D6.2 MARKET OUTLOOK ANALYSIS

Project: Monitoring of Environmental Practices for Sustainable Agriculture Supported by Earth Observation

Acronym: ENVISION

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 869366.

Document Information

Grant Agreement Number	869366	**Acronym**		ENVISION
Full Title	Monitoring of Environmental Practices for Sustainable Agriculture Supported by Earth Observation			
Start Date	1st September 2020	**Duration**		36 months
Project URL	https://envision-h2020.eu/			
Deliverable	D6.2 MARKET OUTLOOK ANALYSIS			
Work Package	WP6 – Commercialisation and exploitation			
Date of Delivery	**Contractual**	M12	**Actual**	M12
Nature	Report	**Dissemination Level**		Public
Lead Beneficiary	ETAM			
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Document History

Version	Issue Date	Stage	Description	Contributor
D0.1	26/7/2021	Draft	Outline with Guidelines, Sources identification and filtering	ETAM
D0.2	6/8/2021	Draft	Status and trends – Market analysis, Project Context, Competition analysis (1st version)	ETAM
D0.3	11/8/2021	Draft	Competition analysis	ETAM
D0.4	23/8/2021	Complete	PESTLE, Tech environment, Review comments	ETAM
D0.5	30/8/2021	Review	Review comments by	INOSENS
D1.0	31/8/2021	Final	Final integration of comments, References	ETAM

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GLOSSARY

AECM - Agri-environment-climate measure
AMS – Area Monitoring System
ANN – Artificial Neural Network
CAP – Common Agriculture Policy
CBs – Certification Bodies
CbM – Checks by Monitoring
DIAS - Data and Information Access Services
DoA – Description of Action
EO – Earth Observation
ESA – European Space Agency
GEOSS - Global Earth Observation System of Systems
GhG or **GHG** – Greenhouse Gas
GNSS – Global Navigation Satellite Systems
IACS – Integrated Administration and Control System
LAI – Leaf Area Index
LPIS – Land Parcel Information System
OSTC – On the spot checks
PAs – Payment Agencies

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PMEF - Performance Monitoring and Evaluation Framework
RDP – Rural Development Program
SOC – Soil Organic Carbon
SWOT - Strengths-Weaknesses-Opportunities-Threats

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1 Introduction

1.1 Purpose of the document

The purpose of the document is to present the status of the market that ENVISION is targeting in terms of the legal environment and technical conditions that affect. It also captures major direct and indirect competition that is already positioned in the market either already active or as a potential player.

By highlighting the forces and conditions in the market, ENVISION will be aware of the driving elements to consider and the differentiation features to target.

1.2 Structure of the document

The first sections (Section 2) of the document are mentioning the exploitable outputs of the project. This is to emphasize on the initial ENVISION objectives and the envisaged positioning of the project in respect to the market needs by *t0* after the end of the project and the delivery of its pilots.

The market addressed is then described (Section 3); though it is a known market, current status and trends are being highlighted. The market features driving forces which accelerate take up of similar products and services by farmers and authorities. Moreover, these trends have already triggered the creation of significant moves by academia and industry, which formulate a competitive field with many remarkable achievements and references worldwide. Competitive actions, either products, companies or projects are enumerated and analysed (Section 4).

Trends and challenges are triggered by international alarms related to food sustainability, environment healthiness, climate change effects which are getting on the top of the planet agenda. Technologies and legislation are finally described, focusing on earth observation, high performance computing and 5G connectivity and b. Common Agriculture Policy (CAP) along with national laws. Section 4 ends up with a Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis and PESTLE overview (P for Political, E for Economic, S for Social, T for Technological, L for Legal, and E for Environmental).

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2 About ENVISION

This section replicates information described in the ENVISION Description of Action (DoA) document in order to describe the way that ENVISION is positioned in the market;

- what are its targets in terms of products and market segments
- to what level it will bring the final results
- in which specific agriculture practices will focus

This will drive also the focus of the market outlook analysis in order to filter in the most relevant information in terms of parallel market facts, achievements, projects, trends that are framing the work and so on.

