smart skills
smart sustainable agriculture

Course 1:

Digital Farming and Precision Agriculture

GIS Mapping and Field Optimization

www.smartskillsproject.eu

Co-funded by the European Union

Learning Outcomes

Learners explore the importance of spatial context in IoT data analysis and gain the ability to identify key components and data types used in the integration of GIS and IoT systems. They learn how to use GIS tools to visualize and interpret IoT data, analyze spatial patterns and relationships based on real-time sensor input, and apply GIS techniques in real-world scenarios such as smart cities or environmental monitoring. In addition, they develop the skills to critically evaluate how effective GIS-based solutions are in addressing location-specific problems.

Understand…

…the importance of spatial context in IoT data analysis.

Identify…

…key components and data types used in GIS and IoT integration.

Explain…

….. how GIS tools can be used to visualize and interpret IoT data.

contents

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01

Introduction

What is GIS?

It adds spatial attributes to the classic information system

In the strictest sense, a GIS is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their locations. Pactitioners also regard the total GIS as including operating personnel and the data that go into the system.

What GIS solves?

Geographic Information Systems (GIS) are powerful tools used to answer a wide range of **spatial and location-based questions**. They help determine **what is found at a specific location**, **where certain features are**, and **how many of them exist** in a given area.

GIS can also analyze **what has changed over time**, such as land use, vegetation, or urban development. Additionally, it can uncover **causes of spatial phenomena**—for example, identifying factors contributing to flooding or pollution. Finally, GIS enables **scenario modeling**, allowing users to explore "what if" questions, such as predicting the impact of rising sea levels or infrastructure changes. Altogether, GIS supports better decision-making in fields like urban planning, environmental monitoring, agriculture, and emergency response.

GIS is not

While GIS (Geographic Information Systems) is a powerful tool for spatial analysis and decision-making, it's important to understand what it **does not** do or represent:

GIS is not just a map. While maps are a key output, GIS is much more than cartography. It involves data analysis, modeling, and spatial reasoning.

GIS is not a GPS. GPS (Global Positioning System) provides location data, but GIS is used to analyze and visualize that data in context.

GIS is not only for geographers. It's used across many fields: urban planning, environmental science, public health, logistics, agriculture, and more.

GIS is not a static tool. It's dynamic and interactive, allowing users to update data, run simulations, and perform real-time analysis.

GIS is not a single software. It's a system that can include multiple tools and platforms (e.g., ArcGIS, QGIS, web-based GIS, databases, etc.).

GIS is not only about visualization. It also includes data management, spatial querying, statistical analysis, and predictive modeling.

Areas where GIS is used

GIS (Geographic Information Systems) is used in a wide variety of fields to analyze spatial data, support decision-making, and visualize geographic patterns.

Most data can be spatially localized.

Examples of GIS use:

- map portals, services
- management of utility networks (distribution companies)
- Environment
- state administration (ministries, regions, cities)
- And more....

Using of GIS in Precision Agriculture

More information about **GIS**

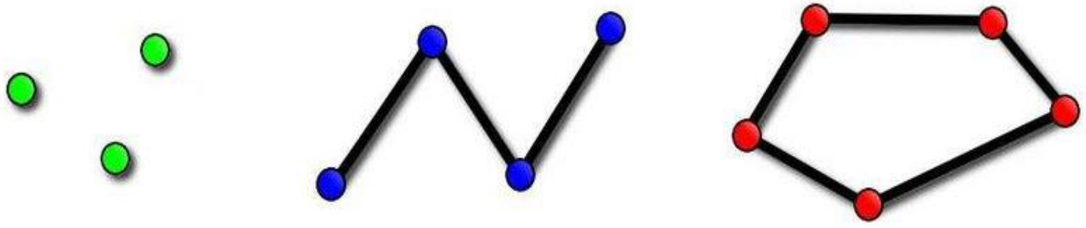
← Unlocking Agricultural Potential: Exploring the Applications of GIS in Agriculture You Must Know!

| Mapever

02

GIS description

Objects in GIS



Vector data is made up of geometrical shapes that represent real-world features. It is divided into three basic types:

Point – represents a single location, such as a weather station, tree, or sensor.

