smart skills
smart sustainable agriculture

Course 1:

Digital Farming and Precision Agriculture

IoT in use – Precision Agriculture

Co-funded by the European Union

www.smartskillsproject.eu

What will you learn?

This module explores how data and modern technologies are transforming agriculture. Students learn how the Internet of Things (IoT) enables real-time data collection from sensors in fields, greenhouses, and on animals—measuring soil moisture, temperature, movement, and more. The module covers data analysis techniques that help visualize and interpret this information to optimize processes. It also introduces Geographic Information Systems (GIS), which allow spatial analysis and mapping of yields, vegetation, and pest presence to support decision-making.

Understand…

…the use of sensors to measure soil moisture, temperature, movement, and more.

Identify…

…key components of control systems, including sensors, controllers, and actuators.

Explore…

…how GIS supports decision-making through spatial analysis and mapping.

contents

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01

IoT in agriculture

IoT in agriculture/ smart agriculture

- **Management systems** - LPIS administration automation, "employee tracking"
- **Security** - Buildings, hay straw fires, floods, animals...
- **Sensors** - weather station
- **Robotisation**
- **Precision farming** - Plant production
    - Fields, orchards, greenhouses
- **Animal production**
- **Forestry**
- **Water management**

IoT in agriculture/ smart agriculture

IoT Technology in Agriculture (see the graph)
provides a comprehensive overview of how IoT is transforming agriculture. Here are the key points:

IoT in Agriculture: The Smart Future of Farming
The Internet of Things (IoT) is revolutionizing agriculture: sensors monitor the soil, greenhouses are controlled automatically, and animals wear devices that monitor their health.

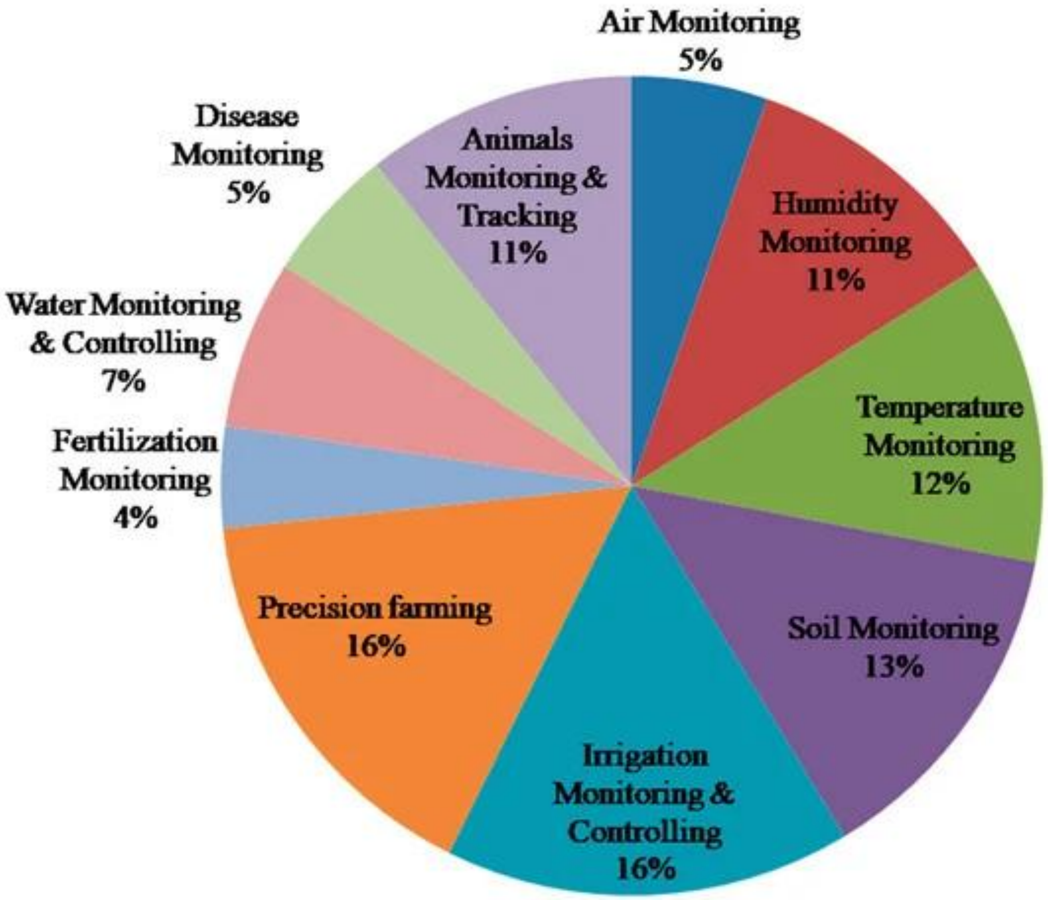
In the 67 analyzed studies (2006–2019), IoT is most often applied in:

