MEF4CAP

Monitoring and Evaluation Frameworks for the Common Agricultural Policy

21 October 2021

Deliverable D2.3

Identified new technological opportunities from collaboration with EU projects and initiatives

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Contents

Executive summary

MEF4CAP is a H2020 project with the main purpose of delivering an innovation agenda and roadmap for future monitoring of EU agriculture Policy. The Common Agricultural Policy (CAP) post 2020 is targeted towards a wider range of objectives covering broader domains such as social, environmental, and economic sustainability in agriculture and rural areas. This fact implies that new data sources are required to measure the effects and performance of the Policy. Up to date, the main information sources in order to monitor and verify how well the CAP objectives have been reached are the applications by farmers for CAP payments (through the Integrated Administration and Control System - IACS) and data from national statistical agencies (e.g. Eurostat and the Farm Accountancy Data Network - FADN).

Given the new policy needs, an increase in the number and type of indicators is expected. New indicators have been identified, developed and tested to adapt to these new policy needs. More data will be required to adequately measure sustainability; therefore, it is vital to consider whether it is possible to utilise existing data sources more efficiently, avoiding duplication and potentially allowing scope for collection of new types of data, e.g. measures of social sustainability and well-being. In order to make the future system cost-effective and limit the administrative burden on farmers, future monitoring and evaluation of the CAP will depend on a framework that is grounded in digitalisation, following the trends occurring in the agriculture sector. To this end, digital data from advanced data capturing methods – mainly ICT based mechanisms - will become essential.

WP2 of the MEF4CAP project focuses on Information and Communication Technological (ICT) developments in relation to the agricultural sector. The main objective is to review and assess current and new technologies that are widely utilised or provide a potential benefit for data capturing and data processing directly or indirectly related with the new CAP monitoring and evaluation objectives. There are various ongoing efforts in the ICT domain in the context of agriculture, sometimes occurring in parallel, aiming to solve common challenges. The work of WP2 aims to support the identification and categorisation of technological solutions and trends with a clear potential or even a proven track record that can be exploited for addressing the data needs of the monitoring and evaluation frameworks for the agricultural and related policies.

This deliverable, D2.3 “Identified new technological opportunities from collaboration with EU projects and initiatives”, is the second deliverable of WP2 and documents the work conducted in the context of Task 2.2 “Continuous monitoring and collaboration with EU projects and initiatives to review and assess new technological opportunities”. The scope of this document is to identify emerging ICT solutions and methodologies that can be potentially useful and that can be directly or indirectly exploited towards the digitisation of monitoring and evaluation frameworks for the future CAP. This work was done at an early stage of the project, through the establishment of collaboration channels with the most prominent EU projects in this domain. To document this, all the results of the liaison activities are presented with which the most advanced technological approaches currently in the research and development phase are evaluated. The recorded outcomes from these initiatives will be combined with outcomes from

deliverable D2.1 “Landscape of agri-food ICT technologies within EU” in order to construct D2.2 “Best practices on the adoption of ICT agricultural technological solutions”.

The final list of realised collaboration activities is the following:

- H2020 DEMETER project
- H2020 ENVISION project
- FaST project
- Open IACS project
- H2020 MIND STEP project
- H2020 DIONE project
- H2020 NIVA project

A more detailed analysis on the usefulness of the presented information sources will be performed in the context of WP3. WP2 Deliverables will be utilised as input by WP3 “Current systems and future pathways” in order to confront promising ICT developments with data needs for an enhanced monitoring and evaluation framework functional to the future and reformed CAP.

List of abbreviations

API - Application Programming Interface

CAP - Common Agriculture Policy

CSA - Coordination and Support Actions

CSV - Comma-Separated Values

DG-AGRI - Directorate-General for Agriculture and Rural Development

EC - European Commission

EO - Earth Observation

EU - European Union

FADN - Farm Accountancy Data Network

FDIS - Field Data Information System

FMIS - Farm Management Information System

GAEC - Good Agricultural and Environmental Conditions

HPC - High Performance Computing

IACS - Integrated Administration and Control System

ICT - Information and Communication Technologies

IDM - Individual Decision Making

IoT - Internet of Things

LOD - Linked Open Data

LPIS - Land Parcel Identification System

MS - Member States

NDVI - Normalised Difference Vegetation Index

OTSCs - On-The-Spot-Checks

PA - Paying Agency

RS - Remote Sensing

SAR - Synthetic Aperture Radar

SMR - statutory management requirements

TRL - Technology Readiness Level

UAVs - Unmanned Aerial Vehicles

List of figures

List of tables

1. Objectives and overview

Objectives

MEF4CAP is a H2020 project with the main purpose of delivering an innovation agenda and roadmap for future monitoring of the EU agriculture Policy. The Common Agricultural Policy (CAP) post 2020 is targeted towards a wider range of objectives covering broader domains – agriculture, sustainability, agri-environmental, food security among others. This fact implies that new data sources are required to measure the effects and performance of the Policy. Performance is the key idea in the new monitoring and evaluation framework of the CAP. At the same time, new technological developments, are enhancing the capability of providing, retrieving and integrating new data sources that are called to achieve those new data requirements. MEF4CAP brings together the expected needs for assessing the performance of the future Policy and the newest technological solutions to address those requirements.

WP2 of the MEF4CAP focuses on reviewing and analysing ICT Developments of the agricultural sector. The main objective of this work package is to review and assess current and new technologies that are widely utilised or provide a potential benefit for data capturing and data processing in support of agri-food monitoring and evaluation objectives. The analysis conducted within this work package will allow the identification and categorisation of technological solutions and trends with a clear potential or even a proven success record that can be exploited for addressing the data needs of the monitoring and evaluation frameworks for the new agricultural and related policies.

The main contribution of this deliverable D2.3 “Identified new technological opportunities from collaboration with EU projects and initiatives”, is to review and document on-going ICT related approaches and efforts in the context of monitoring and evaluation of the future CAP. This work is realised in the context of Task 2.2 “Continuous monitoring and collaboration with EU projects and initiatives to review and assess new technological opportunities”. Within this task, collaboration activities have been established with selected H2020 ongoing projects and other initiatives. Through a number of collaboration sessions we aimed to extract and record up-to-date technological developments in the agri-food sector that are currently under research and development.

D2.3 has the form of a living document on the collaboration activities realised with EU projects and other related initiatives, capturing the outcomes of this liaison work. All the related actions were recorded including the preparation communications with the targeted projects, the rational justifying the establishment of the collaboration, detailed minutes of the collaboration meetings, etc. All these information items are available to MEF4CAP partners for further analysis if necessary.

Next steps include the combined analysis of D2.1 and D2.3 in order to identify the final outcomes on best practices and lessons learned with regards to the utilisation of ICT technological solutions for the agri-food domain in the EU and how these solutions can support future CAP monitoring and evaluation frameworks. This work will be documented in Deliverable D2.2 “Best practices on the adoption of ICT agricultural technological solutions”.

WP2 Deliverables will also be utilised as input to WP3 “Current systems and future pathways” in order to complementarily analyse technological offerings and data demands of future

monitoring and evaluation systems. The outcomes of this analysis will be recorded in D.3.2. “Potential of current systems and ICT developments for future data needs”.

Overview
Section 1, presents the objectives and an overview of this deliverable.

Section 2, provides an introduction to this deliverable that describes the overall rational of the conducted research.

Section 3, contains a list of profile information of the projects and initiatives that were analysed for the needs of this deliverable.

Section 4, contains the analysis of the realised liaison activities and the key technical outcomes.

Section 5, provides the conclusions of this work.

2. Introduction

The CAP is reformed in the light of new societal challenges approximately every seven years. The new CAP, which starts in 2023, aims to foster a sustainable and competitive agricultural sector that can support the livelihoods of farmers and provide healthy and sustainable food for society, as well as vibrant rural areas[1]. The changes are based on evidence-based decision making which in turn implies the need for evaluations based on harmonised data and indicators. The European Commission (EC) has set up the Performance Monitoring and Evaluation Framework (the former CMEF, which is now known as the PMEF) to assess the performance of the CAP. The PMEF is a set of rules, procedures and indicators to evaluate the CAP. The PMEF provides key information on CAP implementation and supports the verification process on how well objectives have been reached. In order to evaluate the implementation of CAP objectives it is necessary to collect data related to relevant indicators[2]. Currently the main data sources are:

- Applications by farmers for CAP payments Integrated Administration and Control System[3] (IACS)
- Data from national statistical agencies, Eurostat and the Farm Accountancy Data Network[4] (FADN).

Given the new policy needs, an increase in the number and type of indicators is expected. New indicators have been identified, developed and tested to adapt to these new policy needs. More data will be required to adequately measure for example sustainability and well-being; therefore, it is vital to consider whether it is possible to utilise existing data sources more efficiently, avoiding duplication and potentially allowing scope for collection of new types of data. In order to make the future system cost effective and limit the administrative burden on farmers, future monitoring and evaluation of the CAP will depend on a framework that is grounded in the trend of digitalisation. To this end, digital data from advanced data capturing methods – mainly ICT based mechanisms - will become essential.

At the same time there is an ongoing trend where innovative ICT solutions are being adopted in support of every day farm operations. Consequently, there is a wide range of data flows to and from farms, part of them being of relevance for policy evaluation and monitoring. A future monitoring system should make optimal use of these different sources of data and modern ICT based data capturing systems. As part of its ongoing move to simplify and modernise the EU's CAP, the European Commission (EC) is already adopting new rules that allow a range of modern technologies to be used when carrying out checks for area-based CAP payments. These include the possibility to completely replace physical checks on farms (On-The-Spot-Checks, OTSC) with a system of automated checks based on Earth Observation data products (EO) (e.g. with the use of satellite data), in combination with Internet of Things (IoT) and other digital technologies (Freire et al., 2019). The development of such automated monitoring systems is expected to

[1] https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en
[2] https://agridata.ec.europa.eu/extensions/DataPortal/cmef_indicators.html
[3] https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/financing-cap/financial-assurance/managing-payments_en
[4] https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/farms-farming-and-innovation/structures-and-economics/economics/fadn_en

reduce the number of OTSCs, fulfilling the EC commitment to modernise and simplify the IACS processes within the CAP. Each EU member state paying agency has been responsible for at least 5% of the physical OTSC, which is both time-consuming and expensive (Navarro et al., 2021).

There are various challenges that need to be addressed towards the integration of the various technological solutions. For example, Earth Observation (EO) technologies are the key for large scale monitoring solutions. However, they still can't perform adequately in respect to small area parcels (<1ha) that for example dominantly characterise the holdings of farmers in South-East Europe. In addition, their performance is affected by weather parameters e.g. cloud coverage, which is often the case at North European countries. Additional challenges with regards to the exploitation of agricultural data streams from innovative sources are related with the data sharing regulatory environment including issues like data ownership, data privacy, and data secrecy. Another crucial issue for exploiting existing data flows to a maximum extent is the technical and semantic interoperability of systems and the heterogeneity in terms of data models and data exchange mechanisms.

The MEF4CAP project – in the context of WP2 – aims to create an inventory of ICT based solutions that demonstrate strong potential toward the further digitalisation of agricultural sector and that can contribute in CAP monitoring and evaluation mechanisms. Towards this scope a series of liaison activities have been initiated with related projects, initiatives and organisations. The overall objective of the collaboration activities is to capture relevant agricultural technological developments that are still on an early stage but have the potential to be adopted on large scale in the years to come.

Summarising, Task 2.1 performed a thorough state of the art review mainly on already published scientific articles and technical reports on agricultural technologies that are already in use across the EU. Task 2.2 aims to capture technological developments that are not yet widely deployed or that still are under research and development. To this end, a series of direct interactions with the selected EU projects and organisations were realised aiming to identify if and how their outcomes can directly or indirectly be exploited towards the digitisation of monitoring and evaluation frameworks for the future CAP. The aforementioned liaison activities as well as the key technical outcomes will be presented in the following sections of this document.

3. Collaboration targets

From an early stage and during the description of work preparation of the MEF4CAP action an initial list was created with targeted EU projects that were considered as the most prominent in providing significant outcomes towards the digitisation of monitoring and evaluation frameworks for the future CAP. During the Task 2.2 execution, this initial list was revised and all MEF4CAP partners were asked to contribute with their knowledge on significant ongoing efforts that are of interest for MEF4CAP project objectives. MEF4CAP partners proposed potential targets along with the respective rationale for establishing the collaboration channel. Given that D2.3 is a living document and that it was made available to all partners on the MEF4CAP project's file sharing repository, the document was also utilised for collaboratively recording the potential liaison targets and the ongoing liaison activities. After various iterations and revisions that took place with the exchange of emails and virtual meetings, the final list of initiatives and projects that MEF4CAP project targeted for collaboration is presented in table 1. The table contains the name of the initiative, a short description of the initiative focusing on parts that are related with MEF4CAP's objectives, the project partner that proposed the collaboration and details on the collaboration status.