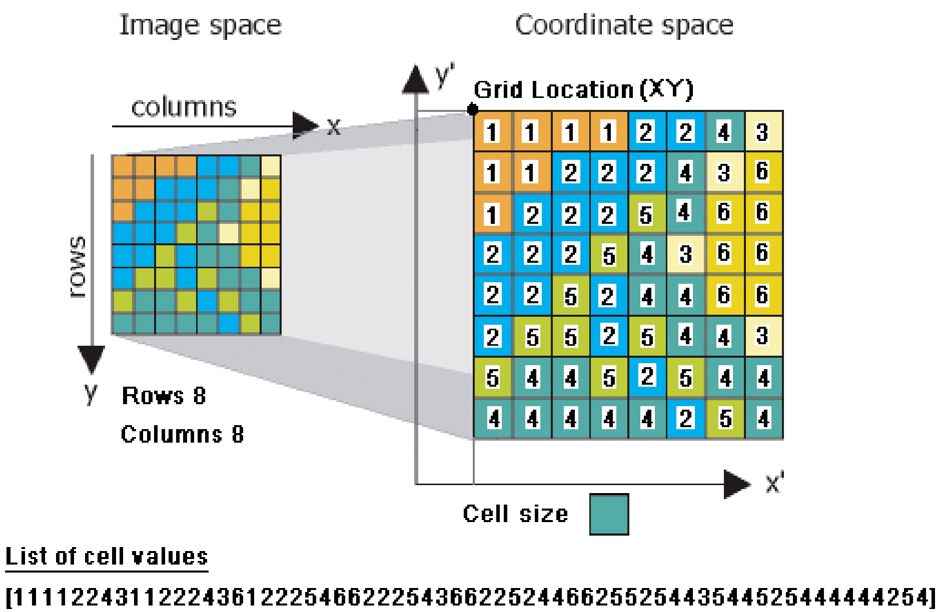
Line – represents linear features like roads, rivers, or pipelines.

Polygon – represents enclosed areas such as lakes, buildings, or land parcels.

