3. A fully autonomous tractor from the manufacturer John Deere. (Image provided courtesy of John Deere)

At the CES 2022 (Consumer Electronics Show) technology fair in Las Vegas, John Deere unveiled a production-ready fully autonomous tractor. The 8R 410 is expected to be available in North America by the end of 2022.

The machine has six pairs of stereo cameras that allow 360° obstacle detection and distance calculation. The images captured by the cameras are passed through a neural network that classifies them with the aim of detecting obstacles and automatically stopping the machine when needed.

The autonomous tractor continuously checks its position in relation to the field boundaries, making sure it is actually working in the correct field. At the same time, the centimetre-accurate distance calculation function enables precise track guidance. To use the autonomous tractor, the farmer only has to drive the machine into the field and set it up for autonomous operation. It is controlled on the John Deere Operations Center Mobile app. While the tractor gets on with the work, the farmer can leave the field and concentrate on other tasks. The machine status is monitored remotely, while the John Deere Operations Center Mobile app provides access to live video, images, data and settings. Speeds, working depths and other settings can be adjusted at any time. Should the quality of work deteriorate or a malfunction occurs, the farmer is notified and can make changes to optimise performance.

There is no launch planned in Europe at present, as today’s safety requirements do not allow the use of autonomous vehicles.

## AI FOR WEEDS EXTRACTION

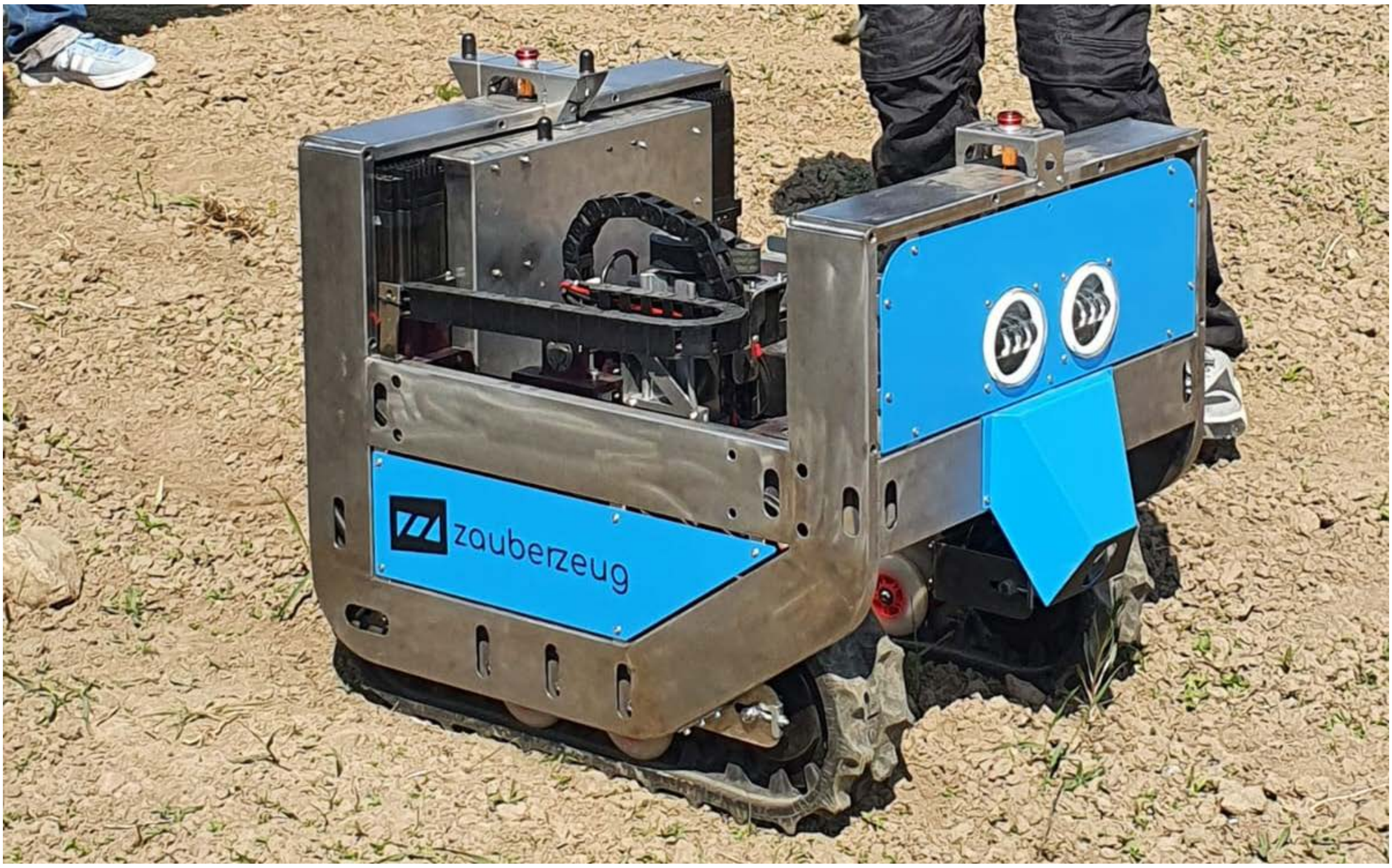


Fig. 4. The Eberswalde University of Applied Sciences for Sustainable Development (HNEE) presents a fully automatic robot for weed control in sugar beet cultivation. (Image: Amanda Birkmann HNEE 2022)

Weeds must be regularly removed throughout the growing season (e.g. sugar beet) to achieve healthy yields. Conventional cultivation relies on pesticides, while organic farming turns to the hoe. Both methods are suboptimal because they are either harmful to the environment or too expensive.

With scientists from the sugar beet research project focusing on AI and robotics, they have developed a robot that drives autonomously over the ground to remove weeds from the sugar beet. The self-driving cultivator can cope with difficult terrain and the AI-based image analysis successfully distinguishes weeds from sugar beet. No need for fossil fuels, the machine is battery-powered and has solar panels to drive it by solar energy in good weather.

The scientists are working on using a drone as support. Future drones will communicate with the robot, record its location and tell it where there is a weed problem.

## WHAT HAPPENS NEXT?

The question is, how can automation make production more efficient while protecting the environment and climate at the same time? Digitisation will make an important contribution to this, as a recent representative survey of 500 farmers in Germany by Bitkom and the German Agricultural Society (DLG) shows.