Table 1. Targeted initiatives for liaison with MEF4CAP project

Initiative name	Short descriptions	MEF4CAP partner	Collaboration status
H2020 DEMETER Building an Interoperable, Data-Driven, Innovative & Sustainable European Agri-Food Sector	The H2020 DEMETER (https://h2020-demeter.eu/) is a large-scale project deployed in 18 countries, 15 of which are EU Member States. The project will analyse data obtained from a wide range of actors (production sectors and systems) to provide an integrated interoperable data model enabling optimal resource management in the European agri-food sector. More specifically, the project focuses on interoperability across data, platforms, services, applications and online intelligence, as well as human knowledge tailored to the needs of the agri-food sector. To this end, the DEMETER project released the initial version of the Agricultural Information Model (AIM) which aims to be a common data model and to enable semantic interoperability between DEMETER and existing agri-food systems and ontologies. IA - Innovation Action Start Date: 1 September 2019 End Date: 28 February 2023	NP	**Established-** Meeting took place on 24/05/2021
H2020 ATLAS Agricultural Interoperability	The H2020-Atlas (https://www.atlas-h2020.eu/) is a sister project with DEMETER having as main objective to address the lack of data interoperability in agriculture by combining the use of agricultural equipment with sensor systems and data analysis. The project will address the lack of data interoperability in	Agroapps	The collaboration didn't take place. There is an overlap with the sister

and Analysis System	agriculture by combining the use of agricultural equipment with sensor systems and data analysis. The ATLAS platform aims to deliver a service offering hardware and software interoperability using data from sensors to demonstrate the benefits of digital agriculture in a wide range of sectors affecting modern agriculture. IA - Innovation action Start Date: 1 October 2019 End Date: 31 March 2023		project H2020-DEMETER
H2020 ENVISION Monitoring of Environmental Practices for Sustainable Agriculture Supported by Earth Observation	The H2020 - ENVISION project (https://envision-h2020.eu/) contributes in the achievement of CAP's environmental objectives, offering the tools for the continuous, large scale and uninterrupted monitoring of farm management activities with regards to sustainability. The project will design a toolbox to monitor service of sustainable agricultural practices all year round. It will use in situ, open data and historical information as well as data made available by the Global Earth Observation System of Systems (GEOSS) and Copernicus, which builds on a constellation of satellites making frequent daily observations. This information will be used to develop cultivated crop type maps and to monitor soil organic carbon, vegetation status and crop growth. The toolbox will be tested and validated in a preoperational environment by potential future customers of its products and services. These tools reinforce the monitoring of environmental and climate-friendly agricultural practices stemming from EU policy ensuring that the agricultural activities do not severely impact the climate and nature. IA - Innovation action Start Date: 1 September 2020 End Date: 31 August 2023	Agroapps	**Established-** Meeting on 4/6/2021
OGC	The Open Geospatial Consortium (OGC) is an international consortium of more than 500 businesses, government agencies, research organisations, and universities driven to make geospatial (location) information and services FAIR - Findable, Accessible, Interoperable, and Reusable.	NP	The collaboration didn't take place as OGC participates in DEMETER project. OGC

	OGC Agriculture Domain Working Group (DWG) https://www.ogc.org/projects/groups/agriculturedwg The purpose of this Working Group is to: • Provide a forum for discussion and documentation of interoperability requirements for a given information or user community. • Provide a forum to discuss and recommend document actions related to Interoperability Program Reports. • Develop Change Request proposals (CR's) for existing OGC Standards. • Develop engineering reports with the intent to seek for approval by the TC for release of these documents as OGC White Papers, Discussion Papers or Best Practices Papers. • Provide a forum for development of concepts relating to testbed, pilot, and interoperability experiment activities in the agricultural domain • Host informational presentations and discussions about the use of adopted OGC Standards in the agricultural market.		representatives participated in collaboration meeting with DEMETER
Joint Research Centre - JRC	JRC/CBM is a set of scripts to perform monitoring on agricultural parcels with Sentinel 1 & 2 developed by JRC in support to Member States implementing Checks by Monitoring. It is an alternative to ESA SEN4CAP and is maintained by JRC Geo-CAP team (https://github.com/ec-jrc/cbm).	ITACyL	This meeting didn't take place. Discussion topics are covered from collaboration meeting with FaST
FaST Farm Sustainability Tool	Supported by the European Commission's DG Agriculture and Rural Development, by the EU Space Programme (DG DEFIS) and by the EU ISA2 Programme (DG DIGIT), the FaST digital service platform (https://fastplatform.eu/) will make available capabilities for agriculture, environment and sustainability to EU farmers, Member State Paying Agencies, farm advisors and developers of digital solutions. The FaST platform solutions aims to take advantage of Europe's space capabilities – Copernicus and Galileo - to help farmers sustainably manage their holdings. Through a core service ensuring the minimum functionality described in the Regulation, the solution will ensure that farmers will be supported digitally in their farm management and compliance requirements regarding nutrient management and further	ITACyL	**Established-** Meeting on 6/7/2021

	sustainability objectives. The Farm Sustainability Tool (FaST) would integrate relevant legal obligations and return publicly-held data, including space data, as useful information to the farmers, while supporting two-way communication with public authorities and the integration of digital solutions in the field. FaST will help lay the foundations of a comprehensive digital ecosystem for sustainable farm and land management in Europe. It will support farmers in their administrative decision-making processes, for farm profitability and environmental sustainability. At the same time, it will provide a reliable on-farm landing spot for digital solution developers (including satellite-based solutions) and service providers. It will reduce administrative burdens for farmers and Paying Agencies, and streamline communication between the farmers and public authorities. Start Date of FaST phase 2: June 2021 End Date of FaST phase 2: May 2022		
Open IACS Open LOD platform based on HPC capabilities for Integrated Administration of Common Agriculture Policy	Open IACS (https://open-iacs.eu/) is a project is funded by the EC through the Executive Agency for Innovation and Networks (INEA). Project partners are a group of Paying Agencies, research experts and an HPC group with high experience. Open IACS general objective is to support the generation, aggregation and cross-border reuse of open datasets, increase the capabilities of HPC (High Performance Computing) and the data capabilities of the European data infrastructure, and promote the use of HPC and data across borders in the public interest. The project will provide a true and open community platform for sharing solutions in the IACS domain though the Linked Open Data (LOD) paradigm. Open IACS infrastructure will facilitate the end-user access to HPC capabilities by means of automated management of service level agreement that assure the appropriate planning and allocation of resources among the HPCs hosting and the possibility to assign jobs seamlessly to the different providers included in Open IACS's HPC infrastructure. Start Date: 1 September 2019 End Date: 31 August 2022	NP	**Established-** Meeting on 9/7/2021
H2020 MIND STEP Modelling	MIND STEP (https://mind-step.eu/) is a European research project aiming to improve exploitation of available agricultural and biophysical data. The project	WUR	**Established-** Meeting on 10/9/2021

Individual Decisions to Support the European Policies Related to Agriculture	will make use of agricultural and biophysical data and include individual decision making (IDM) unity in new and existing policy models for impact assessments. Using agricultural statistics and big datasets, the new IDM models will be estimated and calibrated, drawing on established economic and evolving machine learning techniques. The overall ambition of MIND STEP is to support public decision making in agricultural, rural, environmental and climate policies, taking into account the behaviour of individual decision-making units in agriculture and the rural society. The MIND STEP specific objectives are: • to develop a highly modular and customisable suite of Individual Decision Making (IDM) models focusing on behaviour of individual agents in the agricultural sector to better analyse impacts of policies, • to develop linkages between the new IDM models and current models used at the European Commission to improve the consistency and to broaden the scope of the analysis of policies, • to develop an integrated data framework to support analysis and monitoring of policies related to agriculture, • to apply the MIND STEP model toolbox to analyse regional and national policies and selected EU CAP reform options and global events affecting the IDM farming unit, working together with policymakers, farmers and other stakeholders, • to safeguard the governance and future exploitation of the MIND STEP model toolbox. RIA - Research and Innovation action Start Date: 1 September 2019 End Date: 31 December 2023		
H2020 DIONE Advanced monitoring for modernising CAP	The EU-funded DIONE project (https://dione-project.eu/) offers a unique fusion of innovative technologies that improves the workflow of agricultural monitoring. DIONE project is developing a direct payment controlling toolbox for Paying Agencies to abide by the modernised CAP regulations, involving novel techniques that will improve the capabilities of satellite technology while integrating various data sources (drones, soil sensors and mobile applications). At the same time, a machine learning-	NP	**Established-** Meeting on 29/9/2021

	based system developed on a regional or national scale will evaluate the monitored parameters to form evidence-based conclusions regarding eventual environmental impacts on an entire region. IA - Innovation action Start Date: 1 January 2020 End Date: 30 June 2022		
H2020 NIVA New IACS Vision in Action	NIVA project (https://www.niva4cap.eu/) delivers a suite of digital solutions, e-tools, standards and good practices for e-governance and initiates an innovation ecosystem to support further development of IACS that will facilitate data and information flows. The monitoring systems that are developed within NIVA are making use of remotely sensed, farm-level and field-level data. NIVA aims to modernise IACS by making efficient use of digital solutions and e-tools, by creating reliable methodologies and harmonised data sets for monitoring agricultural performance while reducing administrative burden for farmers, Paying Agencies and other stakeholders. This overall objective is made operational through a number of specific objectives: • Integrate and reuse IACS evolutions based on open standards and common services • Build on farmers' acceptance of the Smart Monitoring methodology • Reduce the gap between current use and potential broader use of IACS data • Create a permanent exchange platform for discussion and exchange IA - Innovation action Start Date: 1 June 2019 End Date: 31 May 2022 (likely to be extended for 6 months)	WUR (WENR)	**Established-** Various MEF4CAP partners (WUR, NP, ITACyL) also participate in NIVA project. A first set of results from NIVA are directly mediated to MEF4CAP through these partners. Further collaboration actions and transfer of results from NIVA project will be realized.

As a first step and in order to establish a communication channel, an invitation-to-collaboration email was send to representatives of each targeted project. The letter is available in Annex A. After a positive reply, a doodle poll was set up in order to identify a common accepted date. A proposed agenda was specified and send by MEF4CAP representatives to the meeting participants. In general, collaboration meetings were held online (due to COVID-19 restrictions) and organised to have a duration of approximately one hour.

All meetings were organised and realised based on the following schedule/agenda:

- Introduction of participants
- Agenda presentation
- Short presentation of MEF4CAP and objectives - rationale for this meeting
- Short presentation of the invited project's objectives
- Presentation and Q&A on selected topics that the invited project members elaborates on and that are of interest for MEF4CAP project's objectives
- Open discussion
- Closing of the meeting

After the completion of the meeting, detailed minutes where extracted and made available through the living document to all MEF4CAP participants.

4. Liaison activities outcomes

This section presents an analysis of the currently available results from the targeted projects that are of interest for the MEF4CAP objectives. The outcomes of each project reported here are derived from two main sources:

a) Review of already published results. The main sources of information are published deliverables, information available at project's website, and presentations (slides) available from various public events.

b) Analysis of the meeting minutes recorded during the sessions (on-line meetings) organised with the MEF4CAP project.

Besides the analysis of these two sources of information, a short summary of outcomes is provided for each project, including also the relevance of the project's objectives with MEF4CAP and the potential for future collaboration activities.

4.1 H2020 DEMETER project

The call took place on the 24th of May 2021 at 11:00 CEST with 14 attendees representing MEF4CAP and H2020 DEMETER projects and lasted approximately one hour and a half.

The meeting Agenda was:

- Introduction
- Presentation of MEF4CAP (10 minutes)
- Presentation of DEMETER (10 minutes)
- Semantic interoperability & Data sharing (30 minutes)

With indicative discussion topics:

  - DEMETER's data and system interoperability mechanisms
  - Field Sensors
  - Farm Calendars
  - Adoption perspectives and challenges

The call started with a quick introduction of all attendees followed by a brief presentation of the two projects respectively. Following are some relevant slides from the presentations.

Figure 1. DEMETER's sectorial challenges regarding the new CAP

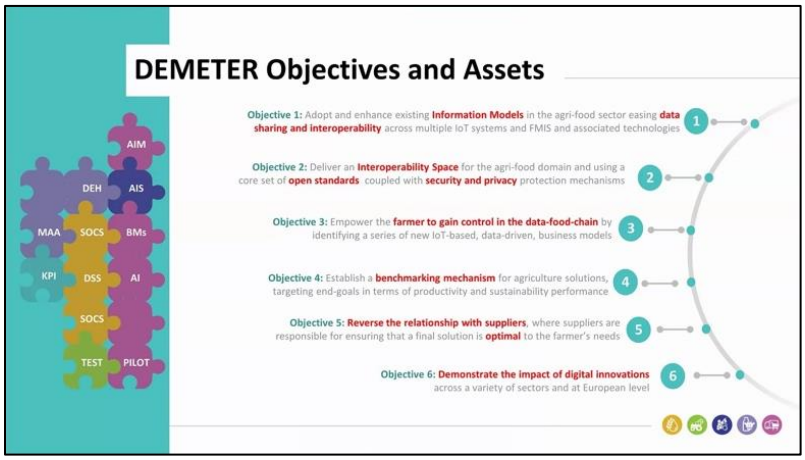

Figure 2. DEMETER's objectives and assets

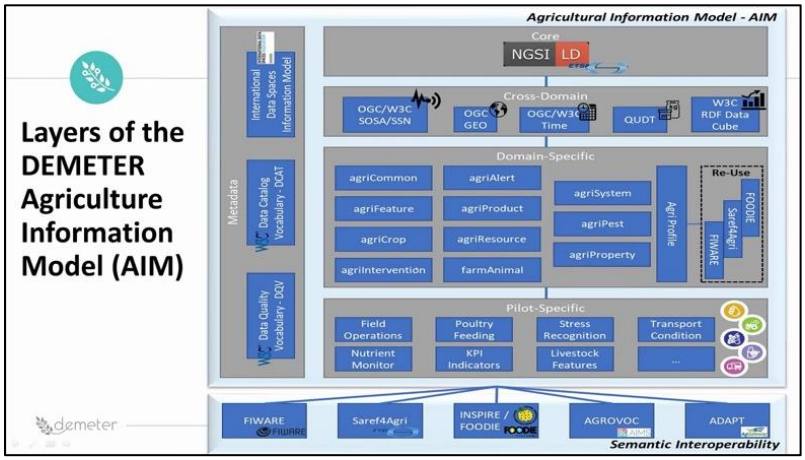

Figure 3. Layers of the DEMETER Agriculture Information Model (AIM)

After the completion of the presentation session, the discussion focused on DEMETER's approach on the topics of semantic interoperability and data sharing in the agri/tech-food sector. The productive discussion between participants led to examining DEMETER's potential to support semantic interoperability needs for the digitisation of monitoring and evaluation frameworks for the future CAP.

Key technical outcomes:

The H2020 DEMETER (https://h2020-demeter.eu/) project is a large-scale deployment of farmer-driven, interoperable smart farming-IoT based platforms, delivered through a series of 20 pilots across 18 countries (15 EU Member States). Involving 60 partners, DEMETER adopts a multi-actor approach across the value chain, with 25 deployment sites, 6,000 farmers and over 38,000 devices and sensors being deployed.