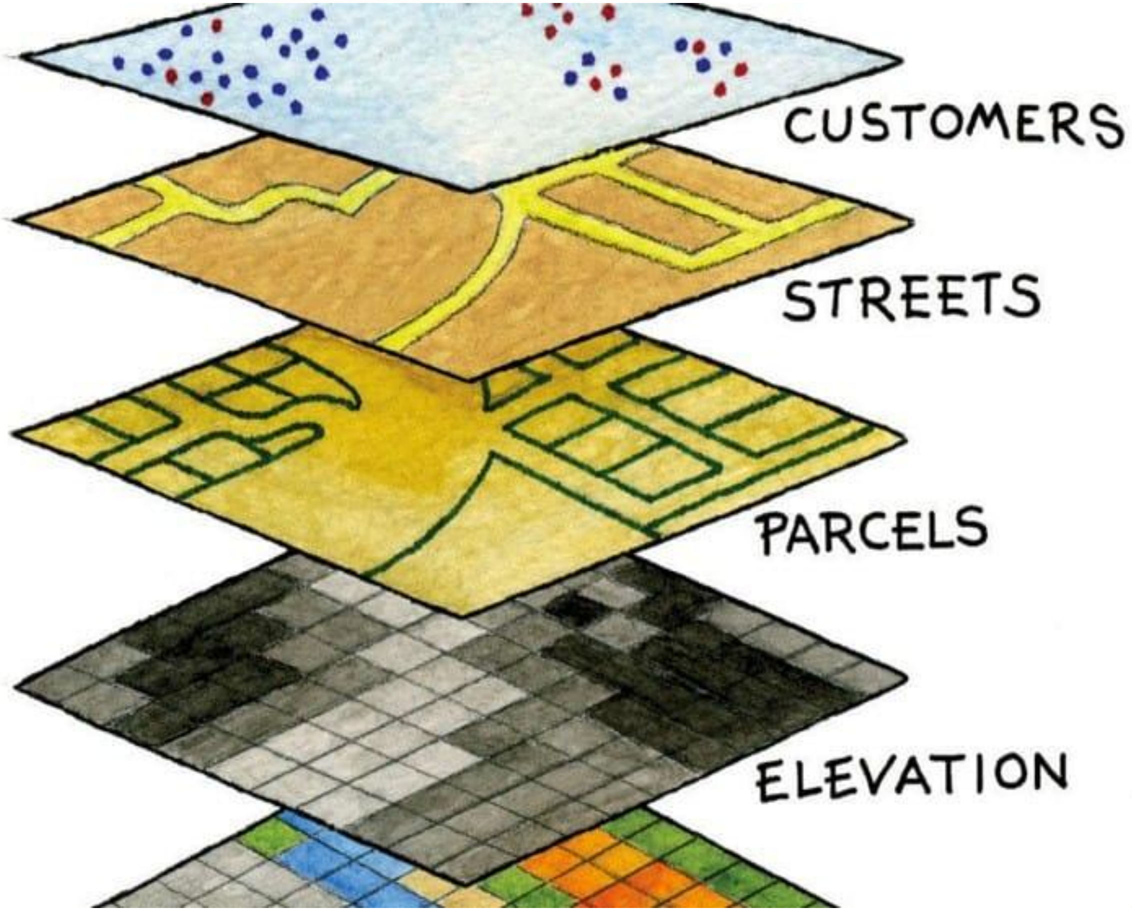
These vector features are ideal for **precise mapping and analysis** of boundaries and structures.

