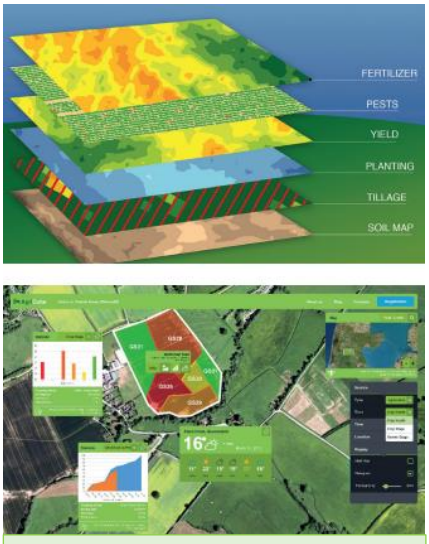
B4. GIS and GPS – overview of disponible equipment

What are GIS? GIS, or "*Geographic information systems*", are computer-based tools used to store, visualize, analyse, and interpret *geographic data*. Geographic data (also called spatial, or geospatial data) identifies the *geographic location* of features. These data include anything that can be associated with a location on the globe, anything that can be mapped. For example, roads, country boundaries, fields are types of spatial data.

A GIS system uses computers and software to gather, manage and analyse data based on geography, and visualizes the data on a map. GIS *mapping software* uses *spatial data* to create maps and 3D models out of layers of visual information, revealing patterns and relationships in the GIS data. Industries and agencies use GIS to better communicate and solve problems associated with geographic locations and properties of objects.



Example data layers (top) stored and accessible within a typical online farm management system

How GIS Works? GIS systems generally consist of the following elements:

- Maps that contain geographic data layers.
- Data, spreadsheets, and imagery that ties data to a particular location.
- Spatial analysis helps decision-making to provide insights, gives users more confidence when predicting situations.
- Mobile apps allow GIS data to be used anywhere, at any time.

GIS generally perform tasks in three steps:

- Visualization of data. Geographic data is displayed in GIS software.
- Combination of data. Layers of data are putting to form maps.
- Querying. Queries are answered for values in layered data.

Sources of Geographic Information Systems:

- Natural Earth Data – GIS data in the public domains.
- Esri Open Data – offers near 70,000 open data sets from 4,000 organizations.
- USGS Earth Explorer – Remote sensing data and access to one of the largest databases of satellite and aerial imagery.
- OpenStreetMap (OSM).
- Socioeconomic Data and Applications Centre (SEDAC): provides global socioeconomic data from 15 different themes including: agriculture, climate, conservation, governance, hazards, health, infrastructure, land use, marine and coastal, population, poverty, remote sensing, sustainability, urban and water.
- Copernicus Open Access Hub[1] or from the EUMETSAT Copernicus Online Data Access point depending on the type of data.

[1] Copernicus Open Access Hub: The data and information delivered by the Copernicus Service are made available to users through the services websites. In most cases, data and information can be browsed/discovered without prior registration but registration is required for downloading. Considered as public goods, the Earth observation data delivered by the Sentinel satellites and the data and information delivered by the 6 Copernicus services are available to users on a free, full, and open basis.

- United Nations Environmental Data Explorer's online database.
- NASA's Earth Observations (NEO) Global satellite imagery accessible in JPEG, PNG, Google Earth and GeoTIFF formats.
- The data delivered by the Sentinel satellites can be downloaded either from the ESA Copernicus Open Access Hub or from the EUMETSAT Copernicus Online Data Access point depending on the type of data

What is GPS – ***Global Positioning System*** is a satellite-based *navigation system* that consists of a set of operational *satellites.* GPS works in any weather conditions, anywhere in the world, 24 hours a day, with no subscription fees or setup charges.

Today, two satellite systems are functioning: *American GPS* and European *Galileo*. The official "United States Department of Defense" (USDOD) name for GPS is *NAVSTAR*. Both satellite systems consist of 24 operational satellites (each with several backup satellites).

HOW SATELLITES WORK? Satellites circle the Earth twice a day in a precise orbit. Each satellite transmits a unique signal and orbital parameters that allow GPS devices to decode and compute the precise location of the satellite. GPS receivers use this information to calculate an object's exact location and once the position has been determined, the GPS unit gives other information about the object.

HOW ACCURATE ARE GPS? Today's GPS receivers are extremely accurate: *Garmin* GPS receivers are typically accurate to within 10 meters, Galileo based receivers are a bit accurate. Accuracy is even better on the water because there are no obstructions to interfere with the signal.

OTHER GPS SYSTEMS

There are other systems similar to GPS in the world, which are all classified as *global navigation satellite systems* (GNSS). Most Garmin receivers track GPS, GLONASS and Galileo, and some regional variations even track BeiDou and QZSS. These are sometimes referred to as *multiconstellation receivers* since they track and utilize multiple satellite constellations. Within newer Garmin products you could be tracking nearly 20 or 30 satellites.

SOME INTERESTING FACTS ABOUT THE SATELLITES

The systems of satellites are orbiting the Earth about 35.500 km above. They are constantly moving, making two complete orbits in less than 24 hours. They travel at speeds of roughly 11 000 kilometres per hour.

The first GPS satellite was launched in 1978 in USA.

A full constellation of 24 satellites was achieved in 1994.

European Galileo programme began in 2003.

The services of Galileo system were fully operational in 2020.

Galileo is compatible with the United States' GPS, Russia's GLONASS, and the Chinese BeiDou system.