Precision agriculture - e.g. targeted irrigation or fertilization

Animal monitoring - health, movement, localization

Greenhouse automation - climate control without human intervention

IoT helps save water, increase yields, and make work easier - even remotely.



smart sustainable agriculture

(Source: Farooq, M.S.; Riaz, S.; Abid, A.; Umer, T.; Zikria, Y.B. Role of IoT Technology in Agriculture: A Systematic Literature Review. *Electronics* **2020**, *9*, 319. https://doi.org/10.3390/electronics9020319

02

Precision agriculture

Precision agriculture

Precision agriculture began to take shape in the **1980s**. The main goal of early research in this field was to develop a **Decision Support System (DSS)** for comprehensive farm management. This system aimed to:

Optimize the return on agricultural inputs (e.g., seeds, fertilizers, water)

Conserve natural resources by applying them only where and when needed

Improve efficiency and sustainability through data-driven decisions

This foundational idea laid the groundwork for today's smart farming technologies, including IoT, GIS, and automation.

Selected areas - plant production 1/2

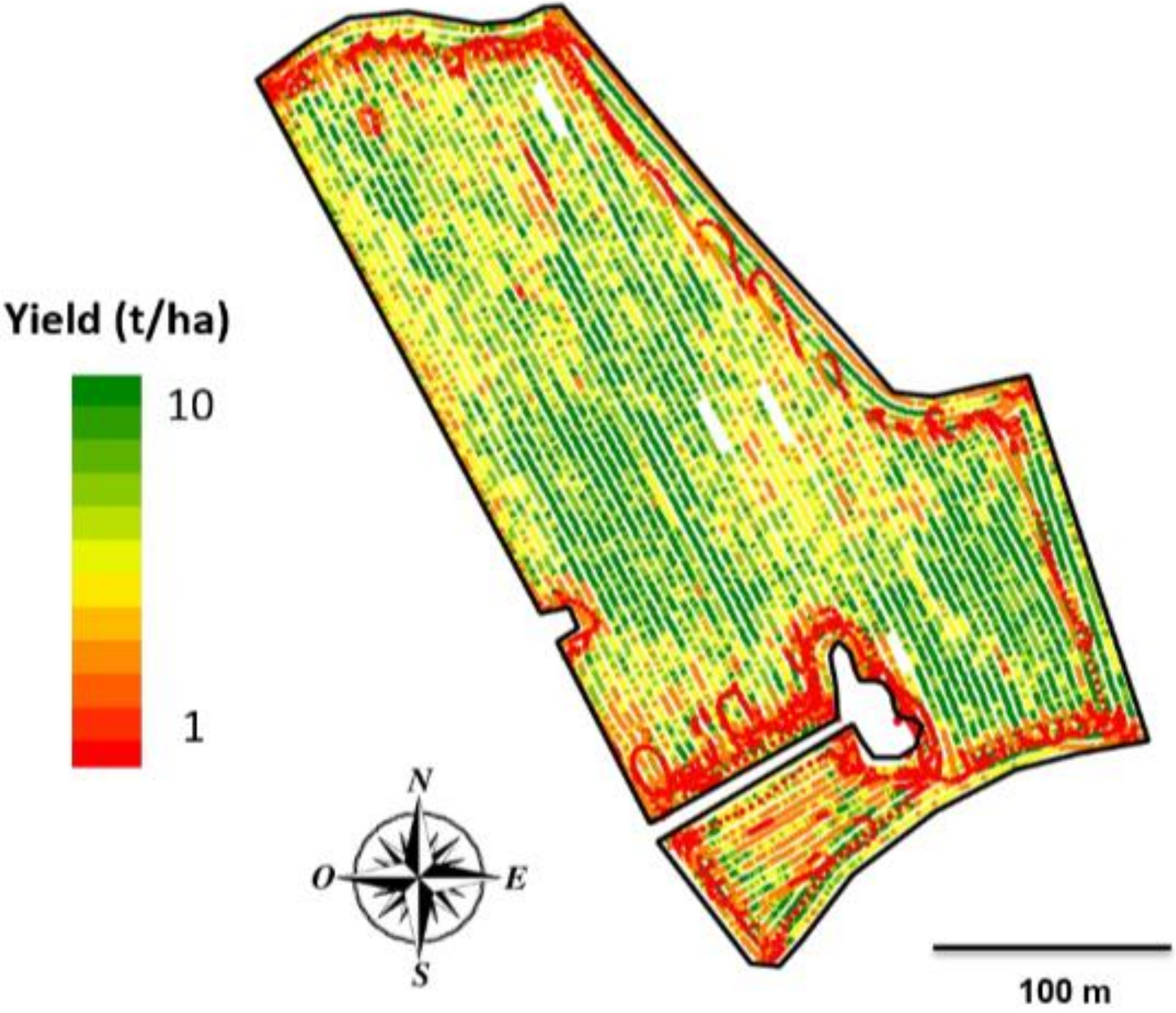
- Automatic control of precision sowing according to sowing map
- Automatic regulation of fertilization dosage based on fertilization map
- Automatic regulation of row seeding based on seeding map
- Automatic setting of fertilization dosage based on current state of vegetation
- Autonomous guiding of agricultural machinery
- Creating application maps for fertilization
- Creation of maps of physical and chemical properties of soil
- Guided drive of tractors and agricultural machinery on parcel
- Guided drive of tractors and agricultural machinery on parcel with 2 cm accuracy
- Mapping harvest yields of root crops
- Mapping the quality of harvested crops during harvesting of cereals and forage crops