•**Raster data** is made up of a grid of pixels (like a digital photo), where each pixel holds a value representing information such as elevation, temperature, vegetation index (e.g. NDVI), or satellite imagery. Raster data is especially useful for **continuous data** and **remote sensing applications**.

Together, vector and raster data allow GIS to capture both detailed features and large-scale environmental conditions.



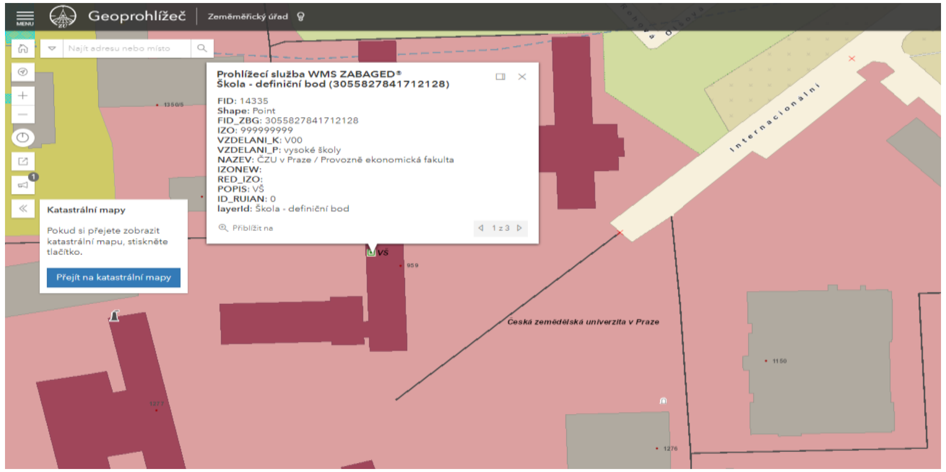
Layers in GIS

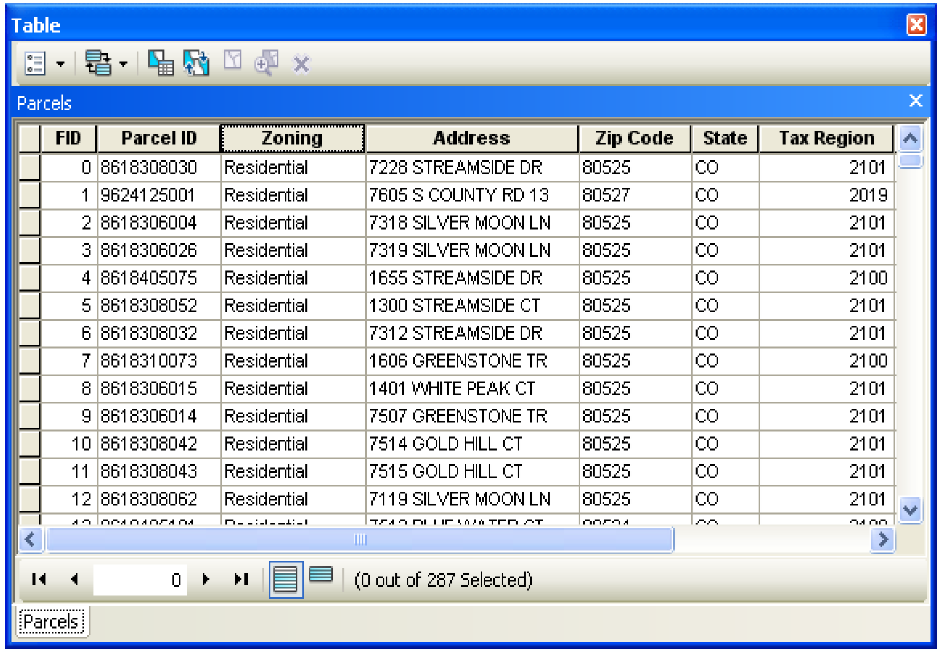


Attribute table

Attributes refer to descriptive information or data associated with spatial features. While spatial data defines the location and shape of features (such as points, lines, and polygons on a map), attribute data provides context and meaning to these features.

- These attributes are stored in attribute tables, which are similar to spreadsheets:
- Each row represents a spatial feature.
- Each column represents an attribute field (e.g., Name, Type, Population).





Table

Parcels

FID	Parcel ID	Zoning	Address	Zip Code	State	Tax Region
0	8618308030	Residential	7228 STREAMSIDE DR	80525	CO	2101
1	9624125001	Residential	7605 S COUNTY RD 13	80527	CO	2019
2	8618306004	Residential	7318 SILVER MOON LN	80525	CO	2101
3	8618306026	Residential	7319 SILVER MOON LN	80525	CO	2101
4	8618405075	Residential	1655 STREAMSIDE DR	80525	CO	2100
5	8618308052	Residential	1300 STREAMSIDE CT	80525	CO	2101
6	8618308032	Residential	7312 STREAMSIDE DR	80525	CO	2101
7	8618310073	Residential	1606 GREENSTONE TR	80525	CO	2100
8	8618306015	Residential	1401 WHITE PEAK CT	80525	CO	2101
9	8618306014	Residential	7507 GREENSTONE TR	80525	CO	2101
10	8618308042	Residential	7514 GOLD HILL CT	80525	CO	2101
11	8618308043	Residential	7515 GOLD HILL CT	80525	CO	2101
12	8618308062	Residential	7119 SILVER MOON LN	80525	CO	2101

0 (0 out of 287 Selected)