DEMETER aims to facilitate the further adoption of advanced technologies (IoT, AI, EO, Decision Support) in order to increase performance in multiple aspects of farming operations. It aims to put these digital technologies at the service of farmers using a human-in-the-loop approach that constantly focuses on mixing human knowledge and expertise with digital information. DEMETER focuses on interoperability as the main digital enabler, extending the coverage of interoperability across data, platforms, services, applications and online intelligence, as well as human knowledge, and the implementation of interoperability by connecting farmers and advisors with providers of ICT solutions and machinery.

Until today only two deliverables are publicly available from the DEMETER project: "D3.1 DEMETER reference architecture - Release 1[5]" and "D2.1 Common data models and semantic interoperability mechanisms[6]". Deliverable D3.1 presents a conceptual Reference Architecture facilitating data sharing in heterogeneous ecosystems of agricultural technologies. According to D3.1, in order to implement this Reference Architecture several key technologies need to be developed. The most crucial of these is the common data models which make the DEMETER Agricultural Information Model (AIM) and which enable semantic interoperability between DEMETER and existing agri-food systems and ontologies. AIM's specification is available at Deliverable 2.1.

[5] https://h2020-demeter.eu/wp-content/uploads/2020/10/D3.1-DEMETER-reference-architecture_v1.0.pdf
[6] https://h2020-demeter.eu/wp-content/uploads/2020/10/DEMETER_D21_final.pdf

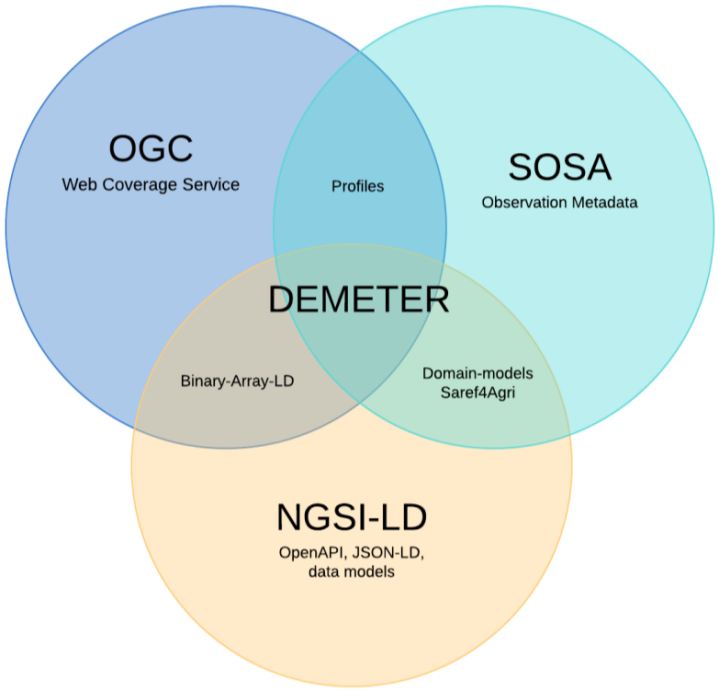

Figure 4. Reuse of existing standards towards semantic interoperability by H2020-DEMETER project

According to D2.1, AIM adopts a modular approach and is based on a rich set of related standards or dominant solutions. AIM distinguishes between four main parts, each with a different role: the AIM core metamodel, which builds on and extends the NGSI-LD meta-modelling approach; the AIM cross-domain ontology, i.e., the set of generic models that aim at providing common definitions for not necessarily tied to the agri-food sector and at avoiding conflicting or redundant definitions of the same classes at the domain-specific layer; the AIM domain-specific ontologies that model information related to all domains linked to the agri-food section, such as crops, animals, agricultural products, as well as farms and farmers just to mention a few of the most important concepts included in these ontologies; and finally, the AIM metadata schema that aims to represent and capture any metadata that may be required by DEMETER. DEMETER AIM aims to support interoperability with regards to several existing standards and dominant agri-food data modelling approaches (such as NGSI-LD and FIWARE, Saref4Agri, ADAPT, INSPIRE and FOODIE, AGROVOC and EO data) detailing the semantic mapping of these to AIM (figure 5).

With regards to DEMETER's pilots, it is of interest for MEF4CAP the pilots that are experimenting and evaluating technologies that support the automated recording of farming practices. These technologies demonstrate the potential of in-situ data collection that can also be utilised for improving the recording and reporting of applied inputs (e.g. fertilisers, pesticides) towards a more optimised CAP indicators' monitoring methodology. Such a pilot is "PILOT 2.2 Automated Documentation of Arable Crop Farming Processes[7]", however no results are yet published from any pilot of DEMETER project.

[7] https://h2020-demeter.eu/pilots-overview/pilot-cluster-two/automated-documentation-of-arable-crop-farming-processes/

Based on the **MEF4CAP - DEMETER session,** the following outcomes are identified:

The DEMETER project focuses on systems and data interoperability for the various digital solutions of the agriculture sector through the use of semantic and syntactic interoperability mechanisms. The DEMETER project introduces the Agricultural Information Model (AIM) which aims to reuse upper-level ontologies in a complementary manner with domain specific ontologies. The DEMETER's approach allows to bridge the gaps that occur through the use of different -sometimes parallel- standards that "pop up" and are applicable to different application domains. The AIM is a "living model" that allows to integrate new terms and ontologies that are currently missing in order to extend the range of standards and models that they are compatible with. This approach affects the sustainability of the model as it is extensible and flexible so that it can be adapted and reused in the future even after the lifetime of the project. In addition, the persistent identification of the ontology provides a permanent way of identifying the ontologies concepts making them independent and beyond the project's lifetime.

As it is already stated, DEMETER project realises a number of pilots where various technologies are implemented. One of the pilots that is of interest for the MEF4CAP's objectives focuses on pesticides applications and their automated documentation in the context of CAP monitoring. There is keen political interest in the use of pesticides and the Farm-to-Fork strategy has specific ambitions to reduce the pesticide use. In addition, statistics offices do collect data on pesticide use but it is a huge administrative burden for farmers. There are also doubts about the quality of the provided data from the farmers. The tested technological approach is promising but there are various weak spots that are identified. For example, it is difficult to record and cross-check what the farmer has actually in the tank with the spraying liquid.

Demeter project's outcomes that are of interest for MEF4CAP are mainly related with data and system interoperability of agricultural solutions but also with regards to the agricultural technologies that are introduced or tested within DEMETER's pilots. Interoperability is considered as a prerequisite for facilitating farm-level data sharing from the various operational ICT systems that support farmers on everyday tasks. Further interactions and exchange of results will be realised with DEMETER when the respective deliverables of interest will be publicly available. However, DEMETER project is not considered as a project that is directly related with CAP monitoring technologies/solutions.

4.2 H2020 ENVISION project

The call took place on the 4th of June 2021 at 14:00 CEST with 12 attendees representing MEF4CAP and H2020 ENVISION projects and lasted approximately one hour.

The meeting Agenda was:

- Introduction
- Presentation of MEF4CAP (10 minutes)
- Presentation of ENVISION (10 minutes)
- Elaboration on ENVISION's Data Products in support of future CAP data needs (20 minutes)

- How ENVISION handles key challenges on agricultural data collection (20 minutes)

<u>With indicative discussion topics:</u>

  - Integration of heterogeneous data and Semantic interoperability
  - Data ownership
  - Diverse maturity level on applied agri-technologies
  - Future steps

The call started with a quick introduction of all attendees followed by a brief presentation of the two projects' objectives respectively. Following are some relevant slides from the presentations.

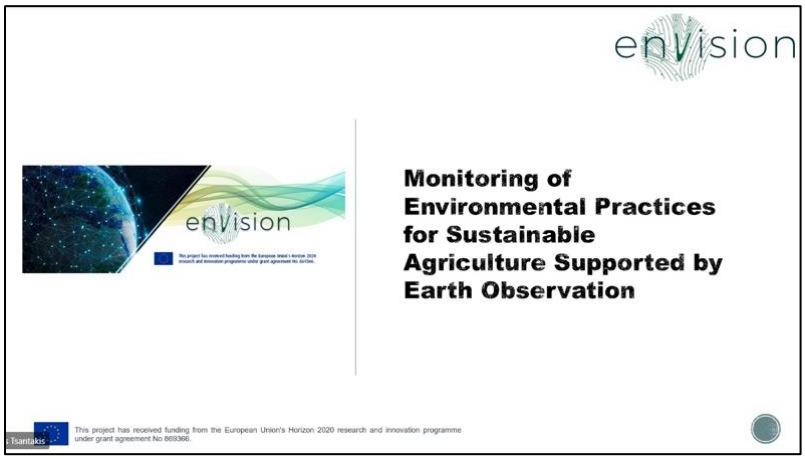

Figure 5. ENVISION's aim

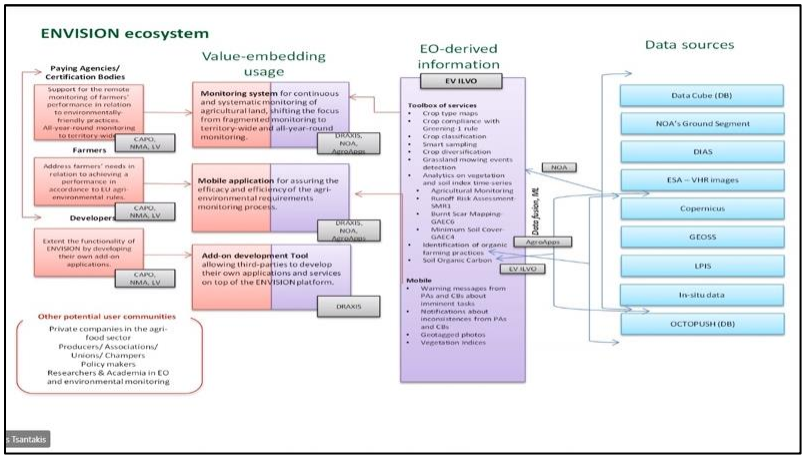

Figure 6. ENVISION's ecosystem

After the completion of the presentation session, the discussion focused on ENVISION's approach on Data Products in support of the future CAP data needs as well as how ENVISION project handles key challenges regarding the issue of agricultural data collection.

Key technical outcomes:

ENVISION project develops and tests innovative tools for the continuous, large scale and uninterrupted monitoring of farm management activities with regards to sustainability, in compliance with the CAP's agri-environmental objectives. The developed tools are integrating data from the following sources: In-Situ Data, Databases, Copernicus EO data, while the targeted data products are related with: Cultivated Crop Type Maps, Soil Organic Carbon, Organic Farming, Grassland Mowing/Ploughing, Soil Erosion. The developed services are targeting the following type of users: Paying Agencies (Web platform), Certification Bodies (Web platform), Farmers (Mobile App), Third-Party developers (Add-on Development tools).

ENVISION has published "D4.1 Architecture and Services Specifications report[8]" which provides the specifications of the tools that are under development by this project. Based on this deliverable, a short summary of the tools that are in relation with MEF4CAP's objectives follows.

Service: Cultivated Crop type Maps. The Cultivated Crop Type Maps is an Earth Observation (EO) crop classification module that exploits satellite data along with the usage of Machine Learning techniques in order to provide products related to the validation of the declared crop type by a farmer. In addition, it provides the knowledge of the compliance with certain environmental rules such as Greening requirements. Thus, it can be used from the Paying Agencies as a tool to enhance the process of checking the declarations of the farmers at the time of declarations, but also to assist via smart sampling of parcel to be checked during the validation process (OTSCs). This can be achieved as the service that informs the PAs about the parcels that have a high probability of being wrongly declared.

The Crop Diversification Service exploits the Land Parcel Information System (LPIS) and the declarations of the farmers. Thus, it will monitor crop types included in the aforementioned files and it will make a merge of crop types if the exhaustive process cannot distinguish between two or more of them. As a result, the predicted crop type of each declared parcel will be generated along with a percentage of prediction's confidence and it will be used as indicator for the declaration process. Last but not least, taking into account last year's farmers declarations, this service will be able to point out possible Land Use/Land Cover (LULC) changes, if they exist.

- **Targeted users: Paying agencies**. The service will provide them with continuous information about the crop type of each parcel. The first classification process will take place early in the year in a higher level giving the potential for the agencies to check the validity of the declaration. Then, multiple executions of the service will produce results in a lower level for each declared crop type. Thus, it can assist the Paying Agencies in decision-making as it allows them to make targeted inspections of parcels in shorter time periods so to validate the declared crop type.

[8] https://envision-h2020.eu/wp-content/uploads/2021/04/D4.1-Architecture-and-Services-Specifications-report.pdf

- **Input data** - The input data required are EO data and Paying Agencies' data to derive crop information:
    - Satellite: Sentinel-2 L2A, Sentinel-1
    - Products: Spectral bands, backscattering coefficients, coherence (if needed), Vegetation Indices (VIs)
    - Paying agencies: Declared Crop Type, Validated Crop type, Polygon data
- **Output data** - The service will provide:
    - Crop type maps as a shape file over the registered parcels early in the year grouped in a higher class
    - Crop type maps as a shapefile over the registered parcels in a predefined frequency
    - Compliance information as a shape file over the registered parcels in a predefined frequency

Service: Grassland Mowing Events Detection. This service will provide a fully automated identification of Grassland Events module, with a view to assist in the valid and on-time identification of main events taking place in grasslands, such as mowing and grazing (if possible). The service will contribute into the direct supervision of the Paying Agencies of the compliancy of grasslands farmers to the respective regulation of pilot countries regulations and indication of possible declination from them. Given that, PAs will be able to organise and realise more accurate field visit campaigns to more specific locations pinpointed from that service and as a result will drive into the reduction of the inspections cost.