Selected areas - plant production 2/2

- Monitoring of outputs from cereal and oilseed harvests
- Monitoring of wildlife animals on farmland and in forests using drones
- Telematics for tractors and other agricultural machinery
- Use of unmanned vehicles for the management of crop production
- Using field robots in fruit and vegetable production
- Using satellite imagery for management of crop production
- Utilization of drones for application of plant protection mixture
- Variable application of plant protection products according to the map of occurrence of harmful factors
- Variable soil treatment

Maps / Mapping

- revenues
- fertilization
- vegetation condition
- soil properties
- plot profile



Maps / Mapping – Real-Time Kinematic (RTK) Positioning

Real-Time Kinematic (RTK) positioning is a satellite navigation technique used to enhance the precision of GPS signals. It is widely used in precision agriculture for tasks that require high spatial accuracy.

Key features include:

Error Correction: RTK corrects signal errors from standard GPS using data from a nearby **base station**.

High Accuracy: Achieves positioning accuracy of **2–5 cm**, essential for tasks like automated steering, planting, and spraying.

Real-Time Data: Provides immediate corrections, allowing for precise operations in the field without delays.

Mapping Applications: Enables the creation of detailed field maps, including yield maps, soil property maps, and application maps.

RTK technology is a cornerstone of modern precision farming, enabling farmers to work more efficiently and reduce input waste.

Remote Sensing Types

- Active - light
- Passive artificial sources
- Drones
- Satellites
  - ESA's Copernicus program
  - Sentinel satellite - EU images freely available
      - atmospheric monitoring (air quality, emissions, ozone layer)
    - marine environment monitoring
    - water monitoring
    - soil monitoring
    - vegetation monitoring
    - climate change monitoring

Remote Sensing Tool

What is CropSat and How Does It Work

https://cropsat.com

CropSat is a free online tool for monitoring the condition of agricultural crops using **satellite imagery**.

- Uses satellite data from the European **Sentinel missions (Copernicus program)**
- **Supports both RGB** (visible light) and **CIR** (color-infrared) imagery
- Displays vegetation indices (e.g. NDVI) to assess crop development

It enables users to:

- Track crop growth over time
- Optimize fertilization and irrigation
- Compare fields across seasons and locations

Remote Sensing Tool

CropSat for Security and Crisis Management

Security & Monitoring:

- Detects drought, deforestation, and land degradation
- Identifies unusual land use changes or illegal activities

Crisis Management:

- Evaluates impact of natural disasters (fires, floods, droughts)
- Supports decision-making for aid distribution and recovery planning

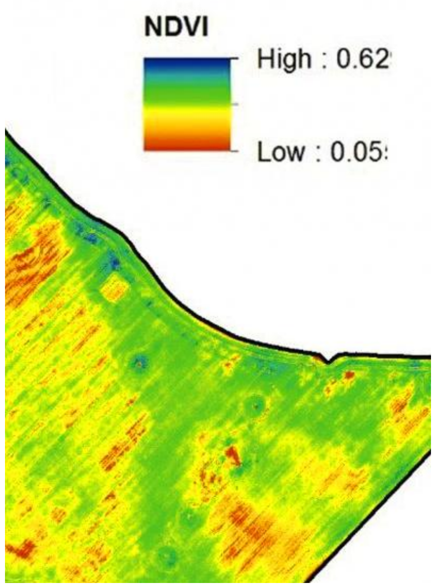
CropSat = a tool for farmers, policymakers, and landscape protection alike.

