

Key technologies of precision agriculture



2.2.1



Dear students,

In this lesson, you will explore key digital tools used in precision farming – from IoT sensors and drones to GPS systems and AI.

You will learn how these technologies collect data, improve decision-making, and automate tasks on the farm. Real-life examples will show how even small farms can benefit from smart solutions.

As you study, focus on what each tool does and how it supports sustainability and efficiency. Think about which technology could be useful in your own farming or local context.



Study text

1. IoT devices and sensors

IoT (Internet of Things) means connecting physical devices – such as sensors, weather stations or fertilizer dispensers – to the internet. These devices automatically collect data and transmit it to a system where it is evaluated and used for decision-making. In agriculture, this means that the farmer does not have to measure everything manually – for example, soil moisture, temperature, rainfall or crop condition. Instead, this information is collected by smart devices in the field or in the barn and sent to a mobile app, where the farmer can view it at any time.



What does it look like in practice?

A sensor in the vineyard monitors soil moisture. When the soil dries out, the app sends a notification: "Start watering."



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The weather station will detect the arrival of strong winds. The system will suggest a shift in spray application so that the wind does not blow the chemicals elsewhere.

The collar on the cow measures temperature and movement. When the animal is sick or in heat, the farmer receives a notification on his mobile phone.

What is needed?

- **Sensors or devices** – e.g. humidity meters, temperature meters, cameras, cattle boluses.
- **Network or connection** – most often via Wi-Fi, mobile data or special agricultural networks (e.g. LoRaWAN – a long-distance wireless communication protocol designed for the Internet of Things).
- **An application or platform** – e.g. Agdata, Farmonaut, CleverFarm, where data is displayed in a clear form.

Sensors installed in fields or greenhouses measure real-time parameters such as humidity, temperature, pH value, or nutrient content. The data is transmitted to central systems, from where the farmer receives recommendations for irrigation or fertilization. According to [Business Insider](#), the use of IoT on farms is significantly increasing due to better water and input management, but connectivity and analytics remain challenges.



 Overview of basic sensor types

Sensor type	What it tracks and usage examples
Soil sensors	Humidity, temperature, pH, salinity – irrigation, crop selection Sensors monitor microclimatic conditions such as temperature, humidity, precipitation and wind (typically integrated in weather stations). They help predict plant stress, disease or the need for aeration. Soil pH and nutrient sensors, i.e. electrochemical probes, measure soil acidity (pH) and nutrient concentrations (e.g. nitrates or phosphates). They allow for precise dosing of fertilizers and reduce the chemical load on the environment. They allow for precise dosing of fertilizers and reduce the chemical load on the environment.
Meteorological sensors	Temperature, precipitation, wind, air humidity – disease prediction, planting planning
Sensors on animals	Movement, body temperature, position – Disease detection, estrus period, monitoring
Environmental sensors	CO₂, ammonia, noise, light – Comfort in the stable or greenhouse Optical and multispectral sensors installed in drones and satellites provide images in different wavelengths. They help identify plant stress, weed occurrence or vegetation variability, suitable for targeted intervention (e.g. spraying, fertilization). Lidar sensors enable laser scanning to create 3D models of terrain and vegetation. They help with zoning, erosion mapping, and pest detection through airspace analysis. CO₂ and air quality sensors measure the concentration of carbon dioxide (and sometimes other gases). They help optimize photosynthesis and monitor the impact of the environment on plant growth. Special sensors (e.g. leaf sensors) monitor leaf thickness and turgor, allowing for very precise irrigation. Water savings of up to 30–50% can be achieved.



An example of the use of sensors in cow breeding: [the smaXtec system](#). The Austrian company smaXtec has developed a small sensor that is inserted into a cow's rumen and continuously measures the animal's body temperature, pH, and activity for up to four years. This data is transmitted to the farmer's system, allowing them to identify health problems in a timely manner or monitor the estrus cycle and prepare for calving. Although this technology is not cheap to purchase, its use saves on veterinary care and increases herd performance through better care.



2. Drones

Drones are equipped with various sensors and cameras and are used in agriculture, for example:

1. Mapping fields before sowing and harvesting
2. Monitoring growth during the season
3. Comparison of plant development with previous years
4. Soil moisture assessment and irrigation planning
5. Detection of pests, diseases and weeds
6. Assessing the need for fertilization based on plant condition
7. Analysis of animal health (e.g. in pasture farming)
8. Sowing or applying fertilizers using a drone (precisely and targetedly)



9. **Multispectral imaging – Drones with special cameras capture more color bands than the eye can see – vegetation map which distinguishes individual zones by color according to the vitality of the vegetation.**
10. **Drones with cameras and GPS, which will allow you to determine where the herd is located, monitor the activity and movement of individual animals, and respond quickly to the loss or injury of an animal.**

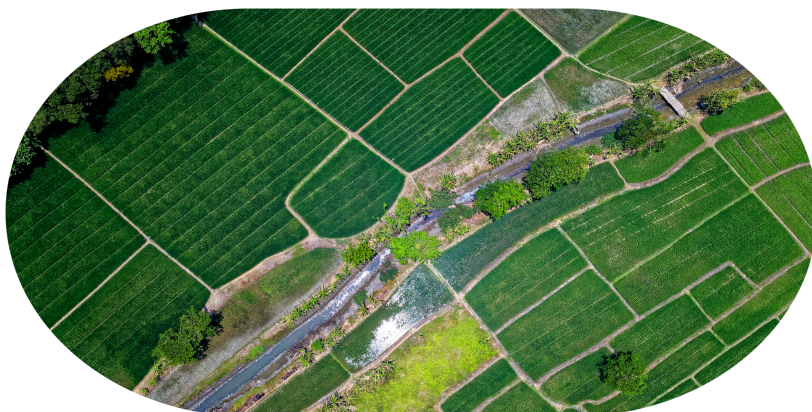
Watch the [video](#) of how drones are being integrated into the precision farming system at the Mikálka farm in the Czech Republic. For example, a scanning drone helps them find vole holes.