2.1 ENVISION objectives

The overall objective of ENVISION is to develop a robust and cost-efficient system fulfilling the need for continuous and systematic monitoring of agricultural land, shifting the focus from fragmented monitoring limited to specific fields and dates to territory-wide and all-year-round monitoring. Thus, ENVISION fully exploits the wealth of data made available through GEOSS, Copernicus and DIAS and its synergetic use with other data to develop data products such as: Cultivated crop type maps; Soil Organic Carbon (SOC); Distinction of organic – conventional farming; Grassland mowing/ ploughing; Soil erosion.

It makes use of heterogeneous types of available data (EO-based, in situ, open data, and historical on-field check data) and state-of-the-art technologies and methodologies (automatic pixel/texture/object-oriented change detection and classification methods, machine learning, data fusion, multi-source and multi-temporal data management) for providing a fully-automated and scalable toolbox of services, built in close interaction with its future customers.

Figure 1: Project logo

These customers are mainly the nominated Paying Agencies and Certification Bodies; however, farmers and developer entities are also having a significant role, even as potential customers and users of ENVISION services.

The project-specific objectives include:

- **Capturing the market needs; to get an insight into payment agencies (PAs) and certification bodies (CBs) need for adapting to new policy requirements.** ENVISION is developing a toolbox of services responding to the need of its potential customers for the continuous and systematic monitoring of sustainable agricultural practices. To achieve this, ENVISION is driven by inherently customer-centric processes; collaboration with future customers, who participate as co-innovators and co-designers from the early stages of the project up until its conclusion, is safeguarding the demand-driven design of the project services and their value proposition, while at the same time paving the way for their market acceptance and uptake beyond the

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project. Other key target customers of ENVISION will be involved in the project through a board of Lighthouse Customers

- **Explore rich datasets available; Harness the full potential of Copernicus and GEOSS EO data, as well as other sources of data and technologies,** to develop operational services for the continuous and systematic monitoring of agricultural practices related to the environment. ENVISION fully exploits the wealth of data made available through GEOSS and Copernicus and its synergetic use with other data (in situ, citizen-provided, open data, and historical on-field check data) to develop data products such as: Cultivated crop type maps; Soil Organic Carbon; Vegetation status; Crop growth (distinction of organic – conventional farming); Grassland mowing/ploughing; Soil erosion. Through fully-automatic algorithms, empowered by object-based impact analysis, thematic maps will be developed, identifying the potential presence of unsustainable agricultural practices, not conforming to the requirements set by PAs and CBs, and resulting in environmental degradation in terms of water pollution, soil degradation, biodiversity loss, landscape degradation, and GHG emissions. By leveraging the power of the aforementioned technologies and data, ENVISION intends to provide a toolbox of services for the regular and systematic remote observation, tracking and assessment of the fulfilment of environmentally-friendly agricultural practices. The monitoring process will use a highly-automated procedure to identify whether a declared agricultural parcel complies with the eligibility conditions related to an agricultural activity or a crop type, and provide information on potential cases of non-compliance through a web-based platform. Besides monitoring itself (which is a corrective action), ENVISION aims to offer complementary tools that customers can use for assisting farmers to fulfil their obligations (preventive action). In particular, PAs and CBs will be able to offer information to farmers (through a mobile app) for detected inconsistencies in their declaration, provide alerts for actions they are required to accomplish, and provide to farmers the ability to send confirmation or evidence for actions they have taken

- **Prove the commercial and market value of the ENVISION products and services.** In the duration of this project, the added value of the proposed new services, compared to existing products and services, will be demonstrated and gaps of relevant existing services provided by competitors will be effectively filled. Work ranges from market and business model analysis and experimentation to commercial contractual relationship with key target customers in business cases

- **Promote the development of new markets of products and services.** ENVISION will encourage the development of new markets of EO-enabled products and services (i.e. environmental assurance services) by allowing third-party commercial actors to develop their own add-on applications and services, extending the functionality of ENVISION through an Add-on Development Tool. A showcase of Add-on applications will be developed, to demonstrate the potential of ENVISION and attract developers.

