Assessing the benefits of Nature based solutions and Permaculture for moisture retention using high resolution UP42 imagery for climate, vegetation and soil moisture related variables.

Case Study – Finca Jelanisol, Huelva, Spain

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UP42

Jelanisoli

Background

- Mediterranean farming systems are exposed to prolonged droughts and increasing temperatures
- Further problems: Soil degradation, overexploitation of groundwater and loss of biodiversity.
- Controversial debate: European Union: 30% of agricultural land should be converted to organic farming by 2030 and 75% of soils should be restored.

► Is there funding for the implementation of sustainable agricultural practices that can improve water retention and microclimate to create agricultural systems that are more resilient to droughts?

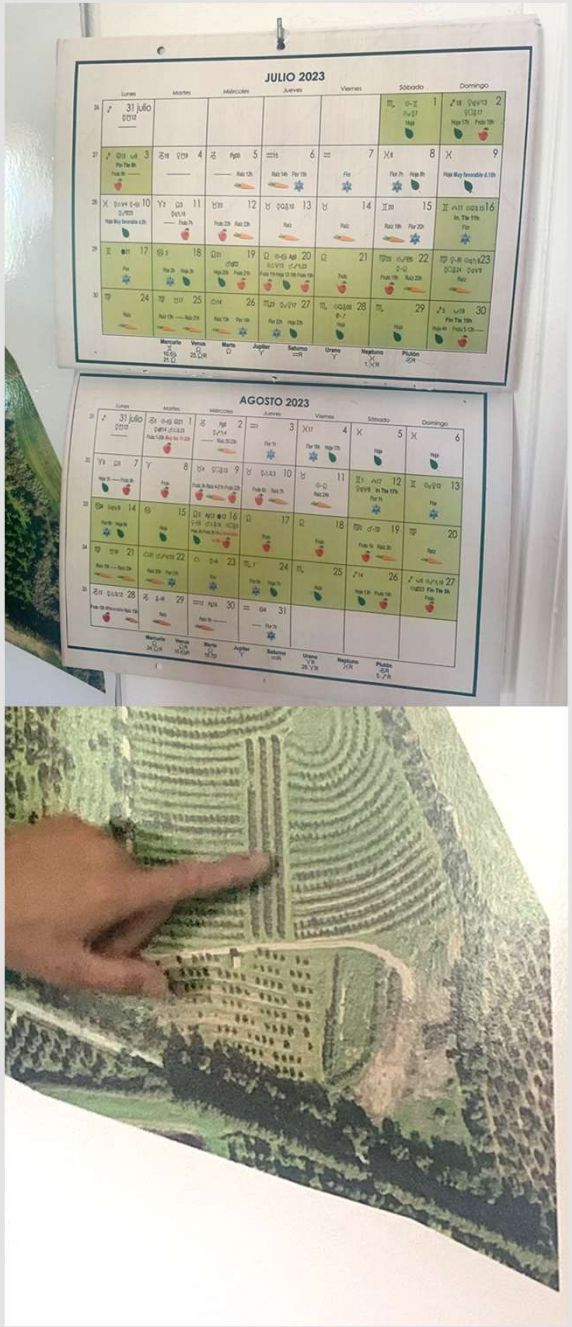
Hypothesis: Permaculture makes farming systems more resilient to climate extremes such as drought

Permaculture practices:

- Mixed crops and live fences
- Key lines
- Water harvesting and storage (ponds)
- Mulching

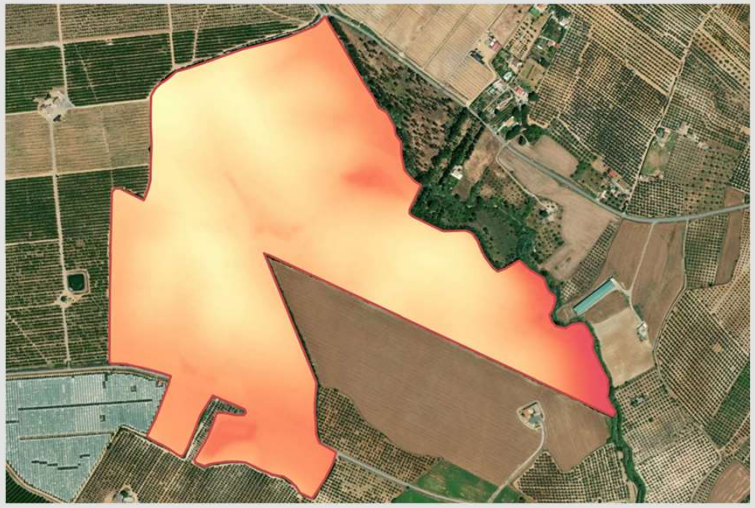
Characteristics of the Finca Jelanisol-Montebello

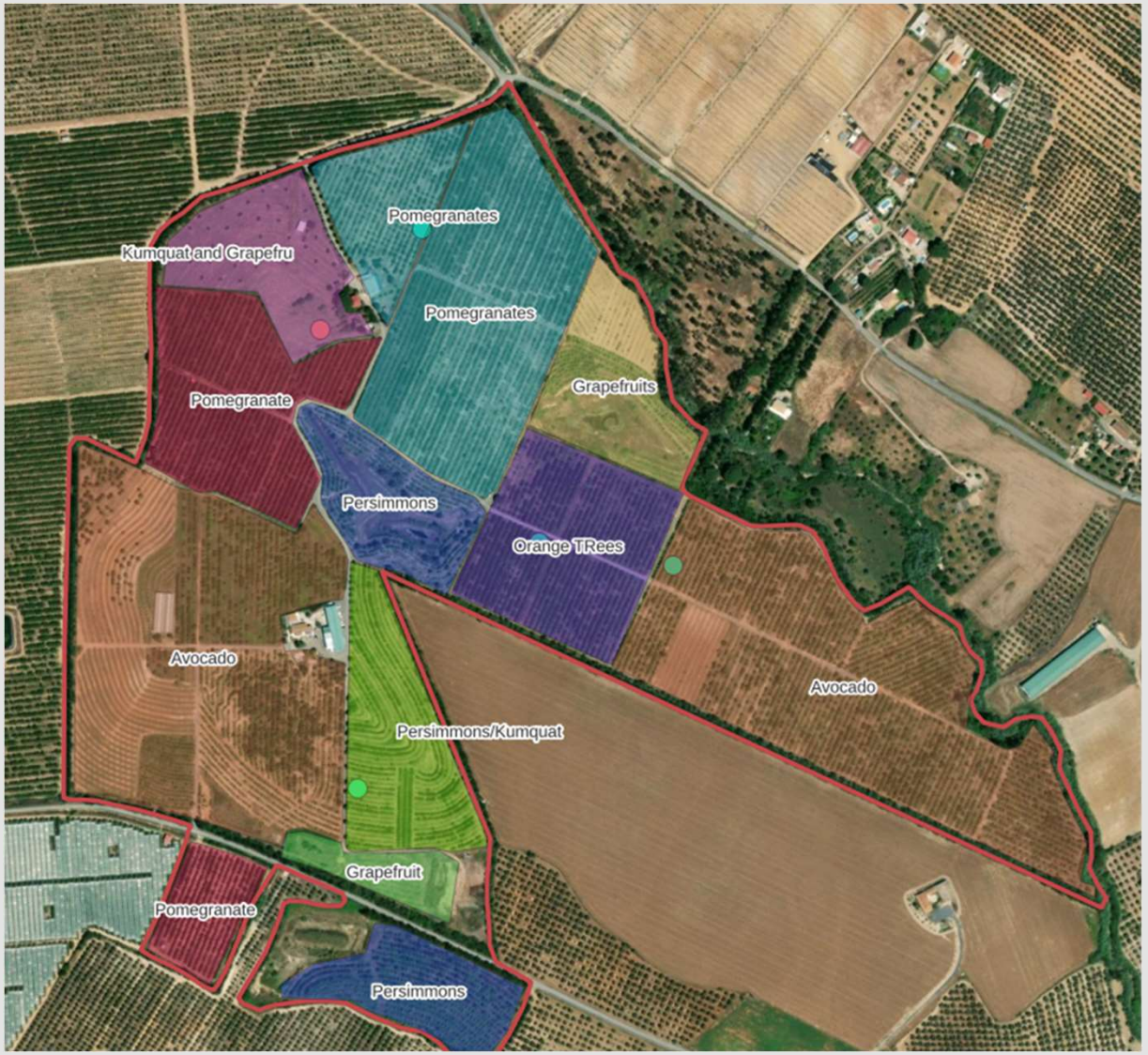
- Size: 50 ha, founded in 1993 by owner Friedrich Lehmann, organic fruit production for export.
- Fruit trees: orange, avocado, pomegranate and persimmon.
- Permaculture practices: mixed cultivation, key lines, living fences, mulching, ponds, composting, ditches, cover crops, biological pest management and many others.
- Fertilisation is done with organic materials and/or manure (compost)
- FertiRiego (drip irrigation with ferlizer)
- Soils: High organic material content of 4% to 6%.