How does it work?

- **A drone flies over a field and takes pictures from above.**
- **These images are then merged together into one map.**
- **The map shows field boundaries, vegetation, weeds, soil moisture, problem areas or even animals.**

Using a 3D map, the farmer can find out:

- **how much land does he actually have under cultivation,**
- **where there is a problem with pests, weeds or disease,**
- **where water is retained and where the soil is dry,**
- **what is the slope and drainage of the field,**
- **where it would make sense to sow more and where less.**



✨ Main benefits of drone mapping

🕒 **Save time and money** – The drone can survey a large area in minutes. The farmer does not have to walk all over the field to find a problem.

📌 **Accurate information** – Unlike just an estimate, drone maps offer data – what is the health of the plants, where is the problem with nutrition, where is water retention.

🌾 **Better planning** – With the help of a map, the farmer can prepare a sowing plan, schedule irrigation, fertilizer dosage or recognize the need for crop treatment.

📊 **Minimizing losses** – Early intervention can prevent damage caused by diseases, drought, or excessive fertilization.



3.

3. Robotics and automation

Agricultural robots help with weeding, harvesting or monitoring crops without human intervention. An example is the American [FarmWise Titan](#), which uses camera-based AI for precise weed removal, or the Brazilian [Solix](#) from Solinftec, which reduces herbicides by up to 95% thanks to targeted intervention. However, these robots are usually intended for larger farms due to their price and size. The solution can then be to share or rent these devices.

Robots and automatons are gradually being developed that can also be used for home or community gardens and small farms, such as the FarmBot Genesis. This robot is capable of mechanically removing weeds and monitoring plants and is also modular. An application has been developed for its use, the robot is 100% open source.

4. Location systems (GPS)

Location systems allow you to pinpoint the exact location of a tractor, drone, sensor or specific animal.

The most common satellite technologies used are GPS (Global Positioning System) or Galileo, the European high-precision location system. Thanks to these technologies, a small farmer can keep records of exactly where he has sprayed or sown, track the exact route of the tractor – this saves both diesel and time. It is easy to locate a collared animal that has strayed from the pasture.

When location data is linked to other technologies (e.g. weather stations, soil sensors), we are talking about **connected farming**. However, this requires connectivity, i.e. the ability to transfer data between individual devices.



5. Connectivity

 **What is connectivity and why is it important?**

Connectivity means the ability of devices to communicate with each other – either locally (e.g. via Bluetooth or Wi-Fi) or remotely (e.g. via a 4G/5G mobile network or low-voltage networks like LoRaWAN).

For example:



The weather station in the field sends current humidity data via LoRaWAN → this is displayed to the farmer on his mobile phone → the application suggests the optimal time for irrigation.

6. Data analysis, software, AI

Software collects, stores and analyzes data. So-called farm-management systems (e.g. AgLeader, Trimble) cover yield monitoring, climate conditions, nutrition and financial results. AI platforms, such as ChatGPT or agronomic assistants, are also accessible to small farmers.

There are applications that analyze historical meteorological data and current weather forecasts that can send recommendations via SMS to regular mobile phones. If farmers follow the recommendations, they can increase their yields. For example, [the Weenat application](#) offers a mobile application for farmers with hourly and 15-day forecasts and historical data. It allows you to set SMS/email/notification alerts (e.g. for rain or frost). Or [the Sencrop application](#) connects agricultural sensors with an ultra-local weather model. It allows you to set alerts via SMS, email or call – for example, for pest risk, ideal times for spraying, irrigation.



✓ **What do small farms get out of this?**

- **More precise agricultural interventions → less fertilizer, water, fuel.**
- **Save time – automatic recording and planning.**
- **Possibility to integrate various tools into one system (e.g. CleverFarm, Agdata).**
- **Improved traceability → higher customer trust and certifications.**

A small farmer can operate a system based on a combination of soil sensors, a drone, and data processing software. This system monitors soil moisture and temperature and uses aerial photography to assess the state of vegetation. All data is stored in a cloud database and analyzed using artificial intelligence. Thanks to this, the farmer has an overview of the conditions in individual parts of the field and can adjust irrigation, fertilization, and harvesting. For example, students from Olin College have developed a drone that autonomously flies to predefined locations, collects data on humidity, temperature, and pH, and uploads it to a web interface (cloud), where it is analyzed for irrigation and fertilization purposes. More information can be found on the [school's website](#).

🌐 **Challenges and recommendations**

- **Investing in connectivity is key to IoT functionality.**
- **Basic sensors are affordable.**
- **Robots can be used without ownership through leasing – reducing costs and risk.**
- **Choose available software – there are also freely available farm-management systems.**
- **Cooperation between farmers increases efficiency and reduces costs (sharing technology).**



Summary

Precision agriculture relies on digital technologies such as IoT sensors, drones, robotics, GPS tracking, and AI to optimize farm management. Together, these tools increase efficiency, reduce input use, and support sustainable farming—even on small farms.