- **Address farmers' needs in relation to achieving a performance in accordance to EU agri-environmental rules.** ENVISION approach allows governance to shift from one-way service delivery to a more collaborative, codesigned, and co-created model. Farmers will be involved in the monitoring process by: 1) receiving warning messages from PAs and CBs about tasks that need to be completed before a specific deadline and acting on them, 2) being informed by PAs and CBs about inconsistences during the controls and overcoming them, 3) sending confirmation that they performed their work correctly (by providing evidence such as geo-tagged photos, a scan of seeds' labels to inform about a requested crop mixture, etc.). Consequently, farmers will benefit from early notification of upcoming deadlines and potential

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breaches of rules, in order to ameliorate their performance, and will contribute to rendering the monitoring process a more effective and transparent one, thus minimizing the administrative burdens and on-farm inspections they undergo.

For each project specific objective, a wide set of measurable indicators are set, in order to assess the final outcome of ENVISION work.

Obviously, ENVISION aims to become a powerful, expandable Area Monitoring System interfacing and facilitating communication, data and transaction exchange between farmers, PAs and CBs within their common work to deploy, consult, approve and certify a wide set of new agriculture practices.

2.2 Exploitable Results

The technologies being employed during ENVISION project on remotely sensed and other data and the development tasks of the project will lead to the delivery of the final data products and services – they are described in a concrete way in ENVISION deliverable D4.1 Architecture and Services Specification report. Each service is contributing to specific environmental impacts as described in the list below. These data products include:

I. Cultivated crop type maps - This service will deliver a number of EO derived products for cultivated crop type maps consisting of:

- Crop type maps
- Crop compliance with Greening-1 rule
- Alert mechanism for smart sampling

The service will make multiple classification of the crops throughout the year to ensure the confidence of the classification process. To ensure high accuracy, the system will utilize both Sentinel-1 and Sentinel-2 data. The provider of the service is NOA, whereas the results of the service will be provided either via a RESTful API or as shape files.

The Cultivated Crop Type Maps (CCTM) 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.

The provided service addresses to**I. 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

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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.

This product addresses the following environmental impacts:

- *Soil degradation* – cultivated crop types characterize the effect of the cropping and management practices on erosion rates
- *Biodiversity loss* – cultivated crop type maps directly address relevant CAP measure (Greening 1)
- *Crop Diversification.* This enhances an area's biodiversity and may improve soil organic matter;
- *Landscape degradation* – monitoring the conversion of forests and grassland through change detection on multi-year cultivated crop type maps;
- *GHG emissions* – by monitoring the grassland to arable land ratio GHG emissions can be estimated (Greening 2).

II. Data Fusion – This service will provide a fully-automated Machine Learning module, aiming to assist in the enrichment of the Sentinel feature space for the rest of ENVISION services providing full time series of observations (no gaps due to clouds). The main goal of this service is to tackle the problem of cloudy observations of Sentinel-2 images, taking into consideration information coming from Sentinel-1 and the rest of cloudless Sentinel-2 cases. Given that, the rest of the services will be able to provide results of higher accuracy and performance, since more complete and dense measurements of the respective indicators and vegetation indices will be at their disposal. The provider of the Data Fusion Service (DFS) is NOA.

The Data Fusion (DFS) workflow combines Sentinel-1 and Sentinel-2 data in order to "increase" the number of cloud-free observations. Optical sensors are sensitive to clouds resulting in gaps in the time series. As the complete time series is crucial for crop monitoring, data fusion comes as a solution to this problem. Sentinel-1 data are weather independent and not affected by clouds, therefore they can assist in predicting the Sentinel-2 values in the case of cloud obstructions.