Mixed crops and living fences

- High variability in types of crops, phenological stages
- Crop orientation depends on the slope (e.g. north-south).



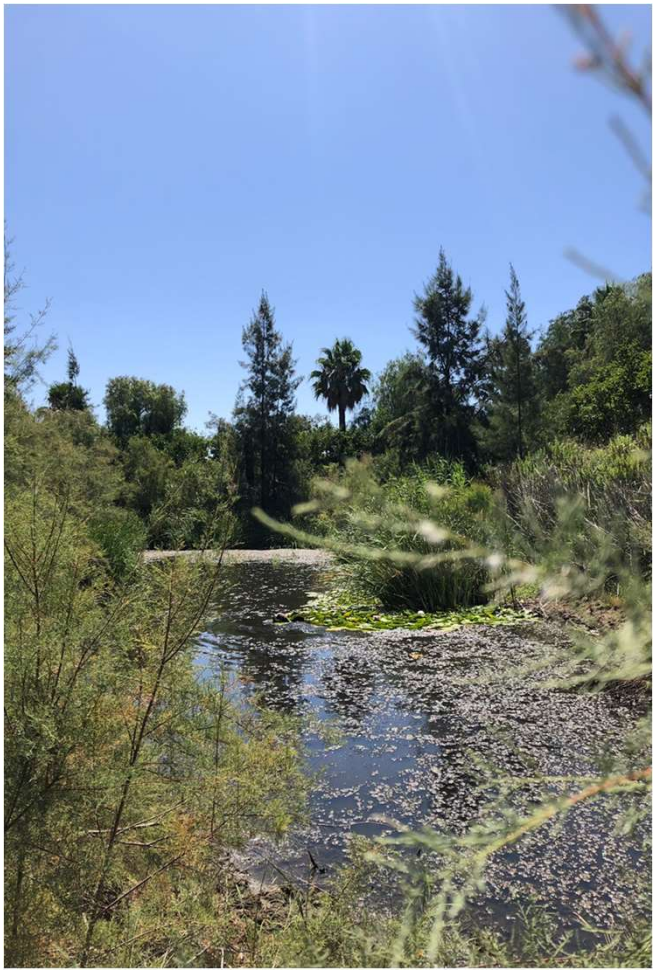


Keylines (P.A. Yeomans)

- Strategic topographic lines to maximise water retention and distribution
- Efficiently capture and distribute water
- Prevent soil erosion
- Improve soil fertility
- specially useful in dry or steep slope areas

Rainwater harvesting and storage: Ponds or ponds to store water, support infiltration into the groundwater and improve the microclimate.

The purpose of these ponds is to improve biodiversity and microclimate.



Mulching

- Soil Moisture Retention
- Weed Suppression
- Temperature Regulation
- Improved Soil Health
- Erosion Control

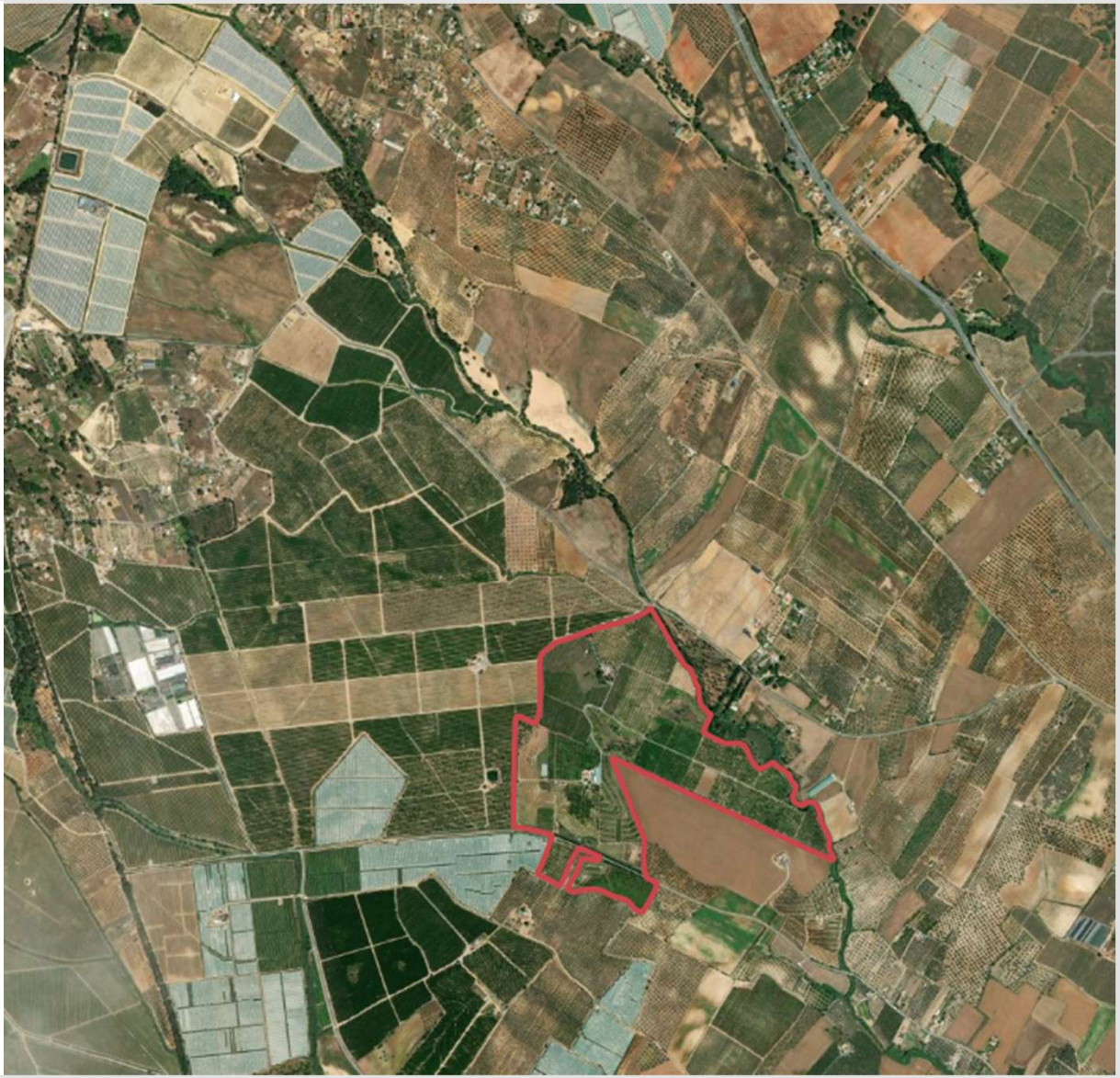
Research Objectives

General Objective:

- To provide evidence on the benefits of permaculture and NBS for resilience against droughts and other hydro-meteorological extremes.

Specific objectives:

- To compare and quantify the effect of permaculture on the water balance versus monoculture.
- To understand the impacts of mulching on soil moisture.



Further objectives - Jelanisol as an on-site laboratory for research and educational purposes.

