HELLENIC REPUBLIC
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"BASIC RESEARCH FINANCING" (Horizontal support for all Sciences)
ID 16618 – Subproject 1 (MIS: 5163923)

Spatial Database and Datasets with input data and evaluation data

Spatially Explicit Digital Twin of the Greek Agro-Hydro-System

DT-Agro

ID 14815

Introduction

The primary objective of this deliverable is to provide a spatial geodatabase with input data for the digital twin (DT-Agro). These databases include meteorological data, soil and land cover information, Earth observation data, and socioeconomic evaluation data. The report provides a description of each dataset, including its source, and importance to the project.

The first step includes essential data collection to gather relevant datasets from current databases, national and municipal authorities, and Earth Observation sources. These data will be acquired from a variety of credible sources and databases, including the Hellenic National Meteorological Service, CORINE, HCMR, Copernicus Climate Change Service (ERA-5 Land), local agricultural and irrigation authorities, and other sources. Each dataset will help to create a firm foundation for DT-Agro by providing information on:

- Meteorological Data: Precipitation, temperature, humidity, wind speed, and solar radiation
- Soil Data: Soil Texture, pH, organic content, hydraulic properties
- Vegetation and Land use: Vegetation cover, crop types and land use classifications
- Soil Moisture, Evapotranspiration (Deliverable D3.1)
- Runoff and water quality data
- Irrigation water consumption: Data supplied by local irrigation organizations.

This data gathering procedure is critical to the quality of DT-Agro since the model needs specific and consistent data to effectively replicate agricultural and environmental activities.

Data description

1. Meteorological Data (Historical and new)

Type: Temperature, precipitation, humidity, wind speed, solar radiation
Sources:

- **Hellenic National Meteorological Service (HNMS)**

It provides comprehensive meteorological datasets, including precipitation, temperature, wind speed, and humidity. Data from 1971 to 2024 will be utilized to analyze long-term climatic trends, seasonal variability, and daily weather patterns that influence irrigation needs. These datasets are critical for understanding the impacts of both historical climate variability and current weather conditions on agricultural water management.

- **Copernicus Climate Data**

ERA5-Land is a reanalysis dataset that provides a consistent view of the evolution of land characteristics across multiple decades, with higher resolution than ERA5. ERA5-Land was created by repeating the land component of the ECMWF's (European Centre for Medium-Range Weather Forecasts) ERA5 climate reanalysis. Using physical rules, reanalysis combines model data with observations from around the world to create a globally complete and consistent dataset. The dataset comprises gridded meteorological data provided on a regular latitude-longitude grid with a horizontal resolution of 0.1° x 0.1° (approximately 9 km at native resolution), offering global horizontal coverage. Certain parameters, such as wind and temperature, are defined at 2 meters above the surface. The data have a temporal coverage starting from January 1950 to the present, with an hourly temporal resolution. The dataset is updated daily and is stored in GRIB format. More information about the data available and their description are available on ERA5-Land hourly data from 1950 to present.

- **MERRA-2 (Modern-Era Retrospective analysis for Research and Applications)**

MERRA-2 (Modern-Era Retrospective analysis for Research and Applications) is a global atmospheric dataset developed by NASA's Global Modeling and Assimilation Office. The dataset provides comprehensive information on a range of atmospheric parameters, including temperature, precipitation, wind patterns, and soil moisture, from 1980 to the present. MERRA-2 is designed to offer high-resolution data for both research and application purposes, particularly for understanding climate dynamics, weather patterns, and environmental processes. It incorporates satellite observations, reanalysis data, and model outputs to deliver accurate and consistent long-term data, making it a valuable resource for studying climate trends, meteorological patterns, and their interactions with the Earth's surface.

- **Lykorrema Experimental watershed**

This experimental watershed, located in the east side of Penteli Mountain, Attica, Greece, was equipped with a dense monitoring network managed by the Agricultural University of Athens. The network has been operational from September 2004 until 2015 and includes five rain gauges, one meteorological station, and four temperature-relative humidity recorders. Data were recorded at a high temporal resolution of 10-minute intervals, providing detailed insights into precipitation, temperature, and humidity.