The combination of both Sentinel-1 and Sentinel-2 using Deep Neural Networks (DNN) or other common Machine Learning (ML) algorithms will generate cloud-free time series ready to be ingested in the data cube and used as input to machine learning and/or other processes or be directly visualized. The cloud free products will enhance not only the size of the feature space but also the discrimination among the crop types.

The service will provide complete Sentinel-2 images (no gaps) for certain Optical Bands and Vegetation Indices such as NDVI, NDWI, etc. (which bands and indices TBC), acting as a assistive interpolation routine in order to fill and replace the respective rasters where cloudy image pixels have been detected and masked out.

The service is provided as a backend module, easy to be exploited by other modules on top of DataCube.

III. Sentinel Data Preprocess – This micro-service aims at the generation of spectral, spatial and temporal features of Synthetic-aperture radar (SAR) data derived from Sentinel-1 (S1) satellites. The provider of the Preprocess Service is National Observatory of Athens (NOA).

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S1 preprocess workflow consists of a series of steps in order to make standard corrections to the initial S1 Ground Range Detected (GRD) data. These steps include, among others, radiometric calibration, terrain correction and noise removal. Moreover, this micro-service gives the potential for spatial adjustment of S1 data to Sentinel-2 (S2) data grids so to enhance the data fusion techniques. Finally, it provides also coherence images calculated from 6-day Sentinel-1 image pairs and in specific S1 Single Look Complex (SLC) products.

The service is provided as a backend module, easy to be exploited by other modules of a potential AMS.

IV. Analytics on Vegetation and Soil Index Time Series – The Analytics on Vegetation and Soil Index Time-series (AVSIT) is an Earth Observation (EO) monitoring module that exploits satellite data along with the usage of Machine Learning algorithms on top of Datacube platform in order to provide into users' realistic indications related to the field activities and the control of cross-compliance policies. More specifically, this module will take advantage of numerous potentials of Datacube introducing an innovative Big Data framework in the field of CAP monitoring from Paying Agencies (PAs).

Initial assessment and visualizations from the derived satellite signals can be performed in order to check the degree of compliance of agricultural parcels and the advisable cultivations periods of the respective Catch crops and Nitrogen Fixing crops, as well as the maintenance of no crops bare lands or spontaneous cultivated areas for the production of green manure such as black and green fallows respectively. Monitoring of activity in the above cases is considered as a necessity from the perspective of GAEC 4 and similar soil-erosion regulations, reinforcing EFA practices. Furthermore, CAP Cross Compliance conditions such SMR 1 and GAEC 1 are tackled by the proposal of a risk assessment for water pollution in the Nitrate Vulnerable Zones (NVZs). The risk assessment employs RUSLE products and the proximity to surface waters. The SAVI index is used for the identification of parcels with high soil coverage, providing a monitoring solution to the GAEC 4 conditions. Finally, Burnt Scar Mapping algorithms are developed to fit the ENVISION needs and specifically answer the GAEC 6 requirement. Last but not least, detection of activity inside Natura2000 regions will be a critical challenge remained to be solved since Sentinels spatial resolution as well as the scarcity of such events as ground truth poses significant deterrents on that venture.
This micro-service combines Sentinel-1 and fused Sentinel-2 data so to generate vegetation and soil indices at national scale. At a next level, the service aims to provide geospatial analysis. This analysis comprises of charts, statistics and data visualizations for understanding complex relationships, finding trends and reveal changes throughout the time. Moreover, it can help on predicting what is going to happen next by pattern recognition.

The service will provide:

- A general monitoring and visualization tool of parcels vegetation status.
- Identification of illegal clearing in Natura2000 zones
- Indications of main events such as Harvest of Main Crops, onset of catch crops
- Depiction of allowable periods for EFA practices application.
- Provision of the respective confidence levels regarding CAP rules conformity.