Parcels

03

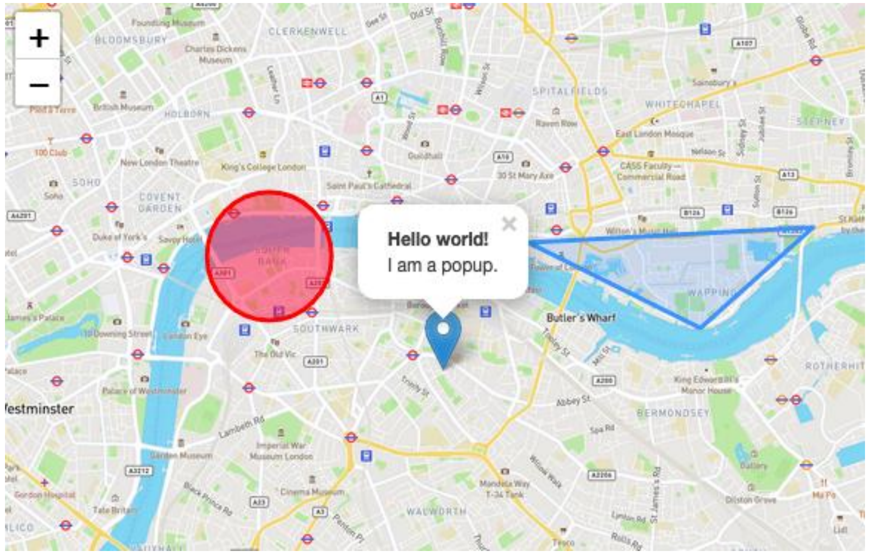
GIS in use

Examples of Open Source

- QGIS
- PostGIS
- OpenStreetMap
- Leaflet

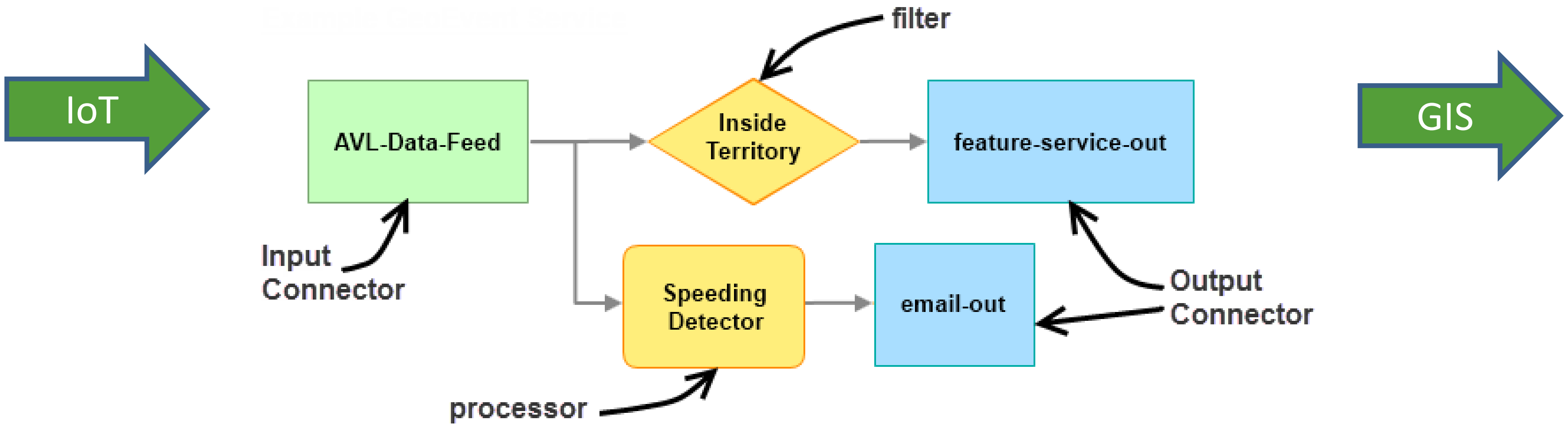
Examples of Commercially

- ESRI – ArcGIS
- Mapbox
- Intergraph



ArcGIS Geoevent

ArcGIS GeoEvent Server is an extension of the ArcGIS platform by Esri designed to process and analyze real-time data streams. It allows organizations to ingest continuous data from various sources such as IoT sensors, GPS trackers, weather stations, or mobile apps. GeoEvent can immediately filter, transform, and evaluate incoming data based on user-defined rules—for example, detecting threshold violations, tracking movement, or triggering alerts. The processed data can then be visualized on maps, stored in databases, or used to initiate automated responses, making it a powerful tool for applications in smart agriculture, logistics, public safety, and environmental monitoring.