The Galileo system was developed by the EU, but with cooperation with China, Switzerland, Norway, Morocco, Ukraine and Israel.

The costs of Galileo have been estimated to climb up to 10 billion euros.

The European Centre of Galileo is located in Prague, Czech republic.

A GPS satellite weighs approximately 900 kg.

GPS satellites are powered by solar energy, but they have backup batteries on board in case of a solar eclipse.

Transmitter power is only 50 watts or less.

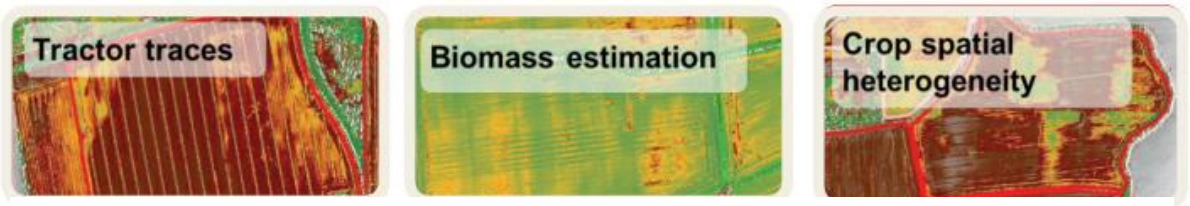
USE SATELITES IN AGRICULTURE

Copernicus is the European Union's Earth observation programme coordinated and managed for the European Commission by the European Union *Agency for the Space Programme* in partnership with the *European Space Agency* (ESA) and the EU Member States.

ESA was developed new systems of satellites *Sentinels* specifically assigned for the needs of the Copernicus programme.

Each Sentinel mission is based on a constellation of satellites which make enable multi-spectral imaging of land, ocean, and atmospheric monitoring.

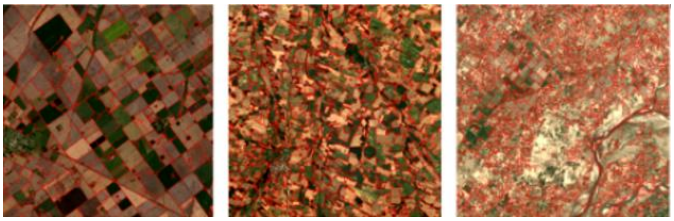
- Sentinel-1 (2016) for land and ocean services.
- Sentinel-2 (2015) is assigned for land monitoring: imagery of vegetation, soil and water cover, inland waterways and coastal areas.
- Sentinel-3, 4, 5 and 6 are systems searching data on environment and climate, on a multitude of trace gases and aerosols affecting air quality and climate.



Spectral images taken by Sentinel 2. A sample of the three layers obtained by processing the spectrum.

The European Commission "*fund Copernicus*", through specialised bodies, provides the technical implementation: ESA (European Space Agency), EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites), EEA (European environment Agency), ECMWF (European Centre for Medium-Range Weather Forecasts).

Diverse areas of farming operation – such as farm planning, field mapping, soil sampling, tractor guidance, crop scouting, variable rate applications, and yield mapping – are made possible through GPS-based applications.



Detailed spectral images of fields from which the quality of vegetation, dry areas, etc. can be determined.

GPS applications can even allow farmers to work during unpleasant weather conditions such as rain, dust, fog and darkness where visibility of the field is minimal. Data collected on location information mapping field boundaries, road locations, irrigation systems, and problem areas in crops (such as weeds or disease), can be combined with GPS data and used for navigating specific locations, building histories of processes, collecting histories of soil samples, and monitoring crop conditions.

Summary:

Geographic information systems are computer-based tools used to store, visualize, analyse, and interpret geographic data. Geographic data identifies the geographic location of features. These data include anything that can be associated with a location on the globe, anything that can be mapped. A GIS system uses computers and software to gather, manage and analyse data based on geography, and visualizes the data on a map. GIS mapping software uses spatial data to create maps and 3D models out of layers of visual information, revealing patterns and relationships in the GIS data. GIS generally perform tasks in three steps: visualization of data (data is displayed in GIS software, combination of data (layers of data are putting to form maps, and querying (queries are answered for values in layered data). GPS – Global Positioning System is a satellite-based navigation system that consists of a set of operational satellites. GPS works in any weather conditions, anywhere in the world, 24 hours a day, with no subscription fees or setup charges. Two satellite systems are functioning today: American GPS and European Galileo. Both satellite systems consist of 24 operational satellites (each with several backup satellites). Copernicus is the European Union's Earth observation programme coordinated and managed for the European Commission by the European Union Agency for the Space Programme. Diverse areas of farming operation – such as farm planning, field mapping, soil sampling, tractor guidance, crop scouting, variable rate applications, and yield mapping – are made possible through GPS-based applications.

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Links to relevant topics:

Satellites for agriculture, AHDB, comms@ahdb.org.uk, website: sa.catapult.org.uk

https://simple.wikipedia.org/wiki/Global_Positioning_System

https://www.geotab.com/blog/what-is-gps/

https://en.wikipedia.org/wiki/Geographic_information_system

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Key words:

geographic information systems
geographic data
geographic location
mapping software
spatial data
Global Positioning System
navigation system
satellites
American GPS
European Galileo
NAVSTAR
Garmin
global navigation satellite systems
multiconstellation receivers

Copernicus
European Space Agency
Sentinels
Copernicus fund