The provided services address to different user segments:

1. 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 visualizations of the service will give them a clearer picture of the current farmers' activity. In parallel, the provision of the respective

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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.

2. 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.

V. Identification of Organic Farming Practices

This service will 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. To ensure high temporal coverage of the data, the system will utilize data from different spaceborne remote sensors, namely the Sentinel-2 and Sentinel-1 missions.

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).

Environmental impacts that can be addressed:

- *Water & Soil pollution*– unauthorized use of fertilizer will be detected

VI. 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. The service will contribute into the direct supervision of the Paying Agencies (PAs) 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 organize and realize 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.

This service will take advantage of EO derived indicators of agriculture monitoring, assisting to track the aforementioned grassland events. These indicators will be constructed using the available Sentinel-1 and Sentinel-2 images. The provider of the Grassland Mowing Events Detection (GMED) service is NOA, whereas the results of the service will be provided either via a RESTful API or as shapefiles.

The Grassland Mowing Events Detection micro-service is an Earth Observation (EO) change detection module that exploits satellite data along with the usage of Decision Trees enhanced with Machine Learning (ML) and Artificial Neural Networks (ANN) algorithms. Based on the reproduction (partially or entirely) and enhancement of other similar projects’ routines (e.g. SEN4CAP[1]) pipelines, the main scope is to efficiently monitor grassland activity and precisely track the key dates of those cultivation

[1] Sen4CAP (Sentinels for Common Agriculture Policy) is a project that has been setup by ESA in direct collaboration and on request from DG-Agri**,** DG-Grow and DG-JRC. The project aims at providing to the European and national stakeholders of the CAP validated algorithms, products, workflows and best practices for agriculture monitoring relevant for the management of the CAP (http://esa-sen4cap.org/)

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events taking place. More specifically, it combines Sentinel-1 data (VV, VH and VV-VH ratio backscatter polarization coefficients and VV, VH coherences) and Sentinel-2 (fused if needed) NDVI time series, incorporating texture features such as homogeneity, entropy, contrast and dissimilarity (if needed), along with FAPAR, fCover and LAI indices and potentially VHR data (if needed), as provided by the PAs.

The product will be updated with every new image acquisition. Continuous change detection products will issue alerts for the detection of a cultivation event, such as mowing, and if it is possible discriminate those from grazing activity. Finally, the grassland events detection product will be provided dynamically accompanied with the respective confidence level, delivering updated versions to the user with every new acquisitions. The grassland mowing detection processing chain will be built on top of the Data Cube, allowing for its large scale and timely application.

Finally, this information can be used from the PAs and in parallel with the grassland regulations provided into the system encapsulating the maximum number of possible events and the exact period these can take place, this service will export an estimation regarding the compliancy from the farmers.

This service will provide Grassland Events Maps via a shapefile which will be exported in order to be transferred via FTP or HTTP in an automated way.

The provided service addresses to different user segments:

1. 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.
2. 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 analyze the potential of grassland maintenance.

Environmental impacts that can be addressed:

- *Biodiversity loss* – to maintain the biodiversity of grasslands, management by grazing or mowing is needed.

VII. Soil Organic Carbon monitoring – The Soil Organic Carbon service (from now on SOC micro-service) is part of ENVISION and will deliver several EO-based services able to support the implementation of Flemish SOC business case (Soil Condition) and the provider is EV ILVO. The SOC service will deliver:

- Image tiles present the SOC spatial distribution (WMS)
- Estimated SOC mean values per agricultural parcel as those exist in LPIS systems. The agricultural parcels will behave as existing geometry objects and will be selected by the end-users.
- Estimated SOC mean values per area of interest (AOI). AOI will be created by the end-users and will act as new geometry objects. Estimated SOC mean values per administration boundaries, for example, the Flemish Region, and per crop type. Existing administrative boundaries will be used as input to the micro-service.