NDVI (Normalized Difference Vegetation Index)

NDVI (Normalized Difference Vegetation Index) is a numerical indicator used to assess the health and density of vegetation using satellite or aerial imagery. It is calculated using the difference between near-infrared (NIR) and red (RED) light reflectance

- vegetation recognition
- determination of vegetation health (amount of biomass)
- amount of chlorophyll

- CWSI (crop wather stress index)



Precision Agriculture – Farm Management

Farm management in precision agriculture involves the integration of digital tools and data-driven decision-making to optimize agricultural operations. By using technologies such as IoT sensors, GPS, and farm management software, farmers can monitor and control various aspects of their production in real time.

Key components include:

Data collection from fields, machinery, and livestock

Dashboarding for visualizing performance indicators

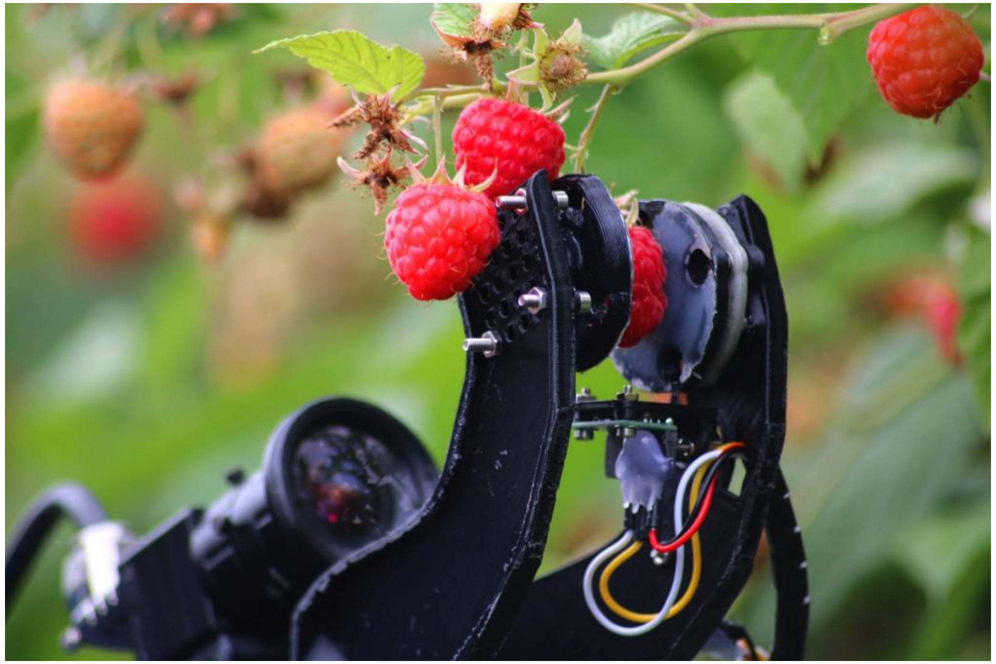
Automated reporting for compliance and planning

Decision support systems (DSS) to guide actions like irrigation, fertilization, and harvesting

Precision Agriculture - Robotization

Robotization in precision agriculture refers to the use of autonomous and semi-autonomous machines to perform agricultural tasks with high accuracy and efficiency. These technologies reduce the need for manual labor and enable 24/7 operations under various conditions.

- At all stages
  - Breeding
  - Field preparation
  - Betting
  - Fertilization
  - Harvesting
  - …



Precision Agriculture - Greenhouses

Greenhouses in precision agriculture use advanced technologies to create controlled environments that optimize plant growth and resource efficiency. IoT sensors and automation systems monitor and regulate key variables such as temperature, humidity, light, and nutrient levels.

- Closed-loop systems
- Hydroponic and aeroponic systems
- Automated climate control
- Remote monitoring and alerts
- AI-driven optimization

Digital Farming

More information about **Digital Farming**

🡐 Why Digital Farming is Important For Farmers? Digital Agriculture

| Discover Agriculture

IoT in use – Case Study

03

Case Study: Senosec.cz: Protecting Wildlife During Grass Mowing

During grass mowing, young deer and other small animals hide in the tall grass, often resulting in fatal injuries. The *Senosec.cz* system uses thermal imaging drones and field sensors to scan the area before mowing. The data is visualized on GIS maps, allowing farmers to avoid harming hidden animals. The solution has reduced animal casualties and improved the public image of farming practices. However, it also presents challenges, including the cost of drones, the need for trained personnel, and privacy concerns related to image data.