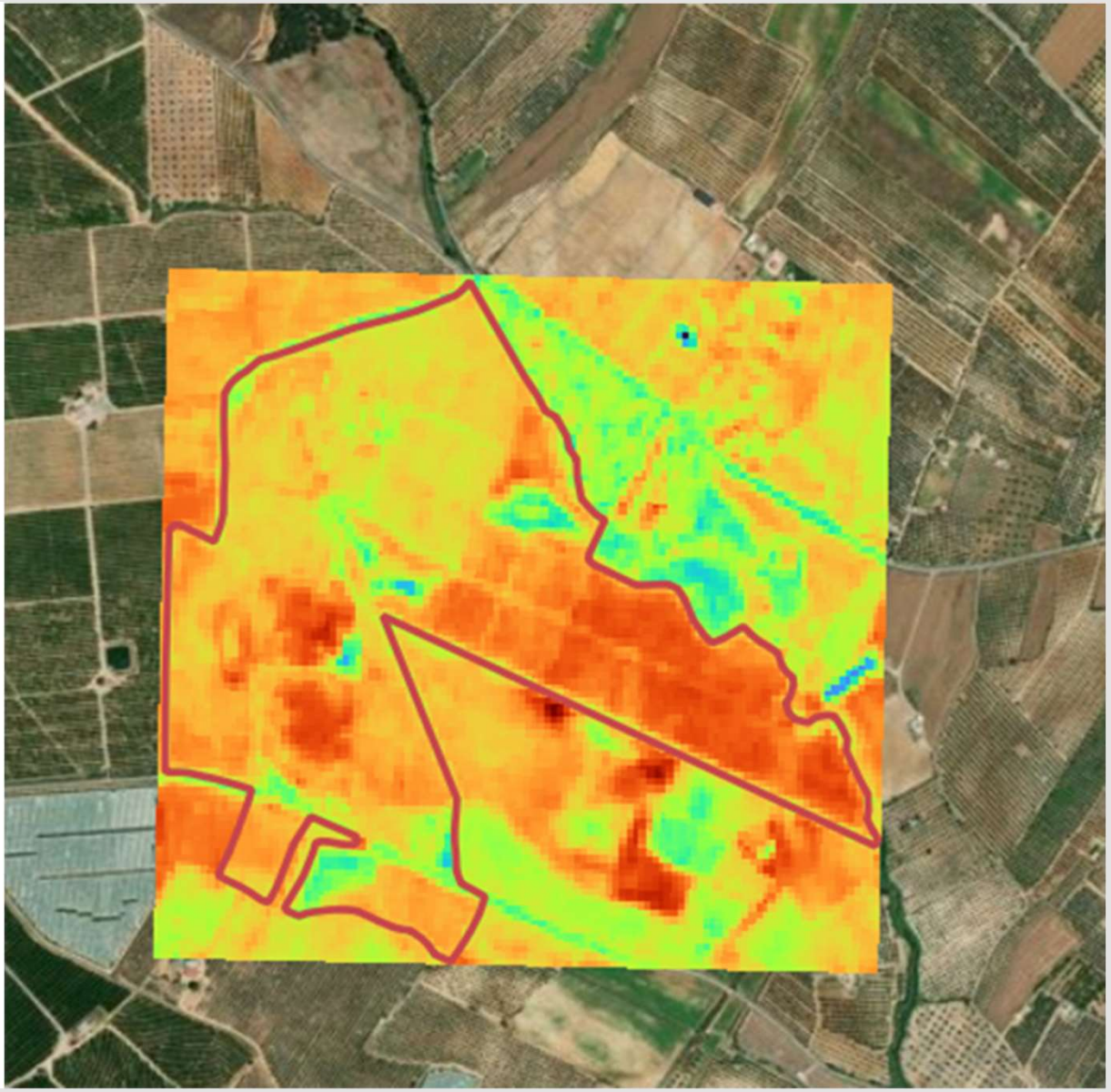
- Generate local water balance information as input for future research.
- Understand the impacts of mulching on soil moisture.
- Quantify the increase in on-farm biodiversity compared to monoculture agriculture.
- Assess the benefits of permaculture in irrigation efficiency and water savings.
- Improve irrigation management (water use efficiency).
- Obtain high-resolution maps of vegetation and crop patterns.
- Modernization and digitization.

Challenge:

obtaining high spatial resolution data for farm-level analyses (water balance, microclimate, humidity).

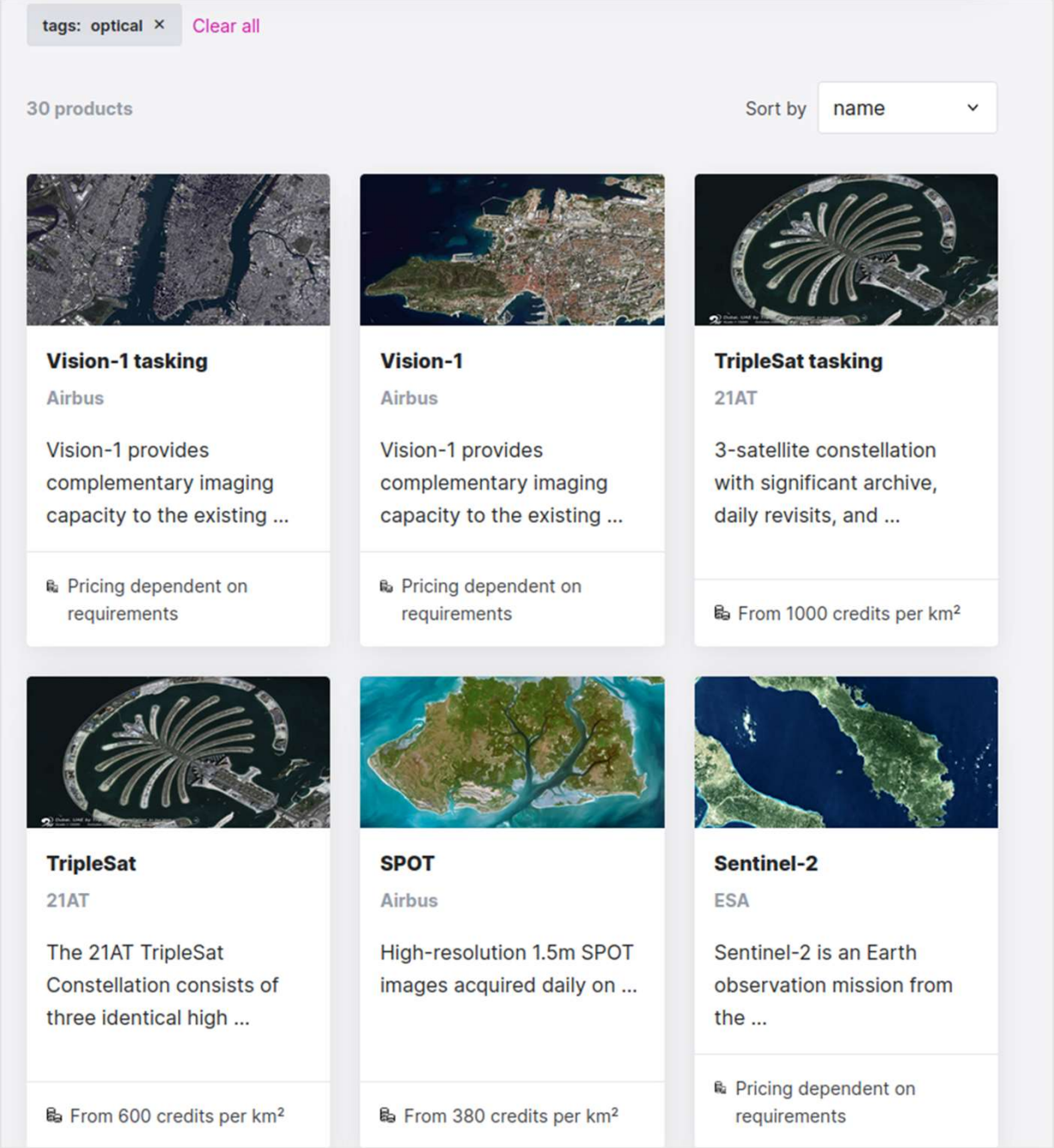
Retrieval of NDMI, resolution 20 m - pixel

- Sentinel 2 (20m) Normalised Difference Moisture Index (NDMI) detects moisture levels in vegetation
- Copernicus Mission, Soil Moisture Index - 1km (Jelanisol is not part of the observed range, so only 12.5 km)
- There is a limit to detailed monitoring of HS or drought in a local area due to spatial resolution.