04

Case Study

Case Study: Geophysical Instruments for Soil Variability Monitoring

Soil variability within a field significantly impacts crop performance, but conventional sampling is slow and low-resolution. Geophysical instruments like the **EM38** (electromagnetic induction sensor) measure soil conductivity, which correlates with texture, moisture, and salinity. Meanwhile, **gamma spectrometers** detect natural radioisotopes in the soil, revealing its mineral composition. These data layers are processed and visualized in GIS systems to define management zones for variable-rate fertilization or seeding. The main challenges include high cost of instruments, the need for trained operators, and complex data interpretation.

- Problem: Soil properties vary within a field but are hard to map manually
- Solution: Use of geophysical tools (EM38, gamma spectrometer)
- EM38 – measures soil electrical conductivity (moisture, texture, salinity)
- Gamma spectrometer – detects soil mineral composition
- Benefits: Supports creation of precise management zones
- Challenges: Data interpretation, equipment cost, need for expertise

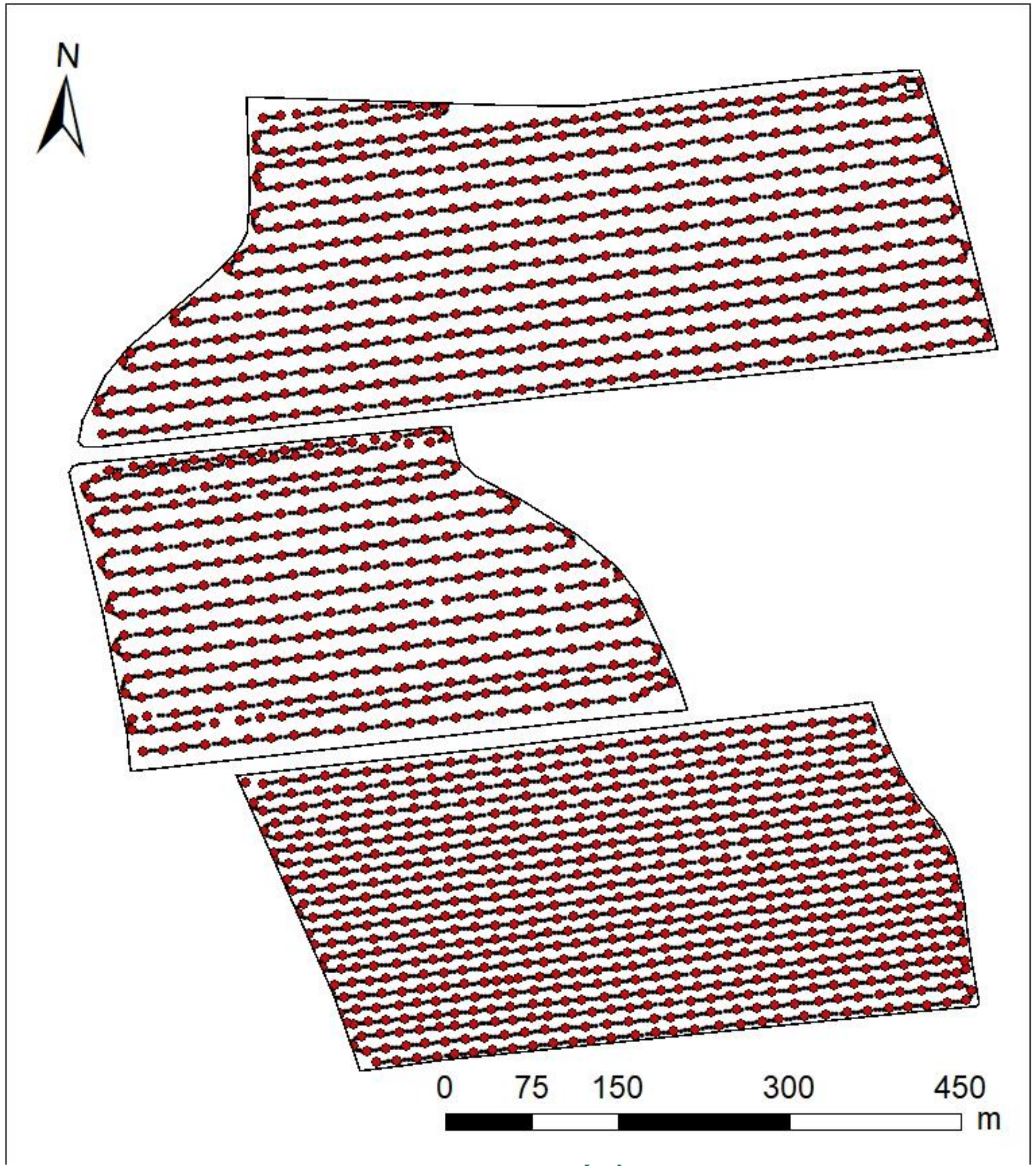
Use of geophysical instruments for monitoring soil property variability