- **Problem: Hidden animals injured or killed during mowing**
- **IoT-based solution: Thermal drones and field sensors detect animals**
- **GIS mapping for precise localization**
- **Impact: Reduced wildlife mortality, improved farm ethics**
- **Challenges: Drone operation, equipment cost, data privacy (GDPR)**

Case Study: Vcelstva.cz: Remote Beehive Monitoring

Beehive health is critical for pollination and honey production. *Vcelstva.cz* enables remote monitoring through smart hive scales and temperature/humidity sensors. The data is transmitted via LoRaWAN to a web interface, allowing beekeepers to check hive conditions anytime. This reduces the need for physical checks and improves the response to issues such as swarming or disease. Challenges include maintaining connectivity in remote areas, ensuring accurate calibration, and protecting sensitive data.

- **Problem: Hidden animals injured or killed during mowing**
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Case Study: PtaciOnline.cz: Bird Tracking and Research

The PtaciOnline.cz project focuses on tracking the migration of protected bird species. Small GPS devices attached to the birds collect position and activity data, transmitted via GPRS. This information helps scientists understand flight paths and behavioral patterns, supporting conservation programs. However, the devices must be lightweight to avoid harming the birds, battery life is limited, and ethical questions may arise around animal tagging.

- **Problem: Need to study bird migration and behavior**
- **IoT solution: GPS collars with GPRS and motion sensors**
- **Real-time data for research and conservation**
- **Benefits: Accurate migration maps, wildlife protection**
- **Challenges: Battery life, device weight, ethical concerns**

Case Study: PtaciOnline.cz: Bird Tracking and Research

FARMBOT is an open-source agricultural robot designed for small-scale automated farming, such as home gardens or research plots. It operates like a CNC machine over a raised bed, performing tasks like sowing seeds, watering plants based on moisture levels, and even removing weeds. FARMBOT connects to a cloud-based platform and can be controlled from a web app. It’s an excellent example of precision agriculture at the micro level—especially for educational use or demonstration purposes. However, its use is limited to small plots and requires internet connectivity and basic technical skills for setup and maintenance.

- **Problem: Time-consuming manual gardening and small-scale crop production**
- **Solution: Open-source CNC farming robot – fully automated plant care**
- **Functions: Seeding, watering, weeding, soil moisture sensing**
- **Benefits: Fully autonomous growing, ideal for education and urban farming**
- **Challenges: Limited scalability, needs internet and technical skills**

04

Further development, criticism, trend

Criticism of IoT

While IoT offers many benefits in agriculture, it also faces several criticisms and challenges:

Data Overload: Large volumes of data can be difficult to manage, analyze, and interpret effectively.

Incompatibility: Devices and platforms from different manufacturers may not work well together, limiting integration.

Privacy Concerns: Use of cameras, GPS, and tracking tools raises ethical and legal issues (e.g., GDPR).

Security Risks: Many IoT devices lack proper cybersecurity, making them vulnerable to hacking or data breaches.

High Costs: Initial investment in IoT infrastructure and training can be expensive for small farms.

Dependence on Connectivity: Reliable internet access is essential, which may be limited in rural areas.

Job Displacement: Automation may reduce the need for manual labor, raising concerns about employment.

IoT Trends

- Trends in IoT use of AI/ML
- Development of wireless technologies (5G, NB)
- Power supply development
  - battery
  - alternative
- Healthcare
- Agriculture, biology
- Safety
- Transport/Cities
- Energy saving

Call to Action

Practical Activity: *"Find a Smart Solution"*

Research a real-world example of an IoT-based technology used in agriculture (e.g., soil moisture sensor, smart irrigation system, livestock tracking).

Task: Describe how the technology works, what benefits it brings, and what challenges may arise in its use. Length: 100–150 words.

Optional: Attach a video or image demonstrating the system.

Call to Action

Discussion Prompt:
Which areas of agriculture do you think should be digitalized next? What ethical, technical, or organizational barriers might prevent wider adoption of IoT on typical farms?

Purpose:
Connect theory with practice, promote critical thinking, and assess the real-world impact of digitalization in agriculture.

Well done!

You finished the first module of **Course 1**! Keep going on this learning journey.

In the **next module** you will learn about **IoT devices, sensors, actuators, converters.**

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Follow our journey

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