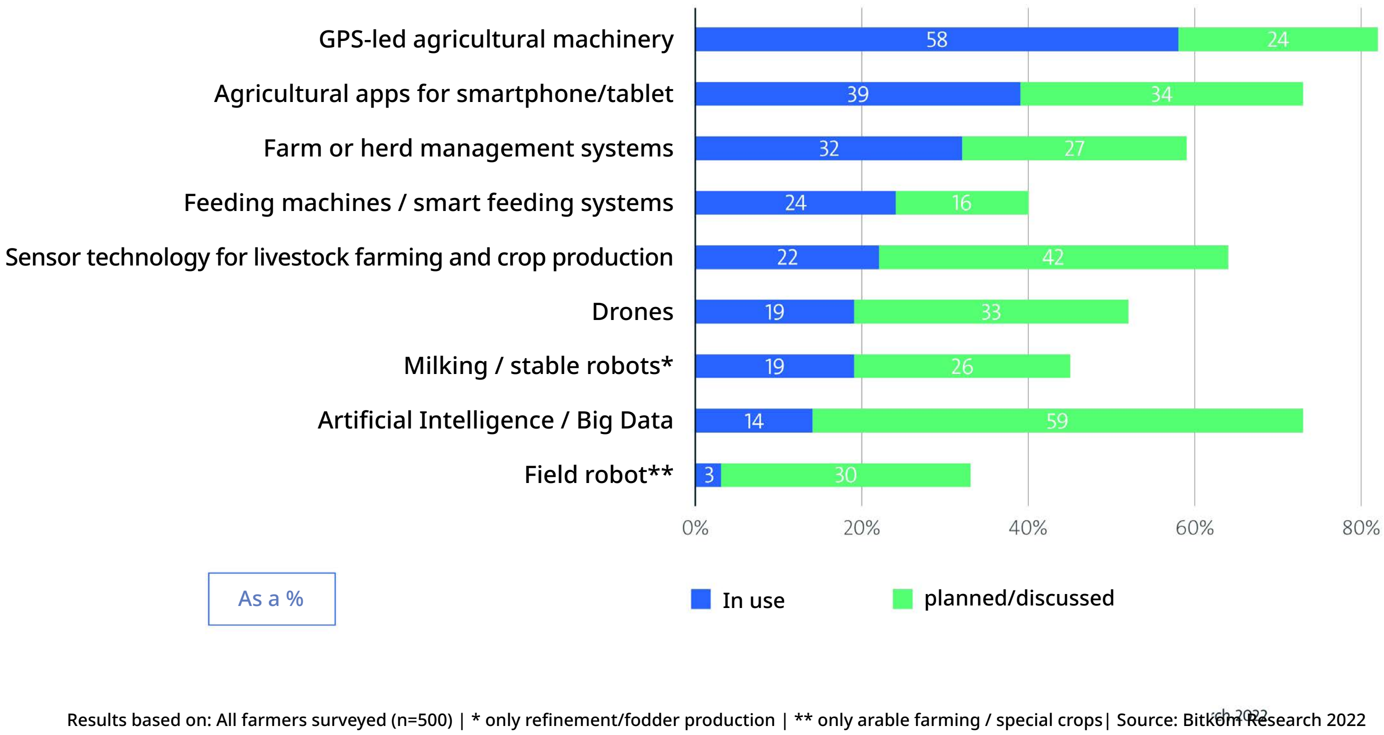


Fig. 5. Which technologies do you use or plan to use? We can already see how much digitisation is helping today. Overall, 79% of companies use digital technologies or processes. (Image: Bitkom)

92% agree that digital technologies help to save on fertilisers, pesticides and other resources. 