- **Targeted users:**
    - **Paying Agencies**: The service will provide them with continuous information regarding grassland activity of each parcel. This will give PAs the ability to monitor abrupt changes into the field's canopy though the entire cultivation period and track the main events taking place and the respective time-periods. Moreover, given the specific regulations applied from each country, grassland mowing events detection micro-service can assist the PAs in the faster and better identification of farmers' compliance.
    - **Policy Makers**: The service will assist policy makers in taking the best decision on planning the more suitable number of grassland events allowed during the entire cultivation period and to analyse the potential of grassland maintenance.
- **Input data** - The input data required are EO data and Paying Agencies data to derive grassland mowing events detection:
    - Satellite: Sentinel-1, Sentinel-2 L2A, VHR
    - Products: Spectral bands, backscattering coefficients, coherence coefficients, Vegetation Indices (Vis), FAPAR, LAI

- Paying Agencies: masked grassland crop type maps, polygon data, mowing regulations for the specific AOI

- **Output data** - Events Map (shapefile) of grassland mowing detection per parcel encapsulating all the extracted information regarding the detected events, their confidence levels and their compliance into the respective mowing regulations.

Service: Analytics on Vegetation and Soil Index Time-series (AVSIT). The service aims at providing vegetation and soil indices, along with geospatial analytics such as growth trends, change detection, phenological metrics, soil specific indicators, static indicators with respect to rainfall erosivity and soil erodibility, cover management factor for soil erosion, Natura2000 areas hotspot detection, Burnt Scar Mapping and Runoff Risk assessment for the reduction of water pollution in Nitrate Vulnerable Areas. The final set of subservices remains to be defined after the processing of user requirements.

- **Targeted users:**
  - Paying agencies. The service will provide them with continuous information regarding the parcels cultivation phases and the respective compliance of the current CAP policies. Multiple executions during the entire cultivation period and visualisations of the service will give them a clearer picture of the current farmers' activity. In parallel, the provision of the respective confidence levels will assist them in decision-making as it allows them to make more accurate field inspections (through RS or OTSC) and reduce the cost of field campaigns.
  - Policy Makers. In the dawn of a new POST 2020 CAP, this service can be a valuable supportive tool on the design of new area-specific cross-compliance policies. Policy makers can use this service as a second hand in order to define new regulations focusing on the topical characteristics and specifications of the inspected regions.

- **Input data:** (i) Satellite: Sentinel-1, Sentinel-2 L2A, (ii) Products: Spectral bands, backscattering coefficients, coherence coefficients, Vegetation Indices (Vis), (iii) Auxiliary Shapefiles: e.g LPIS, Agricultural Practices Descriptions, hydrographic networks, Natura2000 regions, etc.

- **Output data**: The service will provide either in file format (GeoTIFF, Shapefile) or via a RESTful API the following: Vegetation Indices, Soil Indices, Maps and Analytics (Phenological Metrics, Growth trends, Change Detection et cetera).

Service: Identification of organic farming practices. Plants cultivated under organic and conventional farming principles present bio-chemico-physical differences that can be detectable by satellite imagery, especially during the vegetative and reproductive growth stages. The identification of organic farming practices service will benefit from these differences to discriminate between organic and non-organic (conventional) crops. The logic behind the service is to identify distinct patterns characterising the growth and evolution of organic and conventional crops during the growing season, through the use of both high

resolution optical and radar satellite images depicting the phenological status of the cultivated parcels. This service aims to provide a fully-automated Organic crop identification service, which aims at identifying whether a particular crop type declared as organic is classified as such, based on a traffic light system. The service will contribute to replace direct and guide on-field checks for priority control and will result in the reduction of inspections costs and of the Certification Bodies (CBs) administrative burden, thus ensuring targeted and efficient controls and faster delivery of payments/organic certifications to farmers. The service will exploit a number of EO derived indicators and tools to ensure effective monitoring of the crop condition variability and phenological stages, in both space and time**.**

- **Input data:** The input data required are EO data to derive VIs and CBs data to derive crop information.
  - Satellite: Sentinel-2 L2A/Sentinel-1 (EO data)
  - Products: Spectral bands, backscattering coefficients, VIs, Phenology Analytics (Predictor Features)
  - Certification Bodies: Crop Type, Sowing Date, Polygon Data (In Situ Data by the farmer), Farmer's declaration of the cultivation method
- **Output data**: The service will provide maps of decision on the cultivated practices and whether these are organic or conventional over a registered parcel by the end of the growing period or within the growing period, updated every time satellite images are available (Sentinel-2 or Sentinel-1). The product is accompanied with a legend showing the values of "organic", "non-organic", "not classified" (when the decision's accuracy is lower than an acceptable value).

Service: Soil Organic Carbon (SOC) monitoring. The SOC service aims to: Deliver Verified top-soil (0-10 cm) qualitative Soil Organic Carbon estimations, Visualise SOC spatial variability at parcel, area, and regional level, and to Support the further collection of SOC measurement data, as a way to improve the SOC model and to validate its results. The service will be used to monitoring CAP's soil requirements (in terms of soil organic carbon) and support the maintenance of soil organic matter level relative to the current and future CAP requirements. End-users may use service results to get insights and information on tillage, drainage, and overall agricultural management practices.

Input data:

- SOC Carbon images (Maps) presenting topsoil SOC values at high spatial resolution (10-30 meters)
- LPIS data
- Administration boundaries

Output data:

- Synthetic bare soil layer obtained by Sentinel-2 time series (10 m resolution) formatted as Multilayer Raster (GeoTIFF)

- SOC content for croplands (10 m resolution) formatted as Raster GeoTIFF
- Average SOC content for each agricultural parcel (including other statistics) formatted as Shapefile

Based on the **MEF4CAP - ENVISION session,** the following additional outcomes are identified:

All services by the ENVISION project are mainly based on EO data products. However, EO is not an efficient approach when handling small agricultural parcels which is the case for many EU Member States located in the south east area (such as Greece, Cyprus, South Italy). This issue is also acknowledged by ENVISION project as all traditional crop classification techniques do not seem to work in Cyprus that has extremely small parcels. Something different is needed in such situations and they are specifically exploring that. In order to address this issue a pixel-based approach or a semi-pixel-based approach as well as buffers are utilised. In addition, ENVISION is also exploring the shift from the traditional machine learning classification approaches utilised by the majority of EO based CAP monitoring projects (e.g. Vector Machines) to more efficient approaches like convolutional neuro-networks. ENVISION also aims to exploit and augment the Sentinel time series by using the Paying Agency's owned very high-resolution data received from the JRC project.

Regarding satellite data and the purchasing of satellite images of higher resolution, ENVISION members consider that these data will definitely play a role in the immediate future. This makes sense because Sentinel images have zero cost but do not resolve 100% of the problems. On the other hand, the monitoring, inspection and controlling of the CAP is substantial. Reducing cost is feasible by allocating financial resources in order the Member States to have access to proprietary and commercial data as well.

In addition, geotagged photos recorded by farmers are already playing an important role in many Member States and they are going to play a key role in future. However, there are many still unresolved issues with the use of UAVs and high resolution images. For example, in project CALISTO a proof of concept pilot is realised using geotagged photos, street level images and UAV images for the monitoring of the paying agencies. The first results showed that UAVs demonstrate limited capabilities due to legal framework, weather conditions, limited flight time, logistics, etc.

With regards to agricultural activity detection, the use of satellite data are currently offering various promising approaches but there are still issues to be resolved. More specifically, grazing in particular is very hard to be detected because it has to do with observing where the animals have passed through. It is not like having a uniform change in the land over the fields. Grassland grazing has very low TRL in comparison with grassland mowing that is operationally used by quite a few paying agencies. Satellite data can also be used for the identification of illegal stubble burning.

MEF4CAP and ENVISION projects are investigating many topics of common interest. ENVISION project is currently in the process of developing ICT tools specifically for addressing the various challenges towards current and future CAP monitoring. The main information sources that ENVISION tools are exploiting are EO data products. ENVISION project doesn't focus on the various agricultural ICT solutions that provide farm level in-

situ information (e.g. data logs from machinery, FMIS, farmers' digital calendar). ENVISION is considered by MEF4CAP as one of the most related projects with regards to CAP monitoring and the respective outcomes will be continuously monitored.

4.3 FaST project

The call took place on the 6th of July 2021 at 13:00 CEST with 11 attendees representing MEF4CAP and FaST projects and lasted approximately three quarters.

The meeting Agenda was:

- Introduction
- Short presentation of MEF4CAP's objectives (10 minutes)
- Presentation of FaST project objectives and achievements so far (15 minutes)
- Presentation of FaST tools (15 minutes)

With indicative discussion topics:

  - Challenges that are not currently addressed by FaST - future plans
  - Current adaptation by farmers, operational use of FaST tools - first impressions
  - Next steps for FaST

The call started with a quick introduction of all attendees followed by a brief presentation of the two projects' objectives respectively. Indicative slides from the presentations and other material follow.

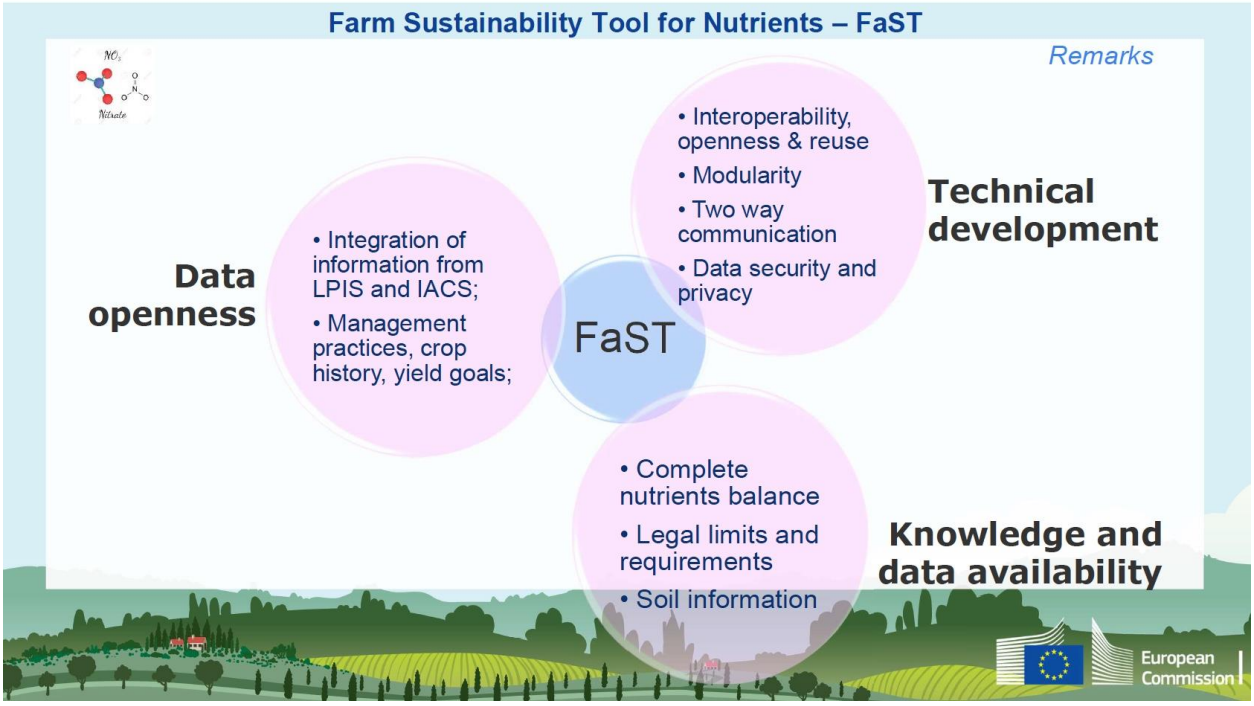

Figure 7. Elements and functionalities of FaST

Figure 8. The FaST tool mobile application

After the completion of the presentations session, the discussion focused on FaST's achievements so far and the project's produced tools such as the FaST mobile application.

Key technical outcomes: The FaST[9] v1.0 has already been released and tested to Andalucia, Castilla y Leon, Estonia and Piemonte as a mobile application that embarks the following features in a user-friendly interface:

- Maps overlaying farm data on GIS layers
- Copernicus/Sentinel imagery: RGB+NDVI
- Campaign management with import of IACS/GSAA farmer data
- Fertilisation recommendation
- Geo-tagged photos
- Two-way communications
- Basic weather/climate

The FaST Stage 2 project has been initiated in order to expand the reach of the platform to the farmers of: Wallonia (Belgium), Bulgaria, Greece, Romania, and Slovakia with the support of the respective Paying Agencies. The second stage is expected to be completed by the end of May 2022.

The platform also provides an Administration Portal, where the Paying Agency can access the regional data, configuration and user profiles and a secured API mechanism to remotely connect to the data store.

The vision is for the FaST tool to become a world-leading platform for the generation and re-use of solutions for sustainable and competitive agriculture based on space data (Copernicus and Galileo) and other public and private datasets. The modular platform - when it will be fully developed - aims to support EU agriculture and the CAP by also enabling the use of solutions based on machine learning applied to image recognition, as well as the use and reuse of IoT data, various public sector data as well as user generated data.

According to FaST documentation[10] and in relation to future CAP implementation, this tool will be capable to support the following entities:

- **Farmers**

Farmers will download and upload data from/to the FaST platform and be proposed value-added agri-services that will be displayed right into the FaST application and web portal. The FaST platform will be interfaced with the administrative databases: the farmer's data will be readily available without needed to re-input them.

- **National and Regional CAP agencies**

The largest part of the EU CAP budget is managed and controlled through IACS in Member States, aiming to safeguard the CAP financials and supporting the farmers. The IACS is implemented at national and regional level through the Paying Agencies of each EU Member State. In the post-2020 CAP reform, Member States will be responsible, through their Paying Agencies, for providing a Farm Sustainability Tool to their farmers (GAEC5). At the same time,

[9] https://fastplatform.eu/
[10] https://fastplatform.eu/whyfast

satellite EO is seen to take an increasing role in the overall implementation of the CAP, from compliance with legal obligations to the implementation of targeted climate and environment measures. With the FaST, PA will register compliance with GAEC 5 and possibly with further SMRs and GAECs[11]. As the FaST platform will provide access to libraries of code, the tool will be customised by Paying Agencies, to offer additional functionalities or to adapt to Member States specificities. Paying Agencies will also use the tool to communicate directly with the farmers (on CAP declaration campaign for example). It should be noted that this feature is not yet developed.

