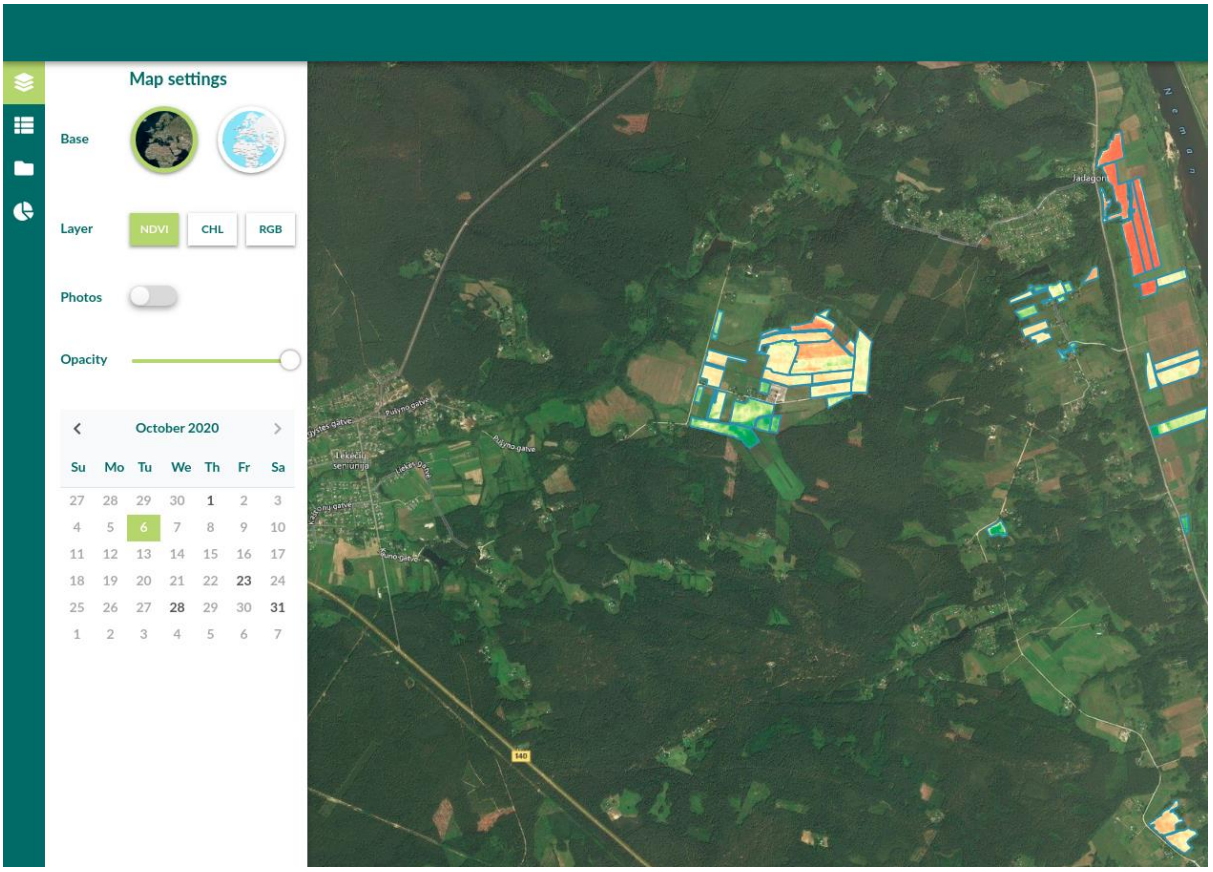
Innovative technologies for agricultural monitoring

Smart agriculture monitoring solutions become commercially available upon closure of H2020 DIONE project



The DIONE Compliance Monitoring Tool Graphical user interface

The DIONE consortium partners signed a Memorandum of Understanding in June 2022 with the intention to establish a DIONE Alliance joint venture, designed to serve as a leader in the commercialisation journey for the DIONE Toolbox. The DIONE Toolbox offers a digital, simplified, continuous and automated provision of agri-environmental information related to farmer parcels, minimizing the need for on-the-spot checks by relevant Paying Agencies and optimising the workflow required for monitoring compliance with Common Agricultural Policy (CAP) provisions. It is an integrated system that aims to address the existing gaps and shortcomings in the CAP monitoring domain and offer clear economic value as it significantly lowers related inspection costs while improving the overall monitoring of farmers' compliance.