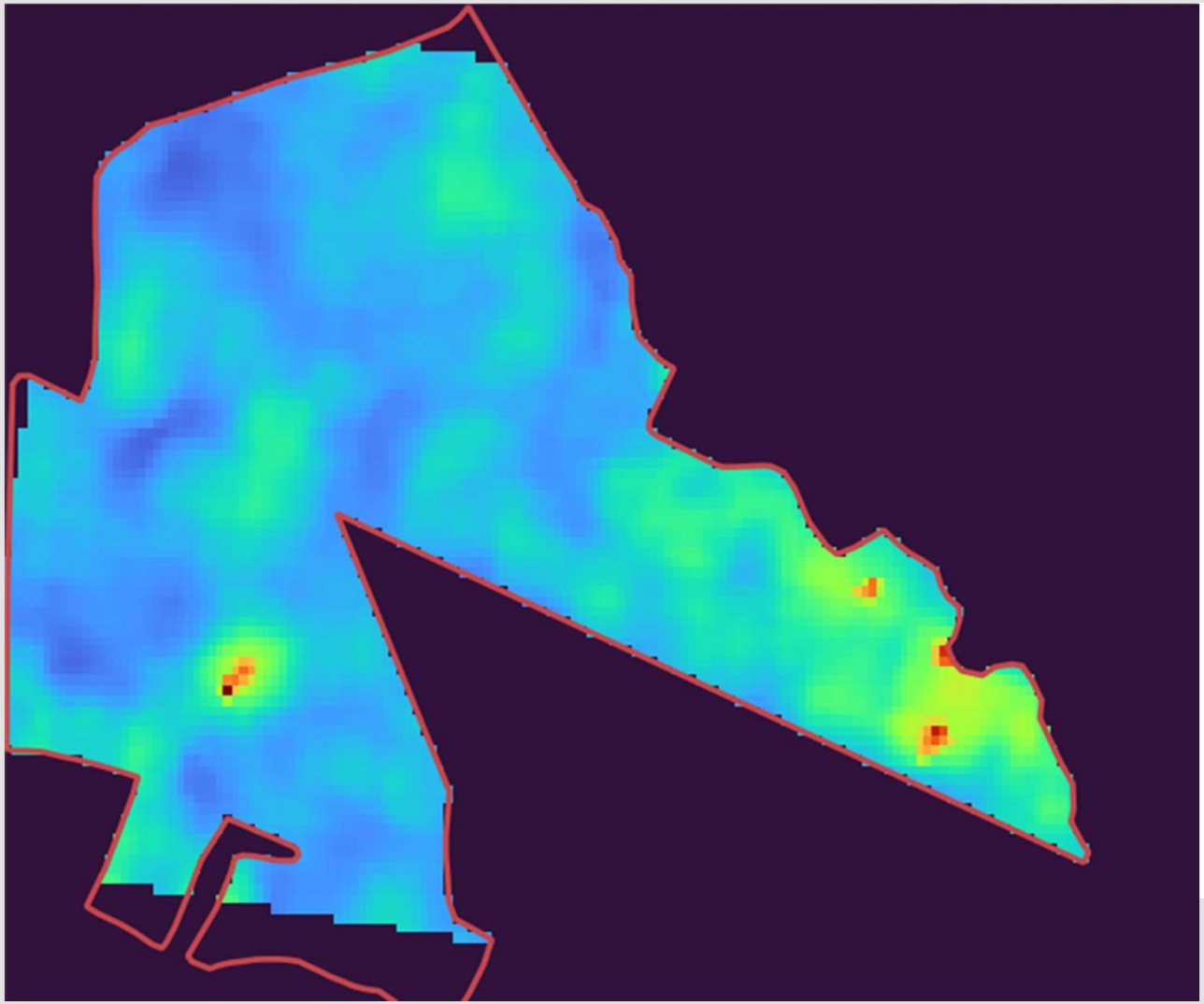


Remote Sensing: UP42

- The UP42 platform offers high-resolution imagery and related processing tools.

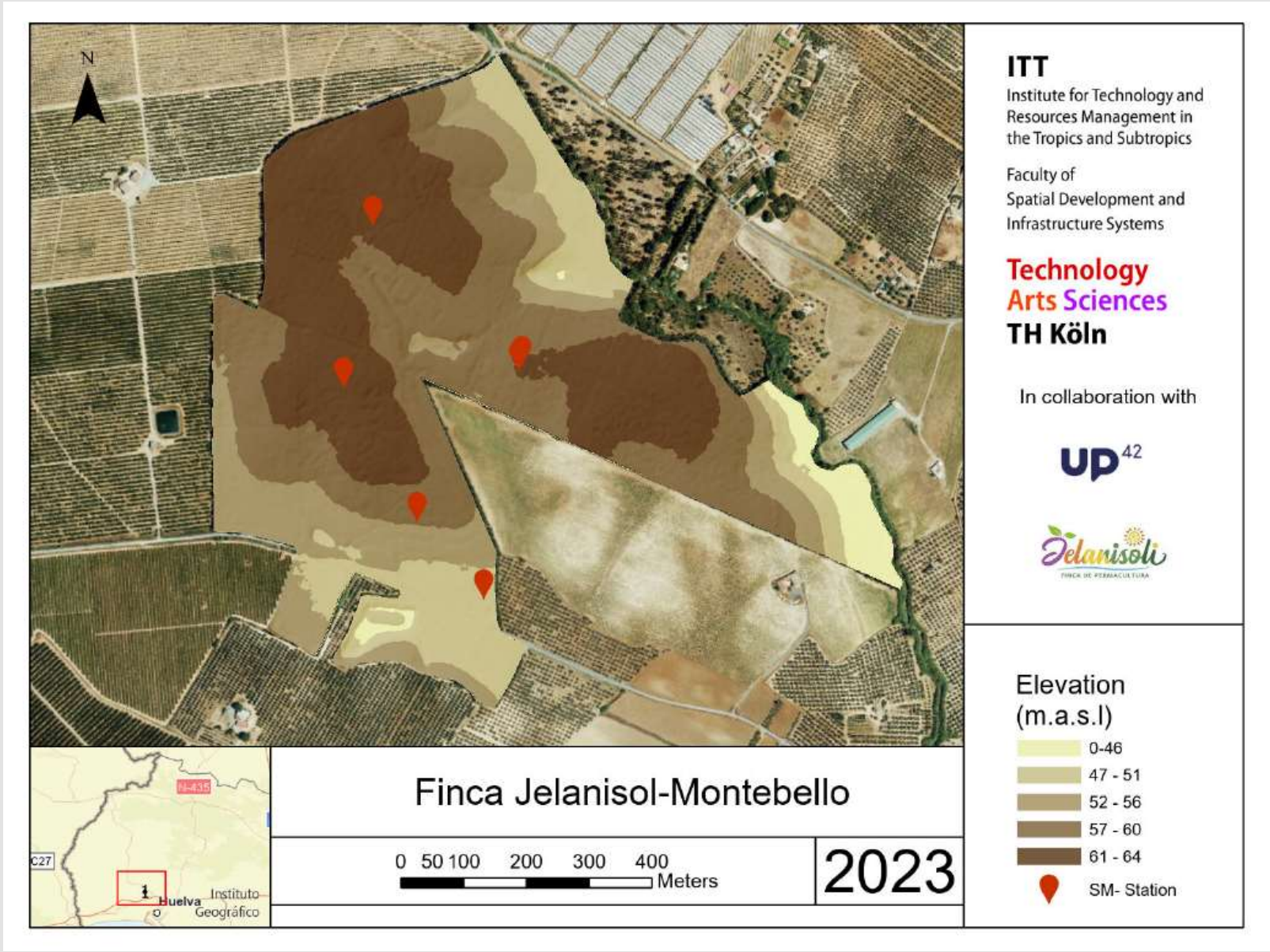


Soil Moisture by Sentinel 1, resolution: 10 m , 5 days

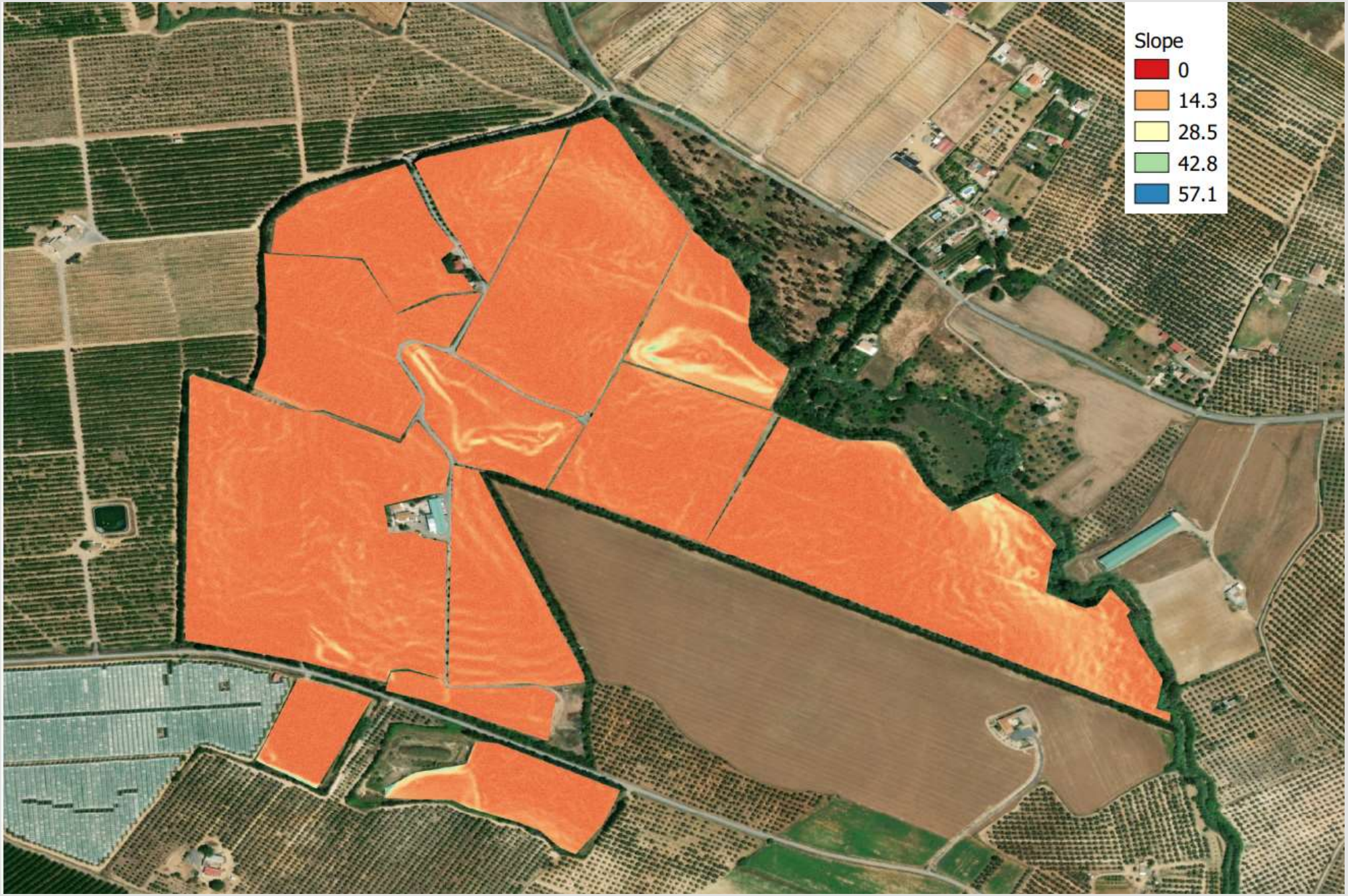


- An important advantage of Sentinel 1 is that it is not affected by cloudiness.