In addition the tool will support National and Regional CAP agencies in the following domains:

- **Environmental monitoring**

Support to monitoring certain environmental parameters (soil quality, air pollution, nitrogen rate, water quality, etc.). Particular benefit to Nitrogen Vulnerable Zones.

- **Compliance**

Relevant advice that is within the parameters of the CAP, ensuring that farmers who follow this advice both are compliant with the CAP and have a record proving this fact.

- **Increased two-way communication**

Rapid sharing of critical information for farmers, such as warnings on declarations, changes in policies, etc. Farmers can also rapidly reach MA/PAs to inform them of any issues when the need arises.

- **Economies of Scale**

Pooling of resources by many Member States on FaST leads to significantly higher value than individual Member States. Democratic access to these resources levels the playing field across the EU.

- **Digitalisation**

Laying the foundations for digitalisation would be a boon to rural development efforts and small holders by introducing them to new technology. Offering users a portfolio of digital services, allowing them to derive value in ways most relevant to their circumstance.

With regards to integration with national/local IACS, the following process is specified[12]:

In order to provide data access to the farmer, FaST connects to the regional/national IACS system (or equivalent farm registry), where the data of the farmer is stored. This data is usually derived from the GSAA (geospatial aid application) of the farmer from the previous year. The data that FaST will need to be able to propose services to the farmer only includes agricultural data: parcel geometries (polygons), previous crops and varieties. The datasets are "pulled" into

[11] A full list of GAECs is available here: https://marswiki.jrc.ec.europa.eu/wikicap/index.php/Good_Agricultural_and_Environmental_Conditions_(GAEC)
[12] https://gitlab.com/fastplatform/docs/-/blob/master/journey_doc/journey_doc.md

FaST but never pushed back into the IACS system. Once the data are inside FaST, the farmer has the possibility to edit it in FaST without any impact to his IACS/GSAA data.

Based on the **MEF4CAP - FaST session** the following additional outcomes are identified:

The FaST platform integrates data from multiple sources such as Earth Observation data (i.e. satellite imagery and navigation) and climate providers' APIs and is operational for both farmers and public authorities. In addition it integrates the following "static" information[13]:

- Soil data: necessary to provide default soil information to users and to be used as default values in the fertilization algorithms
- Surface waters and water courses: necessary for display, to compute constraints and nitrogen limitations that depend on water body proximity
- Nitrate Vulnerables Zones: necessary for display, to compute constraints and nitrogen limitations that depend on being within an NVZ
- Natura2000 areas: mostly for display and to comute constraints
- List of plant species and varieties: this is the list of crop that will be used by all users in your region/country. This list can be different from the IACS crop nomenclature or from the way crops are described within your fertilization algorithm: however, in both cases, you will need to provide a mapping table between each nomenclature.
- List of fertilizer products: if your fertilization algorithm produces actual fertilizer product recommendations (in addition to chemical element recommendation, such as N, P & K), then you should provide a base list of fertilizer products, either organic or mineral
- Legal limits for nitrogen and conditions that apply to each limit, such as crop yield or NVZ

As it is stated, these data sources are considered as "static" because they are not expected to change often and do not depend on user input. It does not mean that they will be fixed forever.ελα

The platform currently supports nutrients/fertilisation advice and management but in the future it will also support water management sources as well as other environmental data. More specifically, the platform supports nitrate management advice which is aligned with the specific policy applied till today and in line with the paying authorities.

Regarding data standards, the platform uses the ALISE standard. They use the dual spatial vocabulary which is maintained by the joint Research Centre of the Commission and the core elements of this vocabulary are extended with more specific and relevant ones for the FaST platform.

As far as privacy issues are concerned, they are obliged to implement privacy regulations on their performed activities. A key issue is that the farmers' explicit consent is needed for the data that is to be shared. No personal data is shared from farmers except for the initial information they provide. It should be added as well that no country has access to others' country data and the same happens to regional level and between Paying Agencies as well (i.e. each group has its own set of data).

[13] https://gitlab.com/fastplatform/docs/-/blob/master/journey_doc/journey_doc.md#integration-of-static-data-sources

FaST is considered as highly related with MEF4CAP's objectives. The use of tools like FaST that are designed to be utilised by individual farmers in order to both provide data to regional agencies but also for the farmers to receive advice (e.g. fertilisation) is of high importance towards the realisation of mutualisation-of-resources vision. FaST tool is already in use in a number of countries, however there are still no clear outcomes with regards to farmer's adoption (e.g. number of farmers that are utilising the tool, data volumes exchanged, efficiency of using the app from the farmers' perspective but also from the PAs). It must also be noted that not all the designed features are yet implemented and tested (e.g. provision of data by the farmers to regional agencies). These outcomes would be of high importance for evaluating the FaST's tool approach. Both projects agreed to continuous collaboration with further exchange of information and results.

4.4 Open IACS project

The call took place on the 9th of July 2021 at 13:00 CEST with 11 attendees representing MEF4CAP and Open IACS projects and lasted approximately 50 minutes.

The meeting Agenda was:

- Introduction
- Short presentation of MEF4CAP's objectives (10 minutes)
- Short presentation of Open IACS's objectives – achievements so far (15 minutes)
- Data sharing in the context of Future CAP - Open IACS's approach (20 minutes)

With indicative discussion topics:

  - Which data types/information items are considered as useful for IACS?
  - How IACS can access and use these data? Technical/Semantic interoperability.
  - How "Open IACS" project handles farmer's data ownership? Farmer's reluctance to share data?
  - ICT solutions for Landscape Monitoring
  - Any other issues

The call started with a quick introduction of all attendees followed by a brief presentation of the two projects' objectives respectively. Following are some relevant slides from the presentations.

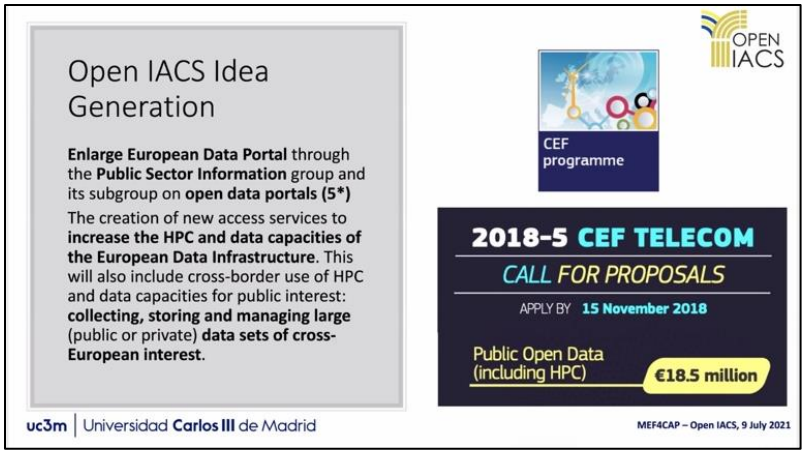

Figure 9. Open IACS's Idea Generation

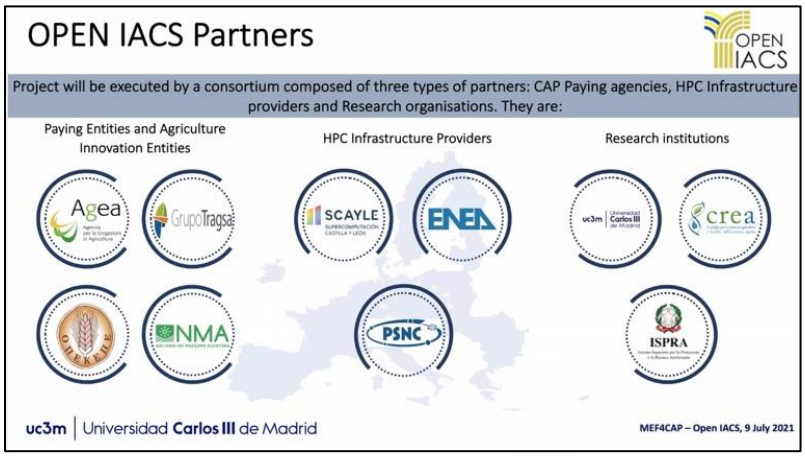

Figure 10. Open IACS's project partners

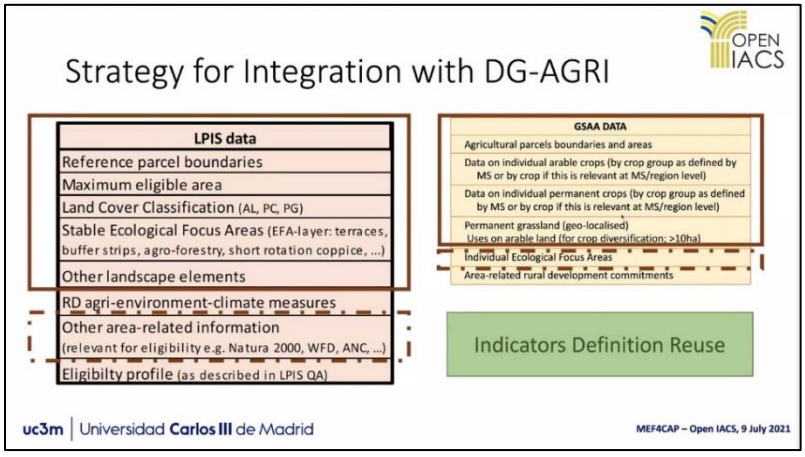

Figure 11. Open IACS's strategy for Integration with DG-AGRI

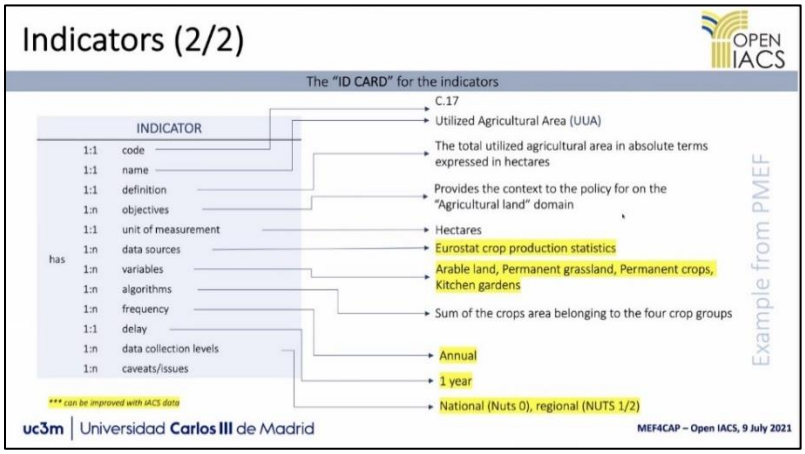

Figure 12. Open IACS's "ID CARD" for the indicators

After the completion of the presentation session, the discussion focused on Open IACS's achievements, how they handle issues of Technical/Semantic interoperability and farmer's data ownership, their view regarding ICT solutions for landscape monitoring as well as the produced project results.

Key technical outcomes:

The main technical goal of Open IACS project is the creation of a common infrastructure for agri-environmental governance of the CAP. In doing so, the action will provide an open community platform for sharing solutions in the IACS domain for the CAP through the Linked Open Data paradigm. This will include generic services to facilitate end-user access to HPC capabilities by managing different HPC providers via a technological architecture that processes service level agreements to seamlessly assign jobs to the different providers involved in Open IACS infrastructure.

More specifically, Open IACS project aims to:

- Design a network of interoperable Linked Open Data (LOD) End-points considering information for Agri-environmental management of IACS policies.
- Implement the common agri-environmental LOD infrastructure for IACS policy management by means of increasing HPC capabilities.
- Demonstrate the usefulness of this infrastructure through its application in different scenarios.

The project has not publicly published any deliverables with results yet.

Based on the **MEF4CAP - Open IACS** the following additional outcomes are identified:

Open IACS project is collaborating directly with paying agencies. They have defined a data model (ontology) in order to address heterogeneity of information modelling that is introduced

by the use of different data sources. Open IACS representatives stated that within the project, farmers do not provide directly any information because they do not have yet such obligations (e.g. on providing information on nutrients utilised to their cultivation). One of the features that Open IACS implements is to support the integration of applied inputs by the farmer as it will be mandatory in the new CAP (e.g. retrieving information from FMIS regarding nutrients, seeds, fertilisers). All these information items are planned to be integrated but are not included in the current version of the Open IACS.

Open IACS's data models are planned to be open to the general public. The relevant information will be available to the whole community directly from the end points but APIs will be provided in order to access information in a more meaningful way. This information will be managed directly by the Paying Agencies allowing them to submit regularly snapshots to the EU data portal. The information services will be transferred to them since they have signed a post-project commitment to maintain the infrastructure provided.

As it was stated by the Open IACS, EC's official position/requirement is that the various initiatives need to confront with the INSPIRE data model (ontology) when collecting and publishing open data with regards to the agricultural sector. In addition, it is foreseen that paying agencies' interest will increase as soon as there are evidences on the power of the combination/integration of different data sources in a simple way.

Open IACS project is not currently addressing the issue of how the various Farm Management Information Systems are able to connect and provide their datasets to the paying agencies. For example, farms are not giving to Open IACS information regarding good practices, other activities or nutrients because the supported communications are from the Paying Agencies to the farmers. However, in the coming years it is envisioned that the information system will have such possibility.

Open IACS project has already specified a data model (ontology) for describing data collections referring to LPIS and farmers declarations which is based on the JRC IACS model. As a starting point, they did a transformation into their ontology and based on that they were able to make the transformation from LPIS data to linked data.

Open IACS is not currently addressing the issue of data ownership and issues like who owns the data and how data are reused. In order to remove complexity from the project, the commitment was to publish only information owned by the Paying Agencies. That is why they are using IACS systems as a starting point. In the coming years, nutrients, fertilisers and seeds will be part of the IACS system due to the new reporting obligations. Paying Agencies will continue to be the owners of these information.

It must be stated that there is no official document by Open IACS project and only references are made in relevant presentations, meetings and events.