- **Varybobi weather station**

This weather station is located at the Kifissos stream in Varybobi of Attica, Greece, recording data since July 2023. The telemetric station installed measures weather variables including air temperature, relative humidity, vapour pressure, barometric pressure, wind speed, gust and direction, solar radiation and precipitation.

2. Soil/Land Cover Data

Type: Land cover classifications and soil properties
Sources:

- **OPEKEPE**

The OPEKEPE (Greek Payment Authority of Common Agricultural Policy Aid Schemes) is the Greek Agency for the payment of Community aid which since 2001 in the public interest and is supervised by the Ministry of Rural Development and Food. It provides detailed soil data for Greece, which include information essential for agricultural and land management purposes. This data is used to generate the soil map of Greece, which classifies soils based on various characteristics such as texture, structure, and fertility. The soil map offers insights into soil types, organic content, pH levels, and other soil properties crucial for assessing land suitability for agricultural practices. This data is used to generate the Soil Map of Greece at a scale of 1:30,000, created in 2018 (last updated in 2020).

- **JRC ESDAC (Joint Research Centre of the European Soil Data Centre)**

The European Soil Database (ESDB), hosted by the European Soil Data Centre (ESDAC), provides comprehensive soil data across Europe, including both vector and attribute data. Available soil data include organic carbon content, soil texture, bulk density, hydraulic conductivity, and water retention characteristics. For this project, soil data from the JRC will be utilized starting from 2001, providing a robust foundation for land suitability analysis, environmental monitoring, and sustainable agricultural planning.

- **CORINE Land Cover Program**

The main available background that captures land use and land cover over time and their changes is the European Union CORINE Land Cover (CLC) background. The CORINE Land Cover (CLC) inventory started in 1985 (reference year 1990) and is continued at regular intervals. The CLC is a European-level land cover/land use mapping project carried out under the Copernicus programme. Updates were carried out in 2000, 2006, 2012 and 2018. The

CORINE programme is implemented in the majority of EU Member States and in other Central and Eastern European countries. CORINE is produced from visual interpretation of high-resolution satellite imagery and consists of an inventory of land cover in 44 classes. It uses a minimum mapping unit of 25 hectares for spatial phenomena and a minimum width of 100 m for linear phenomena.
In addition, the High-Resolution Layers of the European Land Monitoring Service, part of the Copernicus programme, are used. These provide additional information on specific land cover characteristics and consist of five layers. They cover impervious soils, density of tree cover and type of forest cover, grassland, water surfaces, and small woody vegetation. More information available on: Copernicus Land Monitoring Service.

3. Farm Parcel Information

Type: Polygons including details on crop types, irrigation, and agri-environmental measures

Source:

- **Integrated Administration and Control System (IACS) spatial database**

OPEKEPE provides detailed farm parcel information through the IACS. This dataset includes geospatial and tabular data on individual farm parcels registered in Greece under the Common Agricultural Policy (CAP) framework. Data from the IACS will be utilized for the period between 2014 and 2022. The data includes parcel boundaries, land use types, crop types, declared areas, and eligibility for subsidy schemes. Additionally, the dataset includes geospatial coordinates of farm parcels, enabling precise mapping and analysis. This information is regularly updated to reflect changes in land use and cropping patterns, supporting in the monitoring of agricultural activity, ensuring compliance with CAP regulations, and optimizing land and resource management strategies.

4. Earth Observation Data

(see also Deliverable 3.1 for more information)

- **MODIS**

The Terra Moderate Resolution Imaging Spectroradiometer (MODIS) MOD16A2 dataset provides global estimates of terrestrial evapotranspiration (ET) and potential evapotranspiration (PET) at an 8-day temporal resolution and 500-meter spatial resolution. Derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra satellite, this dataset is based on the Penman-Monteith equation, integrating satellite observations and meteorological reanalysis data. The data from this version are available from year 2021 to present.