Integrated EO-based monitoring solution

The DIONE Toolbox is a Software-as-a-Service (SaaS) innovative and scalable solution for modernising CAP

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area-based compliance checks and assessing respective environmental impact. It enables the European Paying Agencies to comply with the Modernised CAP regulations while conducting an environmental performance evaluation of the greening rules at a national or regional level, depending on the agency's jurisdiction. Besides Paying Agencies as key beneficiaries, the DIONE Toolbox is designed to address the needs of a plethora of relevant stakeholders, among them being Certification and Control Bodies, Financial and Risk Management Institutions, and members of the wider EO and Agri-consulting community.

"Unpacking" DIONE Toolbox

DIONE Toolbox primarily consists of three main components: the Earth Observation (EO), In-situ and Green Accountability toolbox.

1. DIONE Earth Observation component

The EO component attempts to replace the necessity for field visits and to provide a sustainable CAP monitoring schema, in which a plethora of multisource EO data enables the identification of different crop types and agricultural activities (e.g. grassland mowing/ploughing events, etc.) whereas the assimilation of aforementioned data sources allows efficient small-scale parcels and features monitoring (e.g. non-productive EFAs types).

What makes the EO component so advanced?

- **Area monitoring markers** include a set of image analysis and machine learning techniques, which utilises Sentinel signals for the identification of various crop and land types (including permanent pastures and Ecological Focus Areas) as well as the detection of agricultural activity (mowing, ploughing, harvesting) at several times during the growing season. The aforementioned outcomes are made available through the marker RESTful API, with the latest version including the following markers:
  - *Homogeneity* - is used to determine if a parcel is described by a monoculture or a multi-culture;
  - *Similarity and distance scores* – are used to give additional context to the crop classification and to detect erroneous claims;
  - *Bare soil marker* – identified parcels under a bare soil condition. This indicates agricultural activity on the spatial extent of a single parcel (ploughing and harvest);
  - *Mowing marker* - used to detect mowing events on meadow/grass-like features of interest;
  - *Crop marker* - used to detect the specific crop growing on the spatial extent of a single parcel;
  - *Land marker* - used to detect the land type and non-productive EFAs on the spatial extent of a single parcel;
  - *Mean NDVI marker* - used to detect erroneous claims with no vegetation existence.
- **The Drone platform** is a combination of hardware and software tools that are employed for the conduction of drone flights in targeted areas of interest. The produced very high resolution data can facilitate small features monitoring in the agricultural parcels as well as address cases of limited data availability in areas with significant cloud cover.
- **Super-resolution** by augmenting the initial spatial resolution of Sentinel-2 with Very High Resolution (VHR) space-borne/drone data to identify essential parameters for CAP such as the small-scale

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features of non-productive EFAs, and many more. The goal of the implemented machine learning and data fusion algorithms is to allow the distinction of landscape features, which would otherwise not be available in Sentinel 2 data..

- **Spatial augmentation of Sentinel 2 coarser resolution bands** is a software tool that consists of a Deep Convolutional Neural Network (D-CNN) that enables the augmentation of the coarser resolution bands of Sentinel 2 bands (20m) to the resolution of the finer bands (10m).

2. DIONE In-situ component

The in-situ component establishes an ecosystem of low-cost smart tools to complement Earth Observation(EO)-based monitoring. It includes a geotagged photos framework (consisting of mobile application for data collection and a server side part for integrity/anonymization of received data), portable soil spectrometers working in tandem with mobile application, a backend tool to support pre-processing, validation and management of soil spectra received and machine learning models to convert soil spectra to soil properties point observations and maps.

What makes the In-situ component so smart?

- The **geotagged photos framework** comprises different components and technical innovations towards assisting and guiding users to capture efficiently representative photos of their parcels while adhering to current technical recommendations and ensuring the security, validity and reliability of the collected photos. The data collection process is supported by a mobile application that allows users to view related content about their parcels, receive notifications about tasks that they need to undertake as well as get Augmented Reality enabled directions regarding the process of capturing appropriately photos of a given parcel. Additionally, in order to ensure that the file of the photo captured by the mobile application is not manipulated and is the same with respect to the location and time the photo was taken, an integrity framework has been also employed. Different algorithms have been implemented for a multifaceted solution and better security.