Open IACS is considered as highly related with MEF4CAP's objectives and future collaboration actions will be realised. Available documentation on Open-IACS objectives and current outcomes are limited and this fact doesn't allow the direct monitoring of project's results.

4.5 H2020 MIND STEP project

The first collaboration session took place on the 10th of September 2021 at 14:00 CEST with 10 attendees representing MEF4CAP and MIND STEP projects and lasted approximately 1 hour.

The meeting Agenda was:

- Introduction
- Short presentation of MEF4CAP's objectives (10 minutes)
- Short presentation of MIND STEP's objectives – achievements so far (10 minutes)

With indicative discussion topics:

- Elaborate on the integrated data framework for policy monitoring developed by MIND STEP
- What data sources and data type are integrated and how? How the generalisation from farm level to regional level is realised?
- Which are the targeted policy indicators
- Elaborate on MIND STEP model toolbox. What is the scope and how do they operate the various tools/algorithms?

The call started with a quick introduction of all attendees followed by a brief but concise presentation of the two projects' descriptions and objectives respectively. Following are some relevant slides from the presentations.

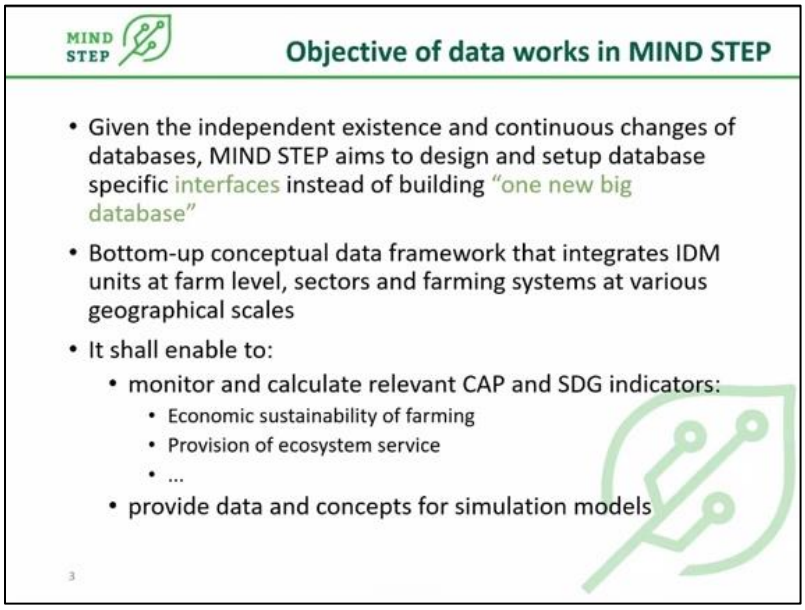

Figure 13. MIND STEP's objective regarding data works

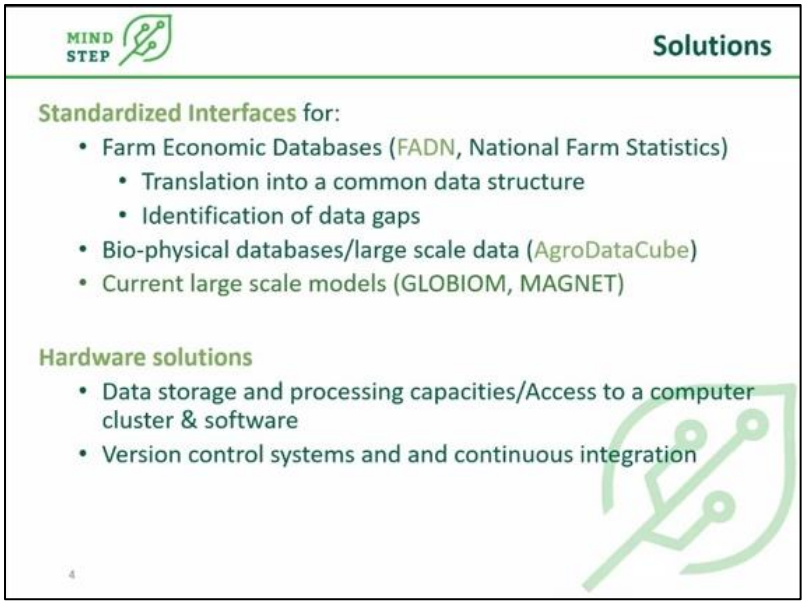

Figure 14. MIND STEP's solutions

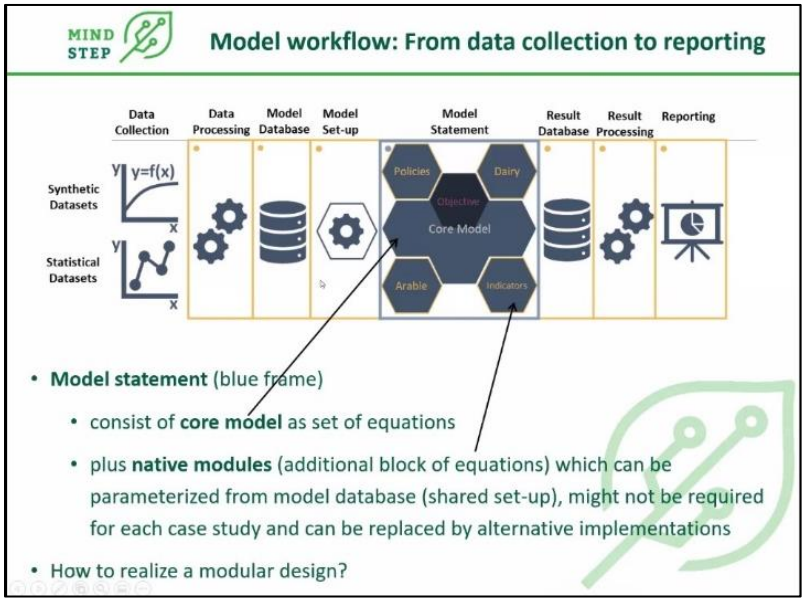

Figure 15. MIND STEP's model workflow

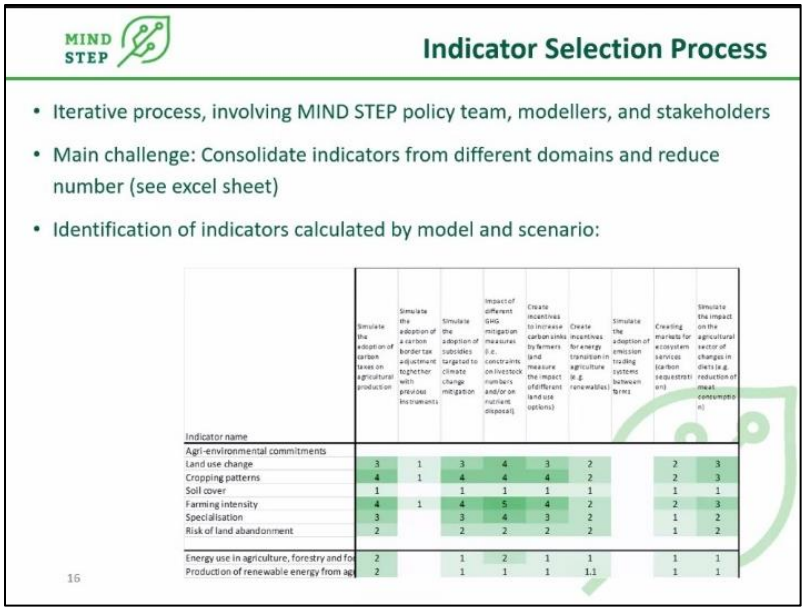

Figure 16. MIND STEP's indicator selection process

After the completion of the presentation session, the discussion focused on MIND STEP's achievements, the developed integrated data framework for policy monitoring, data handling issues (generalisation, integration) as well as the produced tools and solutions.

Key technical outcomes:

MIND STEP's project objectives[14] is to support public decision making in agricultural, rural, environmental and climate policies, taking into account the behaviour of individual decision-making units in agriculture and the rural society. MIND STEP aims to develop a highly modular and customisable suite of Individual Decision Making (IDM) models focusing on behaviour of individual agents in the agricultural sector to better analyse impacts of policies. In addition, the project aims to develop an integrated data framework to support analysis and monitoring of policies related to agriculture and to apply the MIND STEP model toolbox to analyse regional and national policies and selected EU CAP reform options.

MIND STEP aims to select, develop and release interfaces to access economic, bio-physical and data of existing models (like GlOBIOM or MAGNET) using state of the art ICT approaches, like REST API, R package distributions, and services based on Web Map Feature. In addition, it develops and applies methodologies to merge economic (full population and survey data) and biophysical data sets of high spatial and temporal resolution.

[14] https://mind-step.eu/why-mind-step

Currently only one deliverable is publicly available "D1.1 - Key policy questions for ex-ante Impact Assessment of EU Agricultural and Rural Policies[15]". A number of open access scientific articles are already published[16] which are mainly focusing on developing analytical frameworks for researching and evaluating issues like the adoption of digital agriculture technologies by farmers. For example, in the article entitled "Adoption and diffusion of digital farming technologies - integrating farm-level evidence and system interaction", a conceptual framework integrating farm-level evidence on adoption with a systemic perspective on technology diffusion is presented.

Based on the **MEF4CAP - MIND STEP session** the following additional outcomes are identified:

With regards to data collection, homogenisation and classification of agriculture activities the MIND STEP project uses standardised semantics and labelling schemes that are introduced by Eurostat. Location modelling is realised through the use of Nomenclature of Territorial Units for Statistics or NUTS[17]. NUTS is a geocode standard - developed and regulated by the EU - for referencing the subdivisions of countries for statistical purposes. It only covers the Member States of the EU in detail where for each EU member country, a hierarchy of three NUTS levels is established by Eurostat in agreement with each member state.

MIND STEP currently utilises aggregates of input data from FADN on regional bases, however integration of individual farm level data are among future plans. Data management system developed by MIND STEP is adaptable and able to integrate additional data sources. The project's aim is to integrate farm level in-situ data sources such as Earth Observation data products, data collected from sensors deployed at the farms or from connected farmer's digital calendar. Results though depend on the number of farms which have adopted new technologies and are willing to share their data to statistical organisations for processing. Results depend also on whether the relevant agri-tech companies are legally in position to share data, whether farmers are willing to invest on new technologies and what types of farms are going to do that.

The proper use of biophysical data is of high importance for MIND STEP project not only for monitoring but also for modelling and ex ante assessment of policies (for example broad specific data such as distances between plots and farms in order to calculate costs or soil quality indicators for crop specific yields etc.). It appears though that linking parcel information to farms is not always possible and depends on the country and other parameters that vary.

Both projects are researching means for new CAP indicators' monitoring. MIND STEP's outcomes can be considered that are more related with policy makers that need an assessment framework in order to evaluate the implementation of the designed policies. The collaboration between both projects will be further continued with the exchange of insights, deliverables and/or results in forthcoming meetings.

[15] https://mind-step.eu/assets/content/resources/deliverables/817566_D1.1-Deliverable_1.pdf
[16] https://mind-step.eu/resources
[17] https://ec.europa.eu/eurostat/web/regions-and-cities/overview

4.6 H2020 DIONE project

The aforementioned call took place on the 29th of September 2021 at 11:00 CEST with 11 attendees representing MEF4CAP and DIONE projects and lasted approximately 1 hour.

The meeting Agenda was:

- Introduction
- Short presentation of MEF4CAP's objectives (10 minutes)
- Short presentation of DIONE's objectives – achievements so far (10 minutes)

With indicative discussion topics:

- Details on geotagged photos app. What is the potential of using this app for the needs of the new CAP monitoring?
- EO data products in support of agricultural practices monitoring. What are the practices that can be detected? How to handle issues like small farms and cloud coverage.
- How the integration of drones with EO is realised?
- How the connection and data-sharing with Paying Agencies (IACS) is realised? How the data modelling harmonisation issue is tackled?

The call started with a quick introduction of all attendees followed by a brief presentation of the two projects' objectives respectively. Following are some relevant slides from the presentations.