- **MERRA-2 (NASA)**

NASA's reanalysis dataset includes evapotranspiration as part of its land surface modeling outputs. It has a temporal coverage from 1980 to the present. It offers global ET data at a spatial resolution of approximately 0.5° x 0.625° with a sub-daily temporal resolution, enabling detailed temporal and spatial analysis. The dataset is essential for studying water cycles, analyzing agricultural water use, and understanding land-atmosphere interactions under

varying climatic conditions. MERRA-2 is accessible through NASA's Goddard Earth Sciences Data and Information Services Center (GES DISC).

MERRA-2 also offers reanalysis-based soil moisture data as part of its land surface outputs, that have a temporal coverage from the year 1980 to the present.

- **Copernicus Global Land Service**

The Copernicus Land Monitoring Service offers comprehensive soil moisture datasets, such as Surface Soil Moisture, which provides information on the relative water content of the top few centimeters of soil, and the Soil Water Index, which quantifies moisture conditions at different depths in the soil. For Europe, these products have a resolution of 1 km and use data from Sentinel-1 and other supporting missions. The Copernicus Land Monitoring Service provides this Surface Soil Moisture product over Europe, with 1 km resolution, from 2014 to the present.

5. Runoff and water quality

- **Hellenic Centre for Marine Research (HCMR)**

The HCMR provides runoff data with a focus on the interaction between terrestrial and marine ecosystems, including measurements of river discharge rates, nutrient and pollutant transport from watersheds. HCMR collects detailed water quality data to assess the ecological impacts of runoff. These water quality parameters include water temperature, conductivity, salinity, turbidity, pH, dissolved oxygen (DO), chloride (Cl^-), silicates (Si^-), and key nutrients such as nitrite ($N\text{-}NO_2$), nitrate ($N\text{-}NO_3$), ammonium ($N\text{-}NH_4$), and phosphate ($P\text{-}PO_4$). Data for these parameters are available for the years 2008 to 2015, with some stations continuing to provide measurements up to the present day.

- **Lykorrema Experimental watershed**

This watershed was also equipped with one hydrometric station, being operational from September 2004 until 2015. Data were recorded with a time step of 10 min, providing information about streamflow.

- **Varybobi watershed station**

The telemetric hydrometric station is located at one of Kifissos' streams in the area and includes a piezoelectric sensor, an electrical conductivity and water temperature sensor and a radar level sensor to monitor water level changes in real-time since July 2023 in 15-minute intervals. The radar sensor records water level data, which are then processed to determine the water depth in the channel. Runoff can be then estimated from water depth.

6. Evaluation Data (Socioeconomic)

Type: Agricultural irrigation data
Sources:

- **Regional irrigation systems in Kavala, Katerini, and Larissa**

These include data in experimental plots in Kavala, Katerini, and Larissa. In Kavala and Katerini, there is one experimental plot in each location, where kiwifruit is cultivated. Each plot has two stations. These plots are equipped with a soil moisture monitoring station and a flow measurement station, along with meteorological station including a rain gauge, pyranometer, air temperature and humidity sensor, infrared thermometer, and anemometer. In Katerini, the soil moisture monitoring station is situated near the water abstraction point, providing data on the volumes of irrigation water. The data are available from April 2024. In Larissa, a meteorological station provides atmospheric and climate data for the region and three dielectric

soil moisture sensors, which help monitor how soil moisture changes over time due to irrigation, precipitation, or evaporation. Data from these stations are available for a period between the years 2022 and 2023. These monitoring systems supply high-resolution, site-specific data on soil moisture, flow rates, and meteorological variables, essential for evaluating irrigation efficiency and understanding crop water needs.

(Tasks: *T4.1* Collection of input data and data for model calibration and validation. Data evaluation, processing, and storage to the spatial database. (M6-12)

Tasks: *T4.2* Set-up and application of the digital twin based on historical data and for the base scenario. (M12-16) (This Task will be finished in M16).)

REFERENCES

Websites

CORINE Land Cover. https://land.copernicus.eu/pan-european/high-resolution-layers.

ERA5-Land hourly data from 1950 to present. https://cds.climate.copernicus.eu/datasets/reanalysis-era5-land?tab=overview