81% believe that digitisation enables a more eco-friendly agricultural production. Almost two-thirds (63%) say that farms can reduce their costs in the long term with the help of digitisation. Improving animal welfare is also an important aspect of digitisation for 62% of those surveyed.

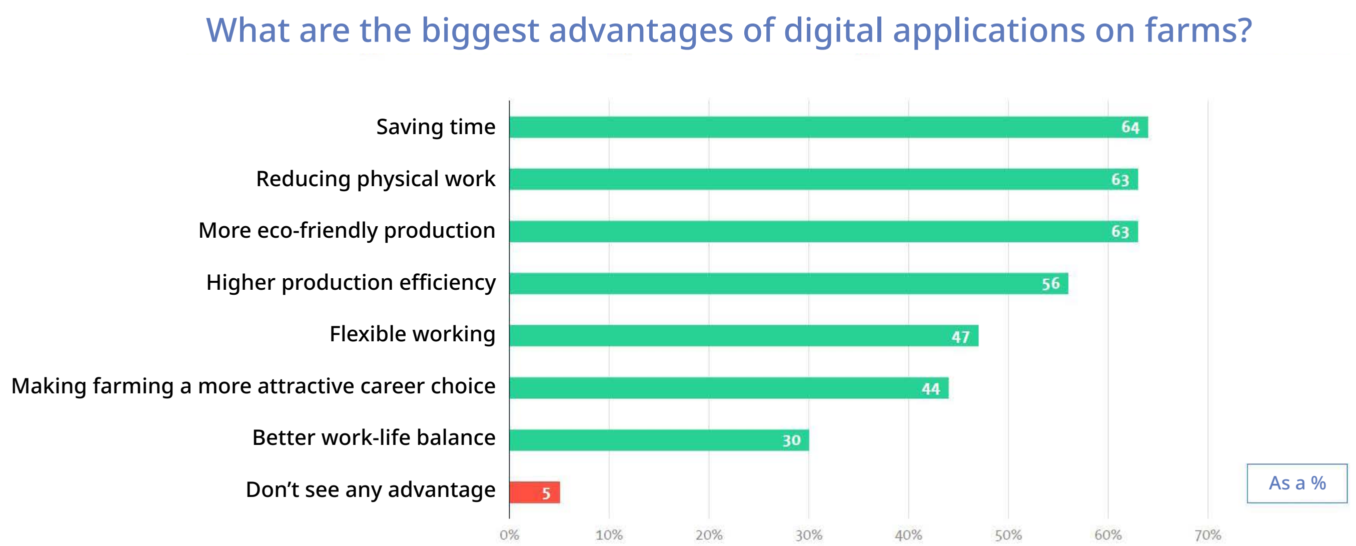


Fig. 6. Digital applications bring clear advantages. (Source: Bitkom Research 2022, Image: Bitkom)