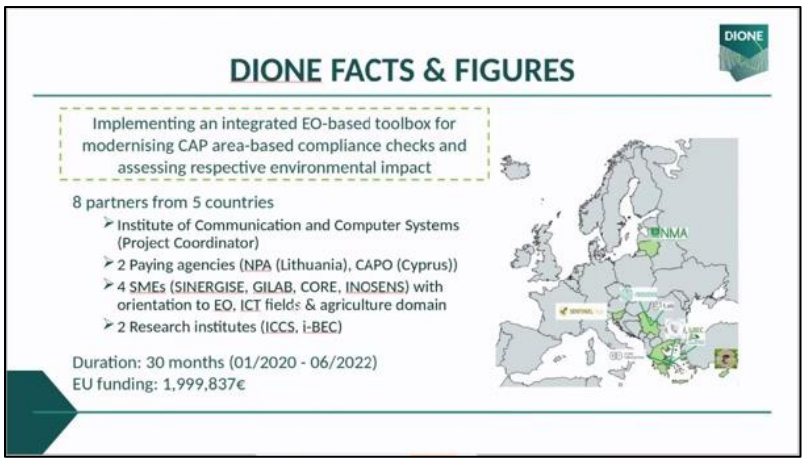

Figure 17. DIONE's facts and figures

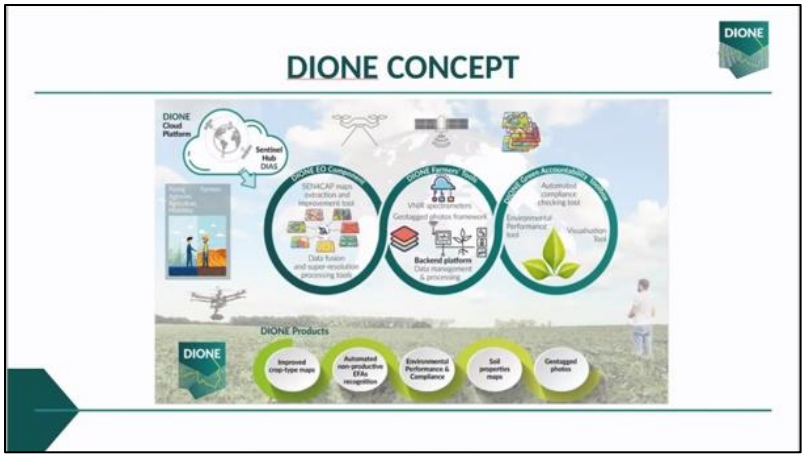

Figure 18. DIONE's concept

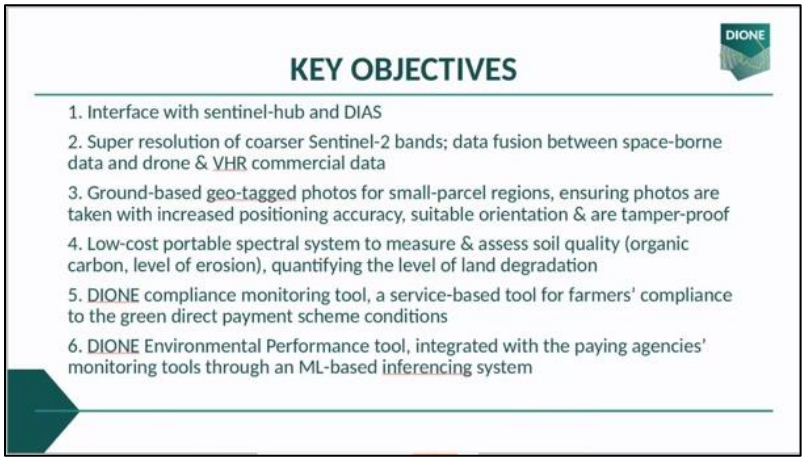

Figure 19. DIONE's key objectives

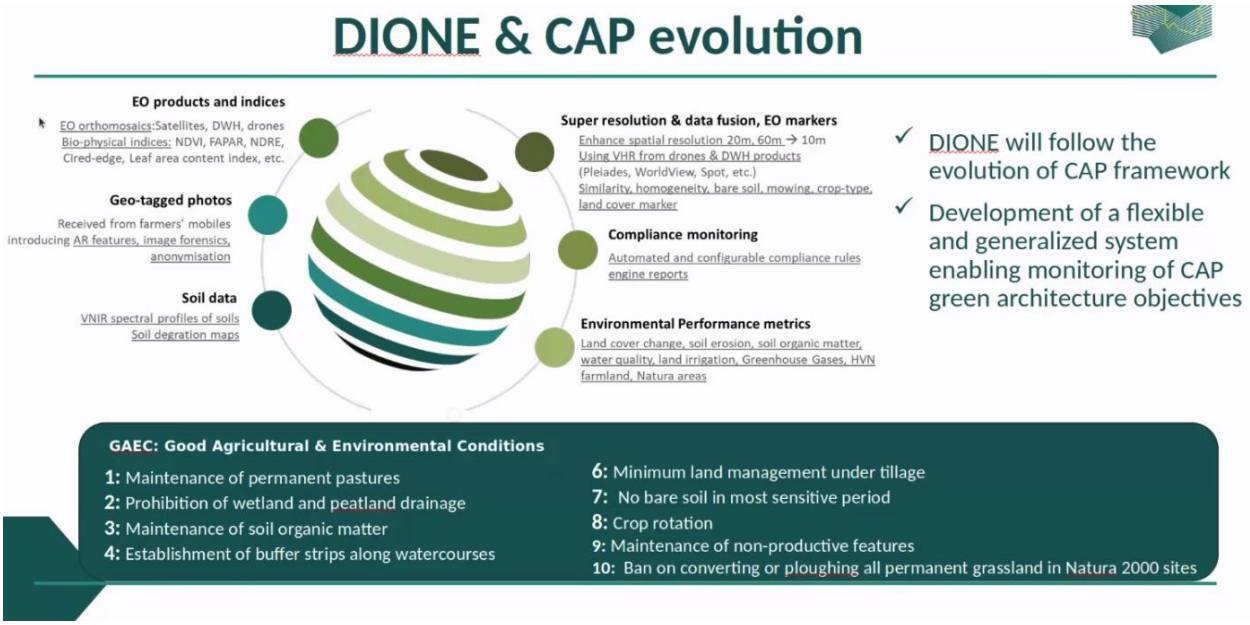

Figure 20. DIONE's view for the CAP evolution

After the completion of the presentations session, the discussion between participants focused on high level objectives of the DIONE's project and on the in-situ soil scanning system. Key partners of the project didn't participated in the session so it was not feasible to elaborate on the targeted topics.

Key technical outcomes:

DIONE project has published deliverable "D4.3: Implementation and development of systems; SSS, data processing and geo-tagged photos framework"[18] which provides the technical specification of the in-situ data gathering tools. Two of these tools are considered as highly related with MEF4CAP objectives:

a) The geo-tagged photos framework

b) The microelectromechanical systems (MEMS) soil quality monitoring sensor

The DIONE farmers' geotagged photos framework aims to complement the Earth Observation data sources with reliable ground-based information about agricultural parcels and thus facilitating CAP compliance monitoring. In this context, the 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 (frontend) that exposes to the user all the related content about their parcels while enabling the conclusion of the process and the provision of the final photos to the Paying Agencies. In this context, various processes are employed so as to enable among other things the provision of the necessary instructions for

[18] https://dione-project.eu/wp-content/uploads/2021/08/DIONE_D4.3_V1.0_Implementation-and-development-of-systems_-SSS-data-processing-and-geo-tagged-photos-framework-alpha-versions-alpha-versio.pdf

farmers to reach a given parcel, the reception of notifications about tasks they need to undertake as well as directions regarding the process of capturing appropriately a photo of a given parcel.

The app provides innovative features like the use of Augmented Reality in order to assist the user in capturing the appropriate photo. In addition, it provides offline mode of operation, navigation and geolocation mechanisms of increased accuracy, privacy protection for individuals.

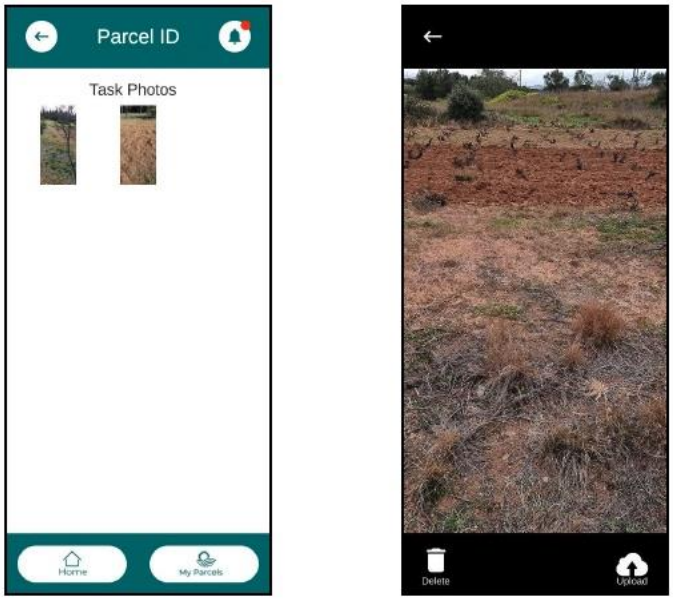

Figure 21. A snapshot of DIONE[17]'s geotagged photo app.

Based on the **MEF4CAP - DIONE session** the following additional outcomes are identified:

In the framework of DIONE project, a soil quality spectral sensor has been developed. The final user can be anyone but realistically this solution is addressed to agronomists, Paying Agencies and possibly clusters of farmers or farmers' organisations. This sensor is a small device that connects via Bluetooth to any smartphone. The device is placed on top of the soil and its function is to take snapshots. It records the spectral signature of the soil and based on these signatures, machine learning models can estimate with high accuracy some of the physico-chemical properties such as soil organic carbon, sand silt and clay, nitrogen content as well as calcium carbonate.

Accuracy, though, also depends on the completeness of the dataset since the machine learning model works better if it is feeded with lots of data. Although they already have a database with spectral signatures, their aim is to expand it in order to achieve better accuracy in results. The described solution is able to produce fertilisation advice and its basic concept is to replace as much as possible the laboratory analyses which are time consuming and costly.

The core of the system is based on Sen4Cap project and it is run on a DIAS platform but the project aims to build on top of the Sen4Cap results and will try to improve the resolution maps for Sentinel-2 in order to derive even better results. Soil texture maps can also be produced with a reasonable good level of accuracy even if the soil quality spectral sensor is not used since legacy data can be exploited (from past soil data analyses).

Another solution that is being developed in the framework of DIONE project is the geo-tagged photos application. It is a specific platform where members of the Paying Agencies can log in. They select a specific point on the map to direct the farmer and the application then alerts the farmer that he needs to perform this action. The farmer navigates to that spot where he needs to take a photo (geo-tagged) and sends it back to the database. Then, the Paying Agency is informed accordingly that the picture has been captured at that specific spot. It is an application that is integrated in terms of the software on the APIs and is standalone. It has already been tested in real environment during August 2021 in the areas of Cyprus and Lithuania and results are under evaluation.

Both MEF4CAP and DIONE projects are elaborating on the evolution of the CAP green framework and aim to find flexible mechanisms in order to enable successful monitoring and compliance checks. DIONE project provides both mechanisms for EO and in-situ based monitoring of information that are related with CAP indicators. DIONE is considered as highly related with MEF4CAP objectives and the collaboration between both projects will be further established with the exchange of insights, results as well as deliverables in forthcoming meetings.

4.7 H2020 NIVA project

The overall objective of the innovation action entitled “New IACS Vision in Action” (NIVA) (https://www.niva4cap.eu/) is to modernise IACS by making efficient use of digital solutions and e-tools, by creating reliable methodologies and harmonised data sets for monitoring agricultural performance while reducing administrative burden for farmers, Paying Agencies and other stakeholders. The project started on June 2019 and it is expected to finish on May 2022 (likely to be extended for 6 months). As it is obvious NIVA project is highly related with MEF4CAP objectives and it has already delivered results on various domains on ICT developments for agriculture. Various MEF4CAP partners (WUR, NP, ITACyL) participate in the NIVA project, thus no collaboration call was needed to be established. Results and insights from the NIVA project are directly transferred through these partners.

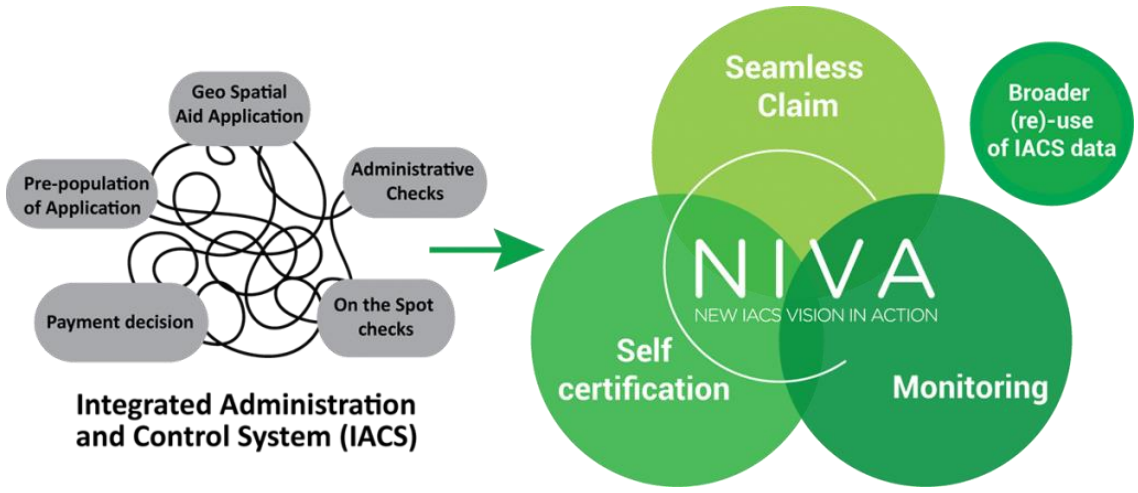

Figure 22. A schematic representation of the IACS as it is now (left) and what is expected to change (simplify) by the newly introduced monitoring approach (right)[19]

NIVA project mainly aims on introducing innovative and digitised solutions for PAs and the handling of subsidies. However, given that PAs and IACS are currently one of the main data sources for monitoring CAP indicators, the same innovative mechanisms are considered of high importance also for the MEF4CAP project and the related developments in ICT. To this end and for the needs of this deliverable, the most related with MEF4CAP and mature outcomes of the NIVA project are reported hereafter.

Key technical outcomes:

According to NIVA project two main categories of information sources (systems) are of key interest for the monitoring and evaluation of the future: Earth Observation data sources and digital solutions deployed and utilised on farm level (e.g. Farm Management Information Systems (FMIS)). On the same time both systems are still raising lots of difficulties towards their integration with existing IACS of the Paying Agencies. In NIVA's "D3.5 Recommendations for standardised connections between IACS and other applications"[20] thorough analysis is presented on how PAs (through their IACS) can benefit from integrating EO data products and data from FMIS. As it is stated, D3.5 aims to provide at least some common basic knowledge, enabling interested entities to be aware of the available data and of the potential exchange solution options with their advantages and drawbacks. Access to big volumes of EO data and derived products for the needs of IACS is still considered as a very complex topic while potential exchange of data between IACS and FMIS is even less researched and analysed.

Use of EO for monitoring

With regards to the utilisation of EO, the following main categories of data sources are identified:

- Sentinel-2 is a constellation with two twin satellites that acquire optical imagery at a spatial resolution of 10, 20 and 60 m. The average revisit frequency of the combined

[19] https://www.niva4cap.eu/project/
[20] https://www.niva4cap.eu/wp-content/uploads/2021/09/D3.5Recommendations-for-standardised-connections-between-IACS-and-other-applications_v1.0.pdf

constellation is 5 days. Sentinel 2 images are the best candidates for EO monitoring because they are optical images (easy for interpretation) with rich semantics, relatively good spatial resolution (up to 10 m) and because they are open data (freely available). In theory, they have a good revisit frequency however in practice there may be clouds in the sky making the images non exploitable. The cloud issue depends on geographic location; in Europe, clouds are generally more frequent in northern and central EU Member States or in mountainous areas. More detailed information about S2 may be found on: https://sentinel.esa.int/documents/247904/685211/Sentinel-2_User_Handbook.