- **The in-situ soil scanning system** is based on a suitably selected low-cost spectral sensor employing microelectromechanical systems (MEMS) technology.. This sensor records the diffuse reflectance spectrum in the near infrared (1750 to 2150 nm) which is affected by several key soil properties. The spectrometer is operated through an Android/iOS application via a Bluetooth connection. The data are automatically transmitted to a central database for storage. Furthermore, at this stage a set of data pre-processing (including spectral standardization), outlier and novelty detection techniques are automatically applied to ensure the integrity and quality of the collected measurements.

- Novel **machine learning algorithms** are utilised for the transformation of the raw data collected through the in-situ soil scanning system to the appropriate soil properties (SOC, clay, pH and CaCO3), whilst a second toolset of machine learning algorithms is also employed that appropriately combines these point measurements with EO imagery and produces maps for the areas of interest.

3. DIONE Green Accountability component

The Green Accountability component consists of a Compliance Monitoring tool, which decides on beneficiaries' compliance and is integrated with the existing tools of paying agencies and an AI-enabled Environmental Performance tool, accompanied with a visualization engine.

What makes the Green Accountability component so eminent?

- **The environmental performance tool** represents an artificial intelligence tool for environmental performance estimation. The following indicators are computed via the tool:

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- *Land cover change* which provides a qualitative and quantitative assessment of the change of land cover
- *Organic farming* provides a characterisation of a parcel into organic, under-conversion and non-organic according to the farming practices and the response of the spectral information.
- *Soil erosion* provides information about those areas affected by a certain rate of soil erosion.
- *Soil organic matter* determines Soil Organic Carbon (SOC) concentration.
- *Greenhouse Gases emissions* for monitoring the concentration of Methane, Carbon Dioxide and Nitrous Oxide alongside the country.
- *Water quality* monitors the Chlorophyll-α concentrations, Total Suspended Matter (TSM) and water temperature.
- *Land irrigation* provides a representation of the parcels that are under constant irrigation.
- *Natura 2000* provides information about the areas that are protected by the legal framework of Natura 2000.
- *High Nature Value (HNV) lands* provide information about areas characterized as HNV.

- **The Compliance Monitoring Tool** is a web-based tool responsible for deciding on beneficiaries' compliance with the CAP green direct payment scheme rules. Through this application, farmers, inspectors, Paying Agency officials, agronomic consultants and other stakeholders can check the compliance status of a farm. The compliance status is evaluated at different points in time (each time new EO or field data is available) using the products delivered by other DIONE system components, through a unified Toolbox Application Programming Interface (API) which integrates these components. The compliance engine uses the different available data together with the compliance rules for the specific country to determine the level of compliance in each parcel. At the same time, the users are able to see the farm's parcels on an interactive web environment with different geospatial layers to illustrate the biophysical conditions on the field (NDVI, Chl index, RGB) and their temporal evolution as well as area monitoring markers (i.e, crop types, land features and agricultural activities) and other relevant data (i.e, drone based orthomosaics, soil measurements). The application supports also the display of the geotagged photos collected by the farmers on the field using the Geotagged photos mobile app, as well as requests for new photos by paying agency inspectors.

DIONE Toolbox pilot demonstration activities in Cyprus and Lithuania

The DIONE Toolbox components are currently being demonstrated in areas of Lithuania and Cyprus under the collaboration of the National Paying Agency of Lithuania and the Agricultural Payments Organisation of Cyprus respectively. Pilot demonstration activities have already been initiated since 2021 and are expected to be finalised by October 2022. The activities are executed in the context of end-to-end scenarios that facilate the assessment of the overall performance of DIONE Toolobox and its success in achieving envisaged outcomes and addressing real operational requirements of relevant stakeholders.

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Editor notes

Short description:

DIONE proposes a close-to-market and integrated area-based direct payments monitoring toolbox that will address the forthcoming Modernised CAP regulation of using automated technologies to ensure more frequent, accurate and inexpensive compliance checks.
The project exploits DIAS' storage of Copernicus data in its fullness, making use of not just the data but also DIAS provided services such as Data Catalogue as well as Sentinel Hub, which is operational on 3 DIASes. DIONE toolbox is enhanced through complementary data sources (VHR images from drones as well as ground-based images taken by the farmers). The DIONE toolbox includes a Green Accountability toolbox, allowing paying agencies to check the compliance of farmers but at the same time monitor the green direct payments' environmental performance.

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