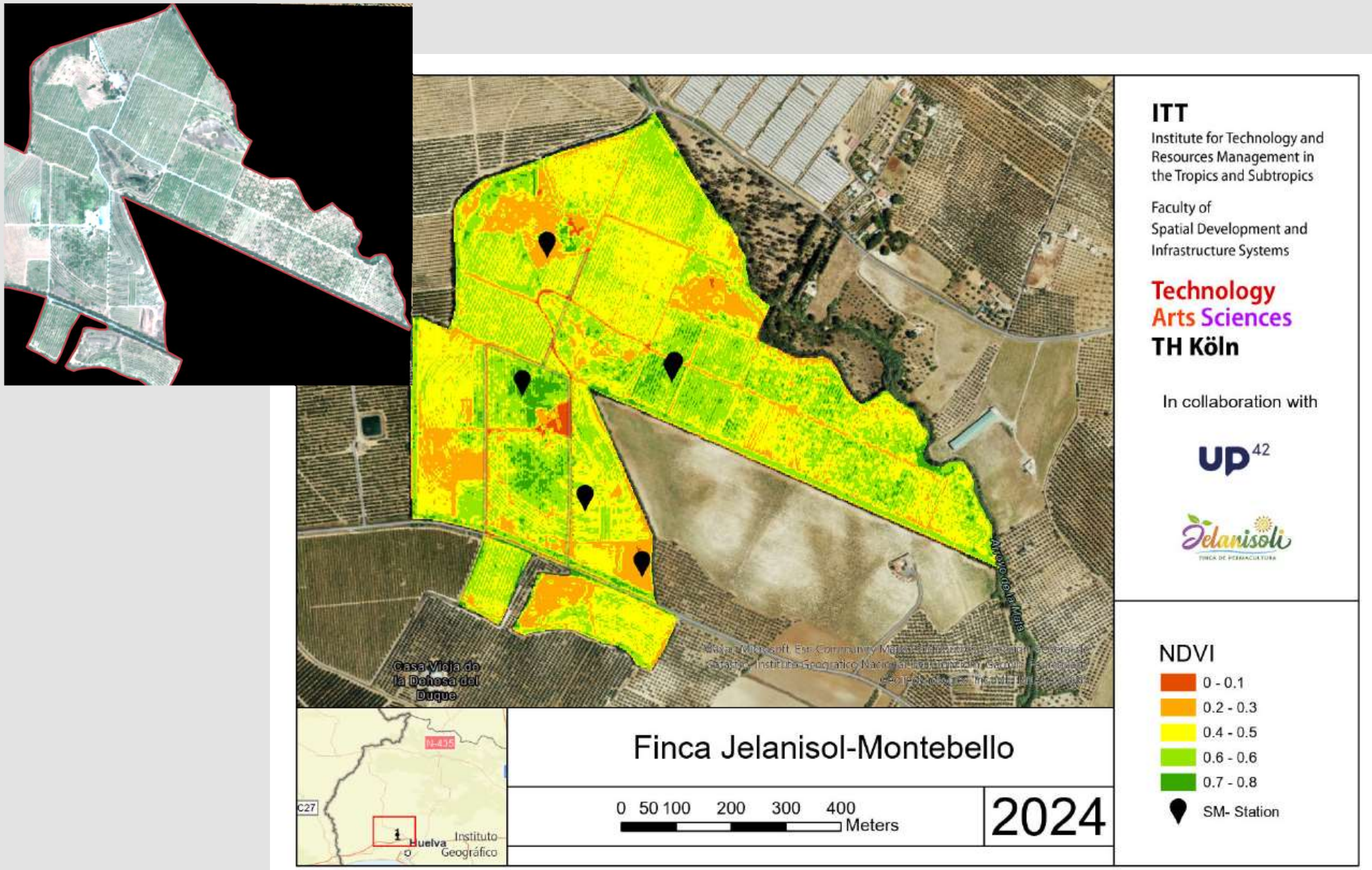
Observe changes in soil moisture at key lines/tilt - High resolution topography: Digital Elevation Model DEM, 15 cm



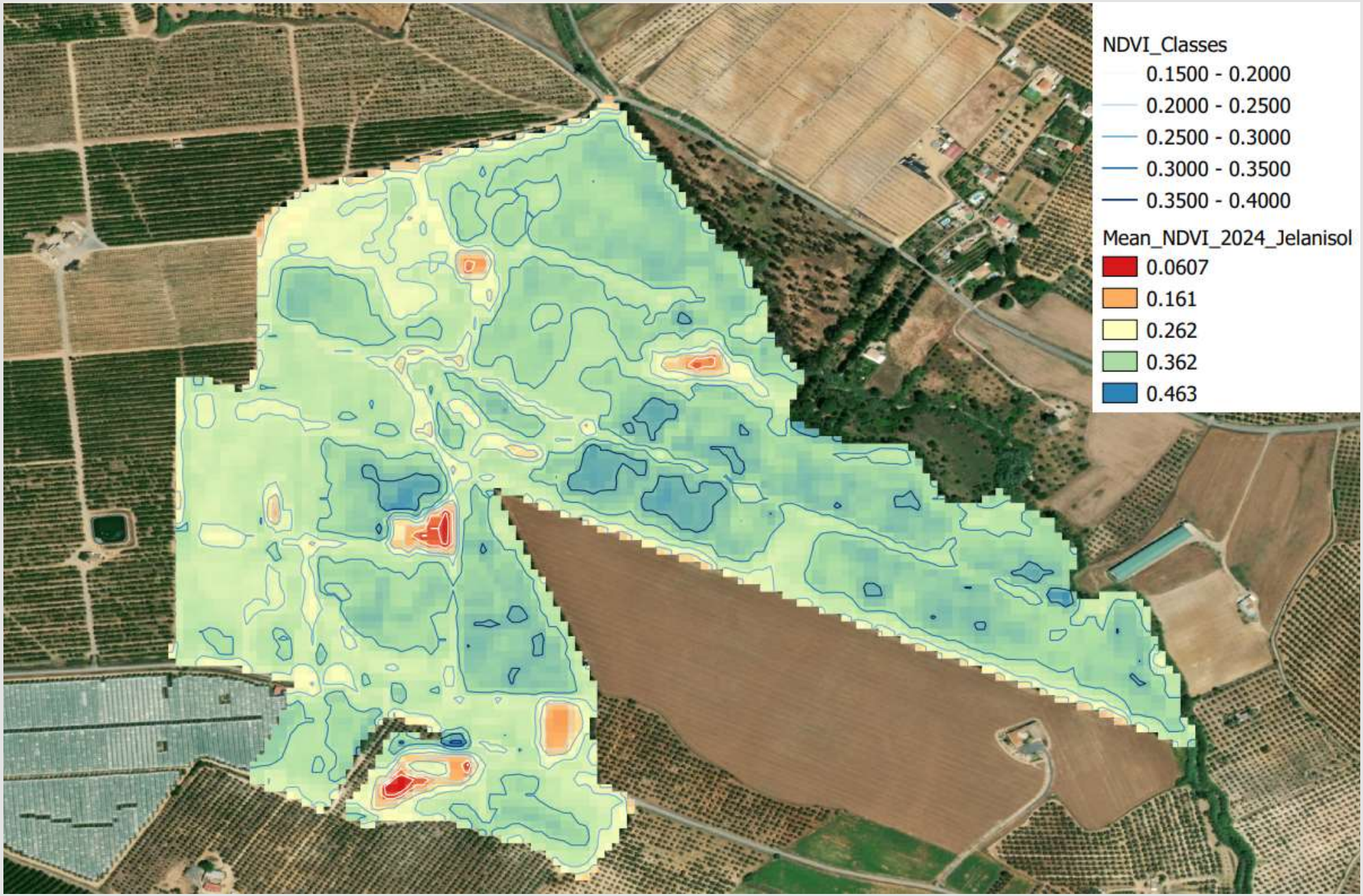
Slope - e.g. analyse the effects of key lines and topography on soil moisture content