Gamma spectrometer (GF Instruments, CZ)

EM38 MK2 (Geonics Limited, Kanada)

Data from Gamma spectrometer

Using data from the EM38-MK2 gamma spectrometer—a specialized instrument for soil monitoring and electromagnetic induction (EMI) measurements—in a Geographic Information System (GIS) involves a structured workflow to convert raw sensor readings into spatial insights about soil properties. This device is commonly used for mapping apparent electrical conductivity (ECa), which correlates with soil moisture, salinity, texture, and compaction.

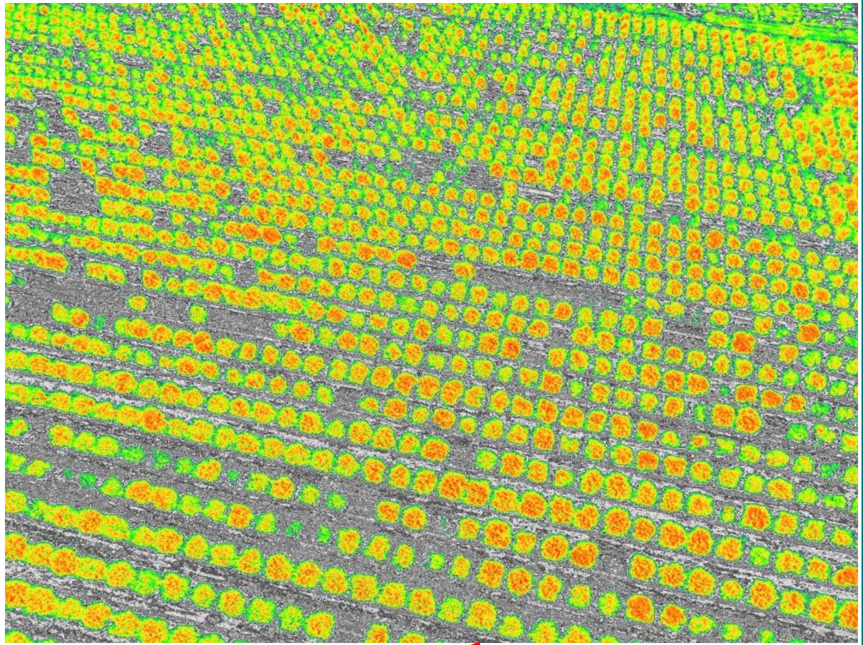


Case Study: UAVs for Disease Detection in Crops

Diseases like fungal infections or nutrient deficiencies can be hard to detect in early stages. UAVs with multispectral cameras can spot subtle changes in reflectance, indicating stress. These images are processed into GIS maps showing likely hotspots. This allows targeted treatment and lower pesticide use. However, interpreting the imagery requires expertise or AI-based tools.

- Problem: Crop diseases often detected too late
- Solution: Drones with multispectral cameras identify stress patterns
- GIS maps disease risk zones before symptoms appear
- Benefits: Early intervention, reduced chemical use
- Challenges: Image interpretation, cost of drone tech

Tree inspection, stand organization, number of trees



RGB image, multispectral image, thermogram (was used).