- Sentinel-1 radar mission comprises of a constellation of two polar-orbiting satellites operating day and night and acquiring imagery regardless of the weather with a spatial resolution up to 5 and revisit frequency of 6 days. Sentinel-1 is performing Synthetic Aperture Radar (SAR) which means that the sensor emits its own energy, in the form of a signal (in a given band - interval of frequencies) and then records the amount of that energy reflected back (reflected backscatter) after interacting with the Earth. Radar can penetrate clouds and because of this, these data provide an advantage over optical/ imagery. Radar signatures require a lot pre-processing before they can be used as input for crop classification or any other EO monitoring process. The pre-processing consumes both data storage and computation power.

- NASAs Landsat-8 satellite sensor is an American Earth observation satellite developed by NASA and the U.S. Geological Survey (USGS). The spatial resolution is of 15m, 30m, and 100m depending on the type of captured image. Its revisit cycle (temporal resolution) is 16 days and the data is freely available. Landsat data is considered of high quality and very stable products as the Landsat satellite program is the longest continuous Earth imaging program in history. Since 1972, Landsat satellites have collected huge amounts of consistent spectral imagery.

- HHR-VHR imagery. In the NIVA context, HHR (High High Resolution) applies to ground pixel size less than 5 m and equal to or more than 1 m whereas VHR (Very High Resolution) applies to ground pixel size less than 1 m. These high-resolution images are available by commercial providers. These are usually tasked imagery, taking an image over a given area of interest on a specific day. HHR and VHR imagery are already by some Paying Agencies in EU. The images are provided to PAs by the European Commission during the Control with Remote sensing (CwRS) Campaign for specific acquisition windows for each agricultural control zone. That relates to the yearly CAP image acquisition work programme where each Member State requests the EU to obtain the satellite imagery for the controls via JRC. These images are traditionally used for the on the spot checks (OTSC) controls for Basic Payment Scheme / Single Area Basic Payment Scheme and crop diversification. This usually applies to a sample of around 5% of farmers to verify farmers' declarations and adherence to eligibility rules. Within the "New Area Monitoring System" some countries (e.g. Malta) use some HHR imagery for checking the small parcels as the spatial resolution Sentinel is not sufficient for concluding on the eligibility status (insufficient number of pixels falling entirely within the field boundaries). Use of VHR or HHR imagery might also be used for validation on sample areas as providing an independent source of data.

Regarding the definition of small parcels, NIVA's survey showed that the definition varies for each country (and PA) as the size of small fields ranges from 0.1-1ha. Also, it was reported that the polygon's (parcel) shape plays a significant role in characterising inconclusive small parcels. For example, various elongated, irregular or concave polygons may not be possible to be monitored based on EO due to their particular shape, even though they may extend a certain parcel size. As it is already stated, for tackling the small parcel issues, most PAs consider acquiring higher resolution satellite imagery from commercial providers (e.g., Planet, SPOT-6/7, and Worldview). Finally, it is stated that the issue of small parcels that can't be monitored using Sentinel data may be mitigated by applying the JRC guidelines that recommend to aggregate adjacent parcels with same declared crop or practice under FOI (Feature of Interest).

Two additional interesting points indicated by NIVA on the use of EO data for monitoring are the following:

a) EO monitoring is generally not using single date satellite images but temporal profiles and time series of observations for the same parcel.

b) Use of existing tools and specialised platforms for processing EO data. Downloading and processing raw images from the official ESA's Copernicus Open Access Hub repository (e.g. https://scihub.copernicus) is not an efficient approach as there are many restrictions (e.g. time-consuming process, requires large volumes of storage and processing power, no direct access to images that are older than 1 year). Proposed alternative solutions are to use of national portals that are providing Sentinel images (at least) on the national territory, usually working as mirrors of the ESA Hub, that may also provide pre-processed Sentinel images or additional satellite images of higher resolution. The other approach is the use of "Copernicus Data and Information Access Service[21]" (DIAS) that provide a centralised access to Copernicus data and information (including Sentinel images), as well as to processing tools.

More interesting results are expected to be extracted after the conclusion of various use cases that are still under development.

Farm Management Information Systems for monitoring

NIVA makes an evaluation on the use of FMISs as potential sources of ground truth evidence in the scope of new CAP monitoring. NIVA adapts the following definition for FMIS: "a planned system for the collecting, processing, storing and disseminating of data in the form of information needed to carry out the operations functions of the farm". The following indicative information items are usually handled by FMISs but also of interest for CAP monitoring:

- Information on agricultural land use: The parcel's area (e.g. in hectares) and location (e.g. polygon coordinates) is among the core information entities that are useful for IACS.
- Agricultural Inputs: The type, amount and time of applied inputs (e.g. pesticides, fertilisers, irrigation) at a parcel is among the most significant information items for IACS; it is expected to be required data for the CAP post-2020.

[21] https://www.copernicus.eu/en/access-data/dias

- Crop type and yield: The actual type of crop cultivated for a specific time period and the harvested yield is of interest by IACS.
- Applied agricultural practices – Planting, Harvesting, Mowing, Ploughing, etc.: This category includes the type of applied practice and the respective time period that are applied. The use of machinery data is also included within this category.
- Organic cultivation practices: This information item refers to whether a cultivation is treated with a manner approved for organic agricultural products or not.
- Livestock - Herd management: Total number of animals, type of animals, annual births/deaths, medicines utilised, animal feed utilised, etc.
- Livestock Pasture management: Conditions of pastures.
- Financial Inputs/Outputs: This refers to financial related information items (cost, amounts, etc.) related with purchased agricultural products (fuels, chemicals, seeds, equipment etc.) and their respective consumption/use. Also the potential income from selling the production is of interest.

Given that IACS act as a centralised repository of agricultural data NIVA also identifies datasets and information items that can be mediated by IACS to farmers (through their FMIS):

- IACS through the Land Parcel Identification System can provide to FMIS data on parcels geometries and unique identifiers through user friendly means of rendering.
- Information on registered animals in the context of livestock management.
- Aggregates on pesticides/fertilisers use for the area that the parcel is located.
- Pest infestation early warnings for the area that the parcel is located along with recommendations for pest management related actions.
- Carbon footprint performance for the area that the parcel is located.
- Soil quality and soil erosion for the area that the parcel is located.
- Other agricultural statistics (e.g. harvested yields, harvest dates, crop types) for the area that the parcel is located.)

More interesting results are expected to be extracted after the finalisation of NIVA's use cases that are still under development.

NIVA project can be considered as one of the projects that aim to address the needs of future CAP monitoring in a holistic way. NIVA aims to evaluate current challenges and potential solutions for agricultural data sharing through semantic, syntactic and organisational interoperability mechanisms. On the same time develops a set of CAP monitoring tools that exploit both EO data products and in-situ sources (e.g. geotagged photo apps, integration from machinery and FMIS). These tools are currently under evaluation by PAs of multiple Member States of EU. NIVA project is currently in its final year of execution, so the outcomes of the various activities are continuously published. MEF4CAP plans to closely monitor and evaluate these outcomes.

5. Conclusions

This deliverable provides a detailed overview of the established liaison connections of MEF4CAP project with the most prominent EU projects focusing on ICT solutions and methodologies in the agri-food domain. All liaison activities' key outcomes are presented in order to assess the more advanced technological approaches that are under research and development. The final list of projects and initiatives that collaboration channel have been established is the following:

- H2020 DEMETER project
- H2020 ENVISION project
- FaST project
- Open IACS project
- H2020 MIND STEP project
- H2020 DIONE project
- H2020 NIVA project

The conducted analysis of the current results for each project is based on two main sources:

a) Review of already published results. The main sources of information are published deliverables, information available at project's website, and presentations (slides) available from various public events.

b) Analysis of the meeting minutes recorded during the sessions (on-line meetings) organised with the MEF4CAP project.

Within this deliverable and for each project a short summary of outcomes is provided, including also the relevance of the project's objectives with the MEF4CAP, the project's direct or indirect relation with CAP monitoring and evaluation, and the potential for future collaboration activities.

In the analysis conducted in D2.1 "Landscape of agri-food ICT technologies within EU" the following categories of technologies and ICT solutions have been identified as relevant and with a potential to have a significant role in future CAP monitoring:

- Telecommunication technologies
- Field sensors
- Farm Management Information Systems
- Agricultural machinery
- Satellite based Earth Observation & Remote sensing services
- Livestock management technologies
- Pasture management technologies
- Platforms for financial information exchange
- Agricultural data models and data sharing strategies

In table 2 a mapping is presented between the MEF4CAP's technological areas of interests and the potential of contribution by the conducted projects.

Table 2. Technological opportunities

Initiative name	Technological opportunities of interest	Further Synergies
DEMETER	Telecom technologies, Field sensors, Farm Management Information systems, Agricultural machinery, Agricultural data models and data sharing strategies	MEF4CAP will further analyse DEMETER's outcomes on data and system interoperability for digital agriculture solutions. MEF4CAP will monitor outcomes from DEMETER's individual use cases/pilots especially those that are related with automated recording of agricultural practices.
ENVISION	Satellite based Earth Observation & Remote sensing services, Pasture management technologies	ENVISION is considered by MEF4CAP as one of the most related projects with regards to future CAP monitoring. Most of the ENVISION's specified solutions are still under development. Follow up collaboration actions will be realised the following months in order to collect and evaluate the respective outcomes.
FaST	Satellite based Earth Observation & Remote sensing services, Farm Management Information Systems,	FaST is considered as highly related with MEF4CAP's objectives. FaST tool is already in use in a number of countries, however there are still no clear outcomes with regards to farmer's adoption and that not all the designed features are yet implemented and tested. MEF4CAP will proceed with follow up collaboration actions in order to collect more outcomes on this project.
Open IACS	Agricultural data models and data sharing strategies	Open IACS aims to offer next generation services focusing especially on data interoperability for national/regional Paying Agencies in EU. Available documentation on Open-IACS objectives and current outcomes are limited and this fact doesn't allow the direct monitoring of project's results. Additional collaboration and results exchange actions will be realized.
MIND STEP	Platforms for financial information exchange, Agricultural data models and data sharing strategies	MIND STEP aims to develop a highly modular and customisable Decision Making models aiming to better analyse impacts of policies (CAP). MIND STEP integrates various data sources and develops and applies methodologies to merge economic and biophysical data sets of spatial and temporal resolution. MEF4CAP will continue the collaboration activities with MIND-STEP aiming to get more insights on the integration of - CAP related-economics data sources and on how to achieve an advanced exploitation of information sources like FADN.

DIONE	Satellite based Earth Observation & Remote sensing services, Field sensors	Both MEF4CAP and DIONE projects are focusing on the evolution of the CAP and aim to find flexible mechanisms in order to enable successful monitoring and compliance checks. DIONE elaborates on mechanisms for EO and in-situ based monitoring. Collaboration with DIONE will continue in order to get more detailed evaluation results on the tested technologies – especially the MEMS soil quality monitoring sensor and the geo-tagged photos app.
NIVA	Satellite based Earth Observation & Remote sensing services, Field sensors, Farm Management Information systems, Agricultural machinery, Pasture management technologies, Agricultural data models and data sharing strategies,	NIVA project addresses the needs of future CAP monitoring in a holistic way. The monitoring tools and methodologies that have been developed and currently are under evaluation in NIVA are of high importance and directly related with MEF4CAP. MEF4CAP plans to closely monitor and evaluate these outcomes and to ogranise follow up meetings with NIVA representatives.

References

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Navarro, A., Silva I., Catalao J., Falcao J. (2021). An operational Sentinel-2 based monitoring system for the management and control of direct aids to the farmers in the context of the Common Agricultural Policy (CAP): A case study in mainland Portugal. International Journal of Applied Earth Observations and Geoinformation. Vol. 103. Retrieved from https://doi.org/10.1016/j.jag.2021.102469

Annex

Annex A – Invitation letter for collaboration

"Dear _____ project representatives,

The purpose of this email is to declare the parties' shared willingness to initiate collaboration among Innovation Action "_____" and Coordination and Support Action (CSA) "MEF4CAP-Monitoring and Evaluation Frameworks for the Common Agricultural Policy (101000662)".

MEF4CAP (https://www.mef4cap.eu/), which is funded under the topic "FNR-02-2020: Developing long-term monitoring and evaluation frameworks for the Common Agricultural Policy", focuses on the development of methods and performance indicators for the effective Monitoring and Evaluation (M&E) of the policies applied in the context of the future Common Agricultural Policy (CAP).

The MEF4CAP project is designed to draw on the insights and perspectives of all relevant stakeholders to identify best practices, ensure the inclusion of all relevant developments and to discuss the potential of widening their application.

Based on collected information, MEF4CAP will identify future pathways through which the novel policy data needs can be addressed, using different technological and methodological approaches. MEF4CAP will make an inventory of future data needs for M&E, describe the current developments in ICT and data capturing techniques and assess the technological readiness of these solutions. Finally, the project will deliver a roadmap for future monitoring, where the needs of different stakeholders are met, and the potential of different approaches is fully and optimally exploited.

In the context of the requested cooperation among the two initiatives we invite to share with us the related outcomes e.g. deliverables, demonstration actions, workshops. On behalf of MEF4CAP we are also declare our willingness to proceed with the organisation of joint initiatives.

In addition, the following actions will be required by your side:

a) Provide your experts opinion by replying on a set of questions that will be send to you by MEF4CAP

b) If necessary, to participate in at least one conference call with MEF4CAP representatives in order to further elaborate on yours organisation/project recent outcomes on the topics of interest for the MEF4CAP project.

To better facilitate the liaison among the two projects, please indicate a person (name and email) that will act as contact point.

Looking forward for your reply,

(MEF4CAP representative) "