Observed changes in vegetation condition: High Resolution NDVI 0.3 m



Selection of Measurement Points based on UP42 15 cm DEM and Slope



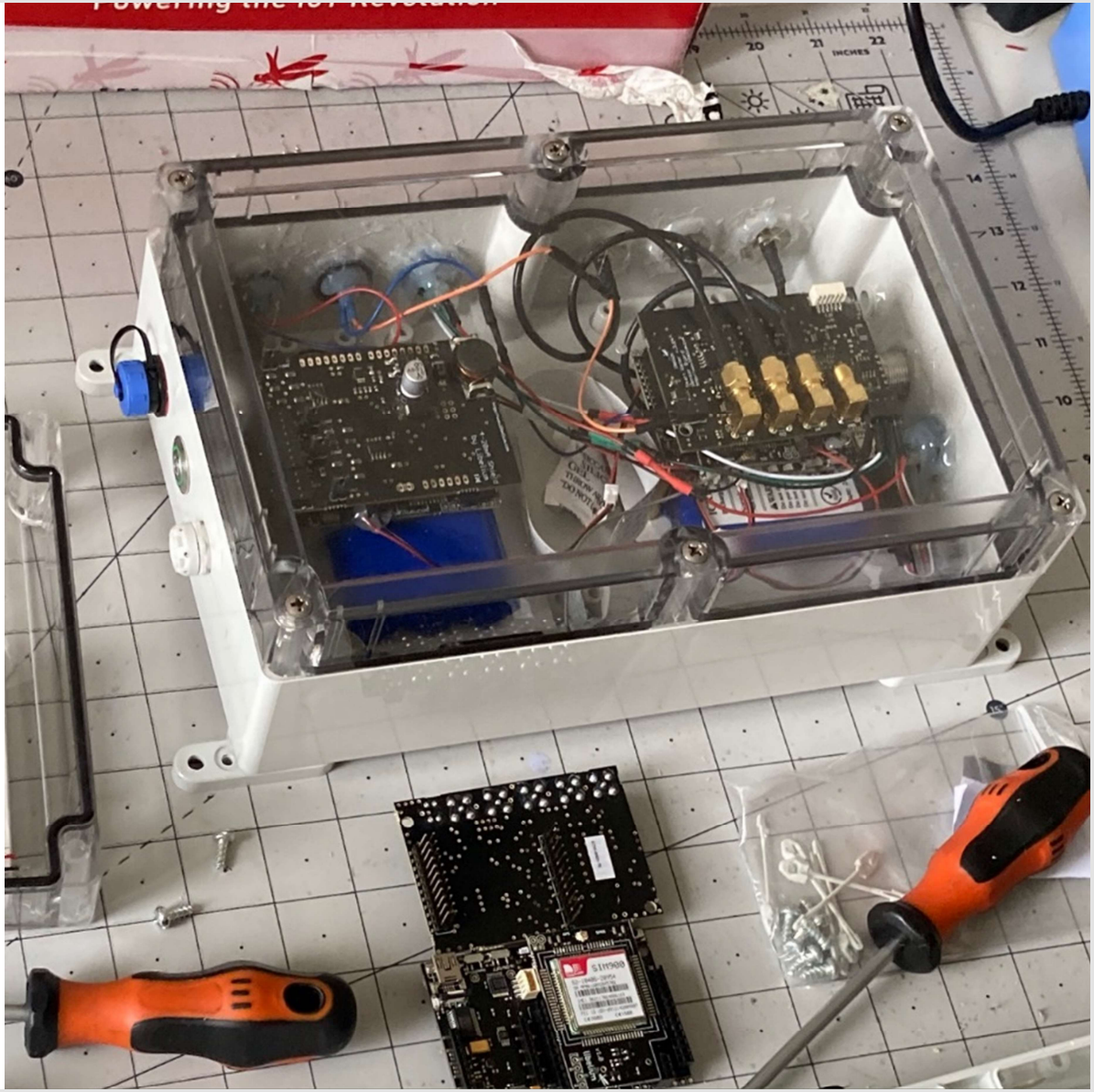
How?

Continuous monitoring of climatic variables and soil moisture.

Low-cost equipment

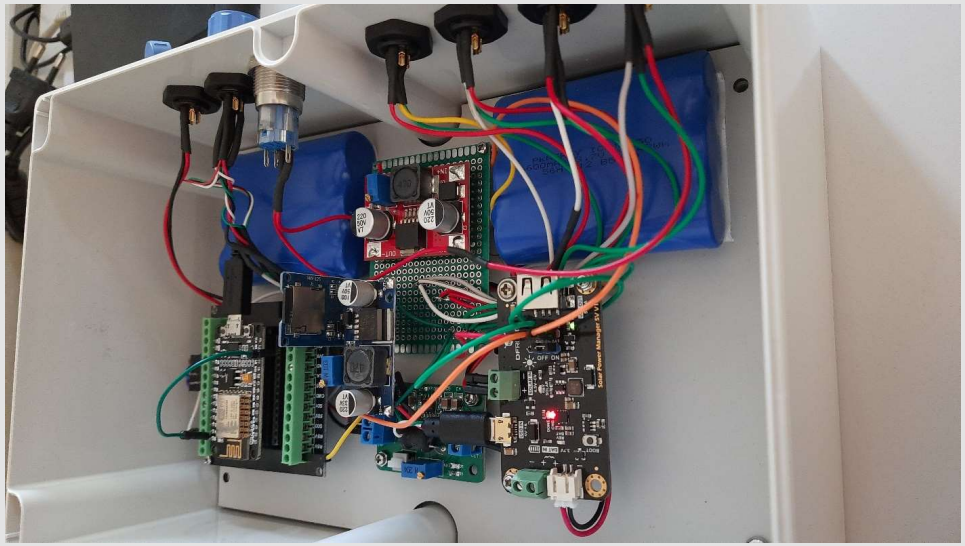
Smart Sense - Low-cost environmental monitoring

- The core of smartsense environmental monitoring is the datalogger.
- Together with a microcontroller on the board, the recorded data is processed and transmitted via GSM/mobile network/wifi.
- Remote transmission guarantees near real-time access.



Smart Sense - Low-cost environmental monitoring

- The photovoltaic power supply allows the installation to be set up in remote regions
- Continuous soil moisture monitoring in agro-photovoltaic systems



Lucas Bastos, blueberry production, Büren, Germany

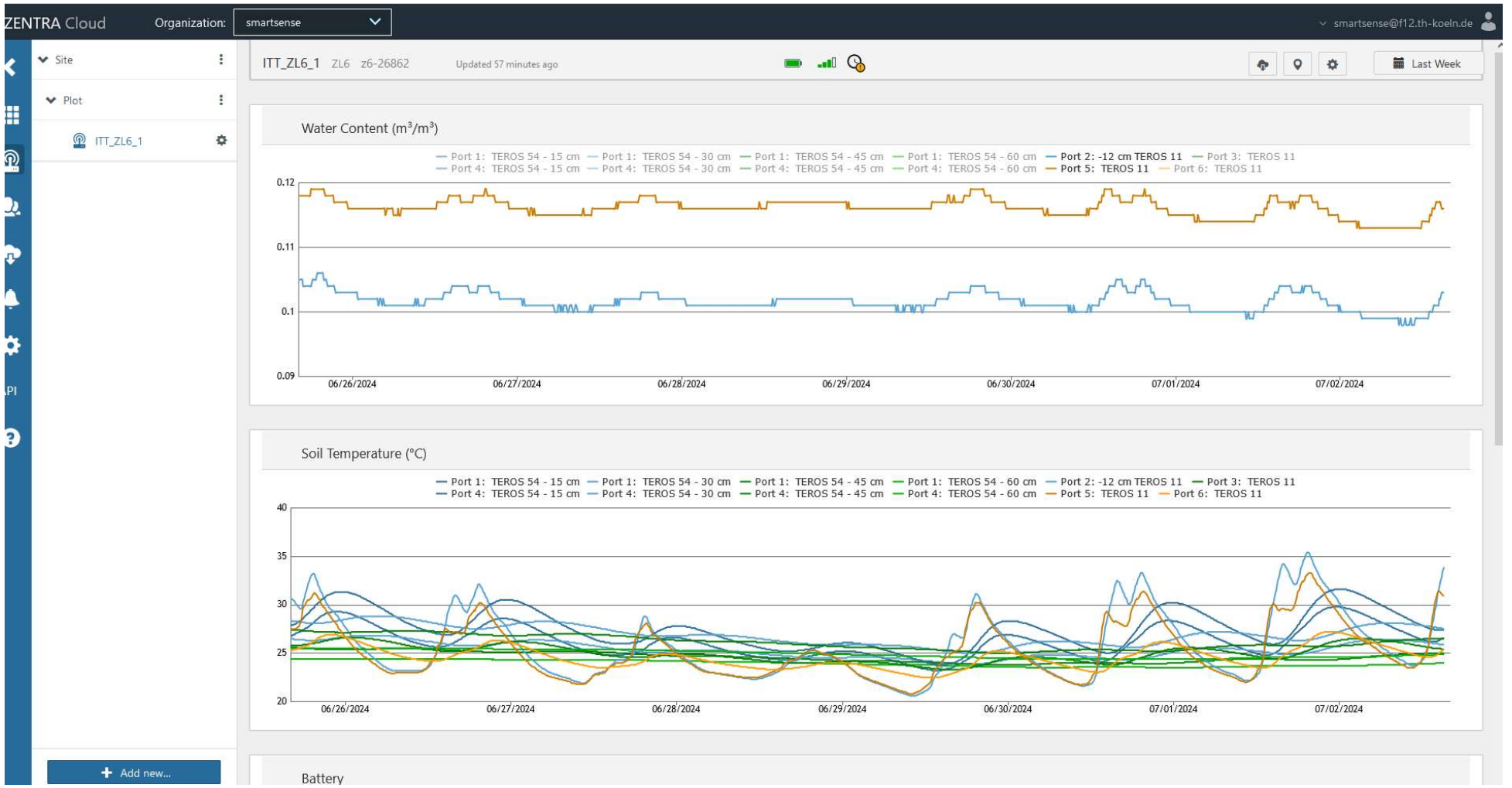
Meteorological Station

Measurements of:

- Temperature
- Air humidity
- Precipitation
- Radiation
- Wind
- Evapotranspiration (Hargreaves)
- Record every 10 seconds.