Example of using UAVs in orchard

In orchards, UAVs can capture high-resolution imagery that, when analyzed in GIS, enables accurate detection of tree number, location, size, and spacing, supporting better inventory and management. Vegetation indices derived from multispectral drone images help assess tree vitality, allowing for targeted water regime adjustments and precise spot applications of fertilizers or pesticides. Additionally, UAV-GIS integration facilitates planning and monitoring of new tree planting based on spatial gaps and vitality patterns, improving overall orchard productivity.

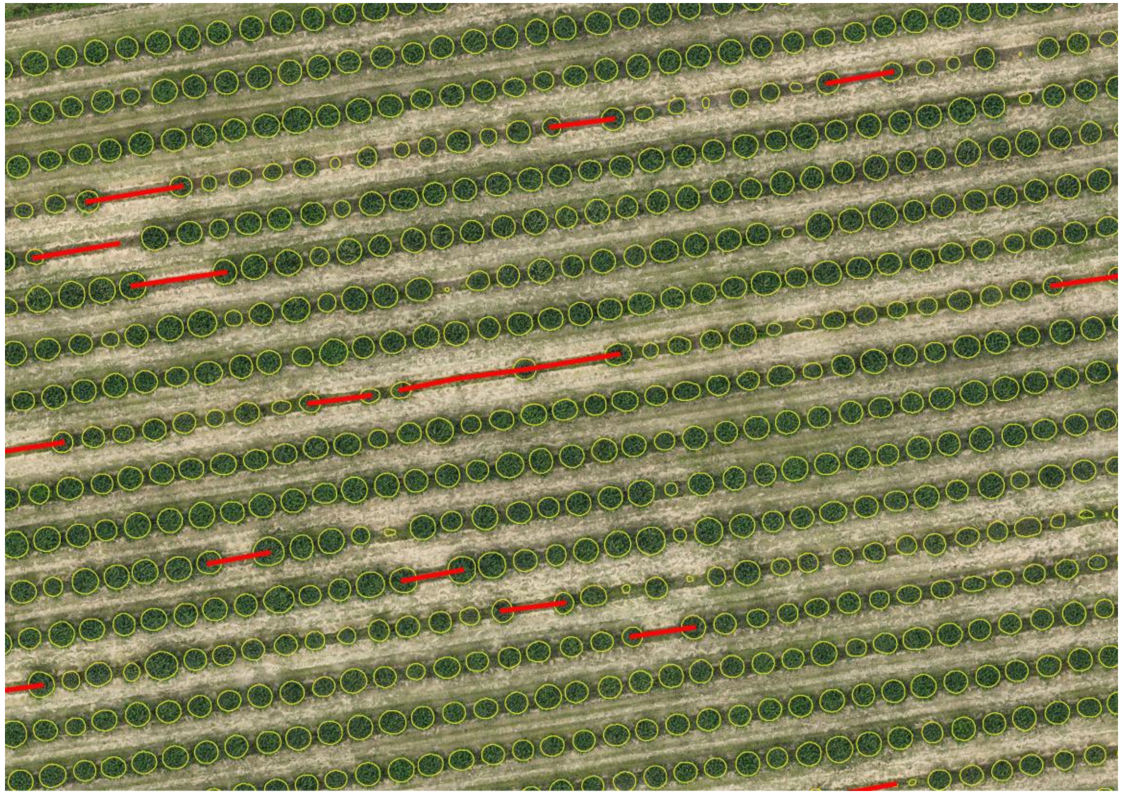
Example of using UAVs in orchard

- Land area: 9.59 ha
- Number of trees: 4 411
- Number of missing trees: 218

- Gap: 4.7 %

- The question is the number of production trees

Example of evaluation of orchard spacing



Creating orchard management

In orchard management, UAVs combined with GIS technology enable detailed mapping from the land level down to individual trees, capturing precise boundaries of plots, rows, and tree positions. This high-resolution spatial data provides critical tree-level information such as health, size, and spacing, essential for effective planning and resource management. Establishing such detailed geospatial layers lays the groundwork for future robotization in orchards, as autonomous systems require accurate environmental and positional data to operate efficiently and safely.

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Well done!

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

In the **next module** you will learn about Advances Tools in Precision Agriculture**.**

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Follow our journey

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