Soil Moisture Monitoring

Online presentation of soil moisture and climate records



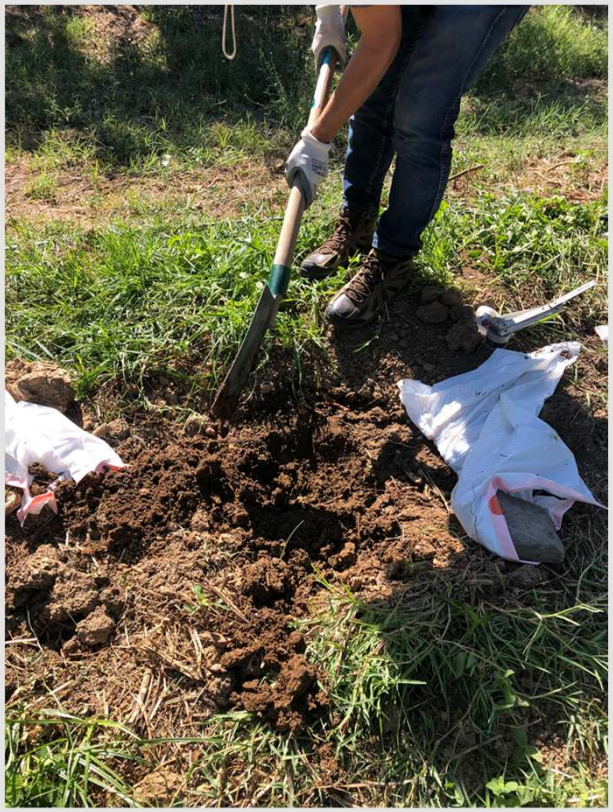
Soil water content: Gravimetric and volumetric method

Objectives:

- Assess soil water storage capacity.
- Determine soil type.
- Information to achieve irrigation efficiency

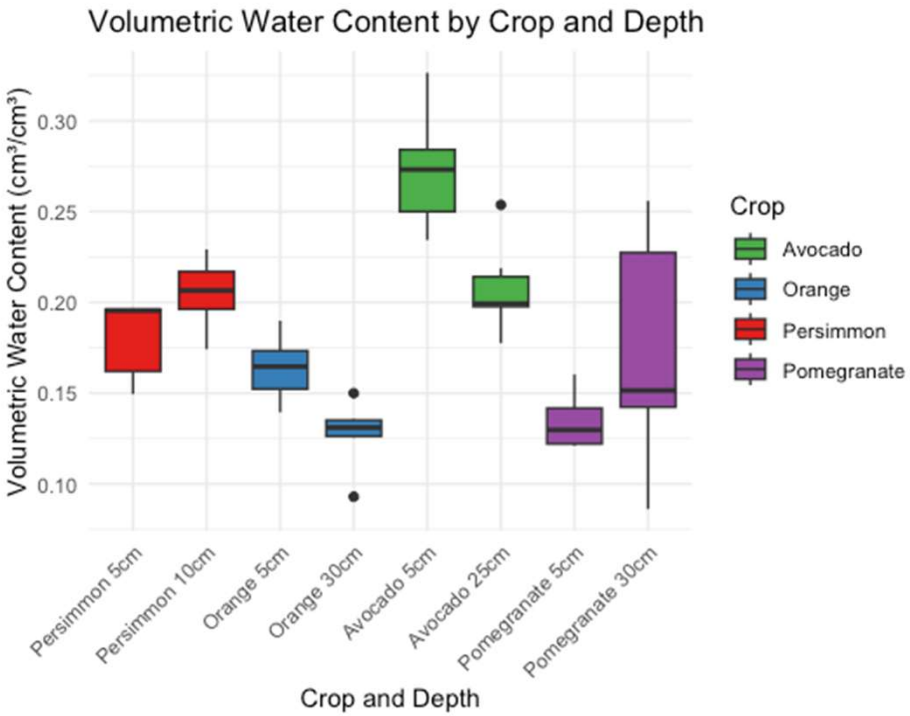
Methodology:

- Soil sampling at the four test sites, each at two depths.
- At each depth, three samples were collected over three days, oven-dried and weighed before and after.



Results gravimetric and volumetric method: Permanent Wilting Point, Field Capacity, volumetric soil water content

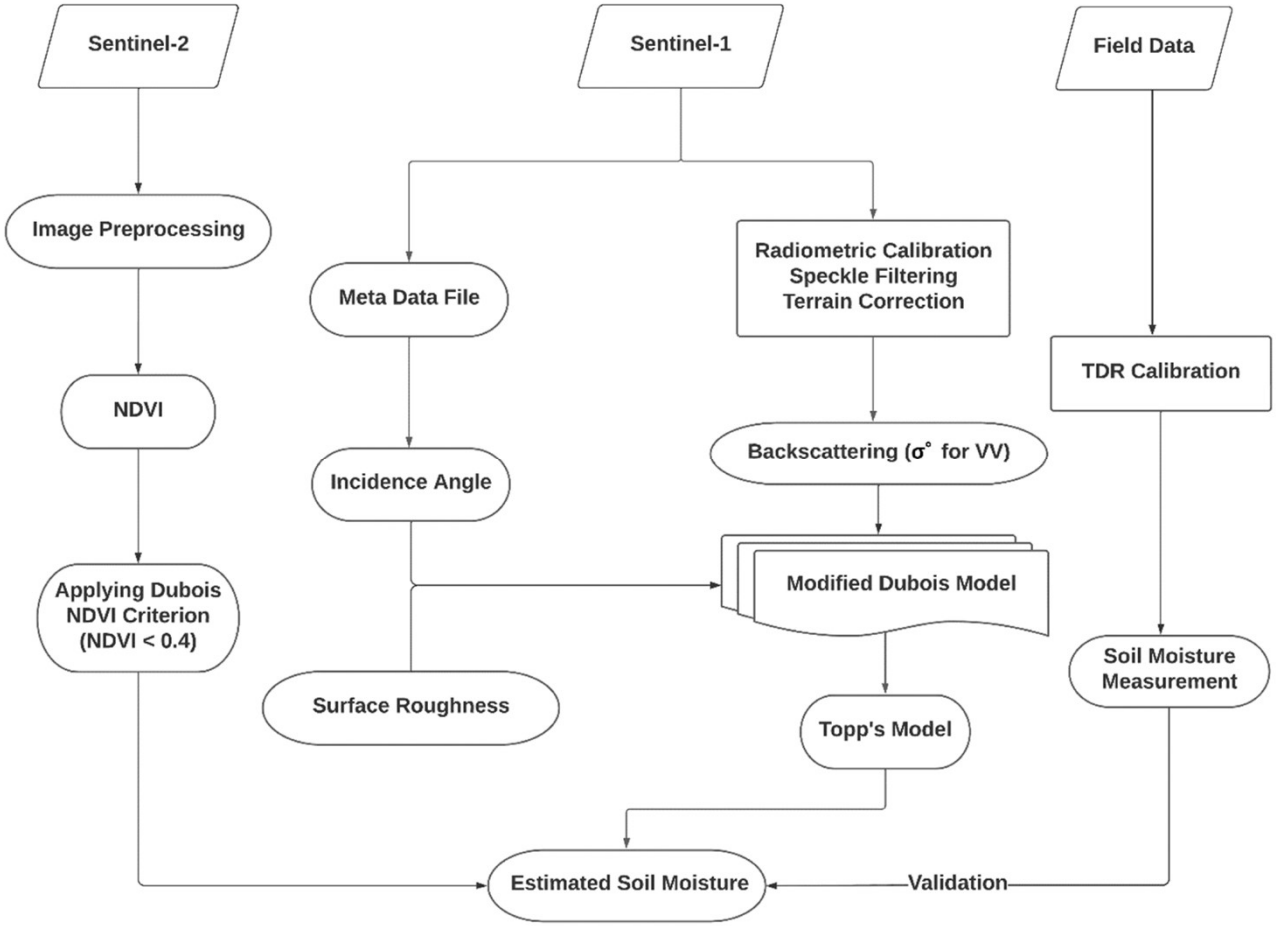
	Water Content (%)	
Crop	Permanent Welting Point	Field Capacity
Avocado	8.51	17.02
Persimmon	9.64	19.28
Pomengranate	7.98	15.95
Orange	10.29	20.57



Potential methods to simulate/estimate high spatial resolution Soil Moisture

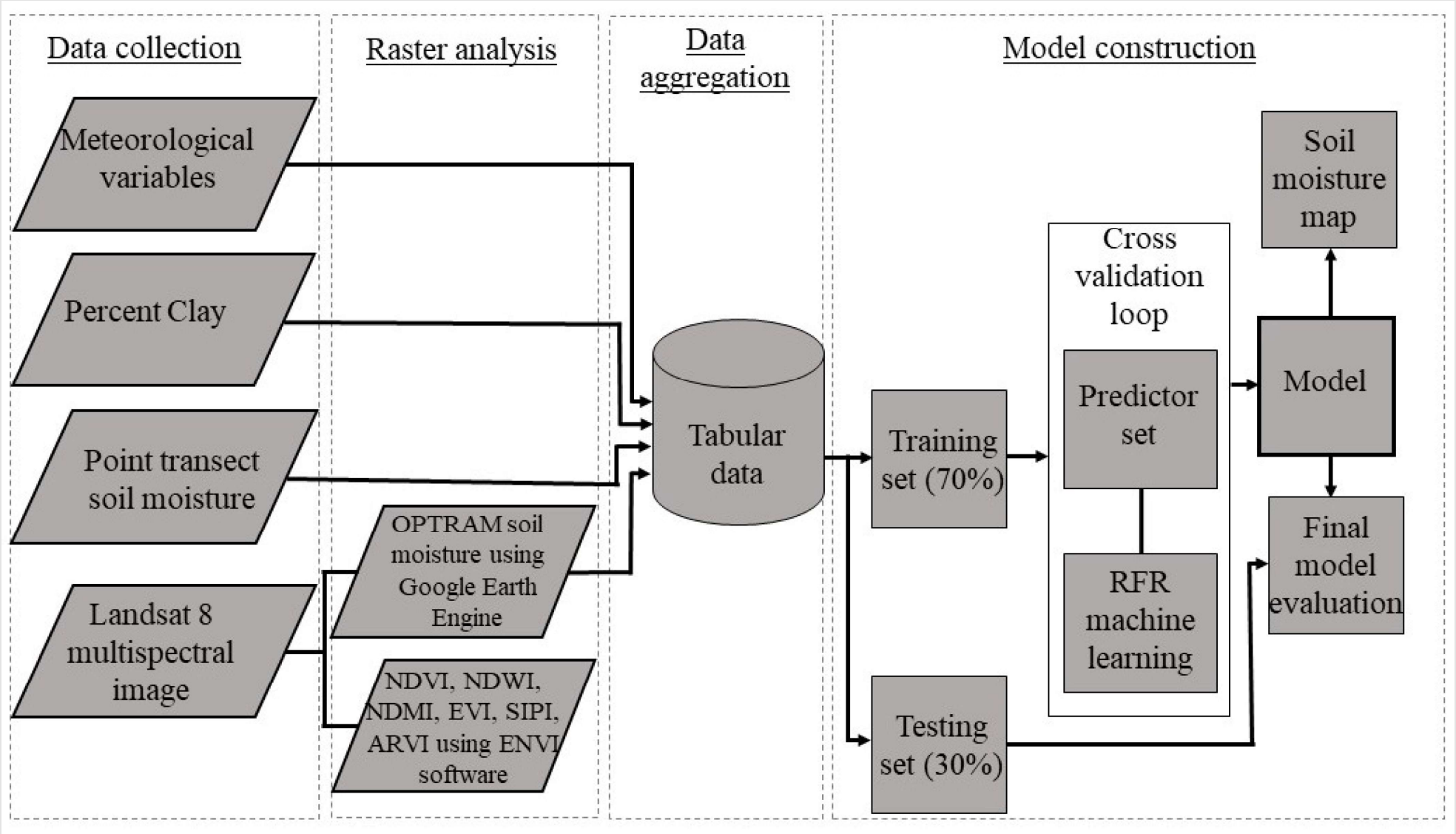
Estimation of Soil Moisture (HS) based on S1-SAR images

- Establish relationships between satellite and optical products such as temperature and vegetation indices-
- validated by on-site observations
- **Challenge: roughness given by dense vegetation (physical models, empirical)**



Esimación de la Humedad superficial del suelo mediante el modelo Dubois y Topp

Soil Moisture Estimates based on non-linear relationships (Artificial Intelligence)



(Acharya et al., 2022)

Methodological Approach

Current approaches are the water cloud model (WCM), which describes the sum of the contribution of vegetation and soil, multiplied by the attenuation factor (vegetation water content, leaf area index, vegetation height).

Challenge:

- Limitation as physical models of field measurements to determine vegetation-related parameters.

Approach:

- The performance of machine learning techniques using AI methods has developed rapidly.
  - Artificial Neural Networks (ANN)
  - Support Vector Machines (SVR)
  - Random Forest (RF)

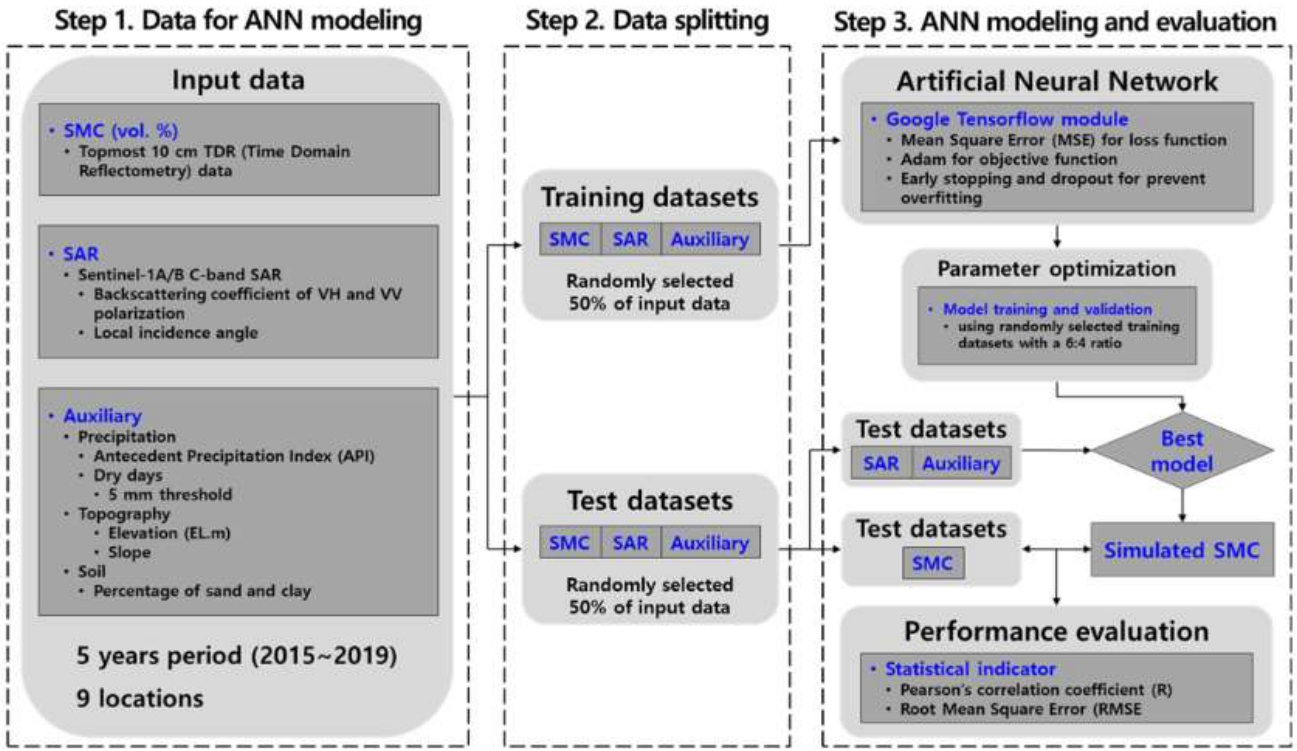


Figure 3. Flow of ANN simulation.

(Chung et al., 2022)

Activities requiring funding:

- Inventory best practices of permaculture and other Nature Based Solutions (NBS) in agricultural and agroforestry systems (Dehesas) that can improve moisture conditions and cope with climate extremes: agroecology, permaculture, agroforestry, water storage (check dams, sand dams, ponds, marshes...), sustainable grazing (Dehesa), sustainable irrigated agriculture, river restoration.
- Implement / demonstrate these measures, such as ponds, permaculture and river restoration, at farm and catchment level.
- Demonstrate and quantify the benefits of these solutions, e.g. by monitoring land use change (satellite based) following the introduction of small reservoirs in the Dehesa/Montado and increasing soil moisture following the introduction of permaculture.
- Develop an efficient monitoring concept for the continuous observation of relevant variables: soil moisture, ambient humidity, temperature, precipitation, evapotranspiration, wind, radiation, groundwater level.

¡Gracias!

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