Additionally, the SOC micro-service will provide two extra abilities:

- To calculate and return SOC changes for a specific period. Condition for this is the existence of SOC maps that represent the SOC values in the range of the requested period. This function will support the PAs to effective monitoring of the SOC in time, classify and encode the changes

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using CAP implementation policy criteria. The Flemish SOC business use case will be the pilot for the definition of service functions and the first finalization of the implementation criteria. For example, it will be possible for the end-user to request the presentation of the SOC changes for a particular agricultural parcel for the period between 2018 and 2023. SOC microservice return data can be combined with other data, in a way to identify correlations between SOC degradation and other parameters like farm management practices.

- To provide SOC measurement data, coming from in-situ measurements and metadata that describe the applied collection methodology, etc. The incoming SOC data together with the new satellite data streams can be used by the SOC image providers, in this case, EV ILVO and LV, to further evaluate and tuning the SOC model and deliver new SOC images with higher accuracy/quality.

The SOC service aims to:

- Deliver Verified top-soil (0-10 cm) qualitative Soil Organic Carbon estimations,
- Visualize 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

During the project and specific at the Flemish SOC Business case, end-users will have access to the results of the SOC services throughout the web application. The web application will provide the needed functionality to ENVISION customers or better say end-users (like Flemish farmers, or LV or other policymakers) to monitor the SOC conditions (parent or general use case) under the following possible interaction ways :

- Per agricultural parcel
- Per agricultural area or AOI (polygon)
- Per administration boundary (for example the Flemish region) and per crop type.

Depending on the specialized use case needs, the end-user will have the ability to:

- Select the SOC monitoring period, for example, the period 2018-202136 and the period 2022.
- Define on a map with digitization the AOI who wants to monitor.
- Select on a map and/or select from a list the administration boundary who what to monitor.
- Select on a map and/or select from a list which agricultural parcels what to monitor.
- Select for which crop types what to aggregated the SOC results.

After this and by using the UI, the end-user will be able to see the displayed in graph SOC values and changes for each specialized use case, see the SOC values at pixel size in a map for each specialized use case and to upload SOC measurements.

To perform the above functions the UI needs to consume data coming from the SOC service and more specific needs to a) get SOC values, b) get Map tiles and c) post SOC values.

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.

This product addresses the following environmental impacts:

- *Soil degradation* – the quantity of SOC within agricultural soils provide information on tillage, drainage and overall agricultural management practices.

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2.3 Areas of ENVISION pilot cases

The project includes four business cases (pilots) into specific areas. The already defined pilot areas include:

- Monitoring environmental and climate requirements
- Monitoring of soil conditions
- Monitoring organic farming practices

More details for each pilot are given below:

Monitoring multiple environmental and climate requirements of CAP National Paying Agency (NPA) (Lithuania Agricultural Payments Organization (CAPO) - Cyprus Market drivers)

The inspection of Cross Compliance, Greening, and RDP's climate- environmental- requirements, including "Agri-environment and climate", "Organic farming" and "Natura 2000 and water framework directive payments", is currently a challenge to PAs because they consist of many different rules with different inspection dates. These requirements necessitate actions such as the verification of

1. crop types
2. land abandonment,
3. use or not of herbicides, or mechanical weed control

The option to monitor the requirements remotely will reduce control costs for PAs and the administrative burden on farmers, thus ensuring faster and more efficient controls and faster delivery of payments to farmers.

Currently the environmental and climate requirements are controlled by on-farm visits and visual inspections. The large number of different cross compliance requirements and the environmentally friendly agricultural practices requirements under the RDP that have to be checked, coupled with the fact that they need to be inspected on different dates and/or apply to specific farmers significantly hinders the work of PAs. Other PAs use a traditional method of monitoring and inspecting farmers' practices. This method consists of four steps: 1. submission of farmer's electronic application, 2. on-farm checks and some remotely sensed controls (using VHR data that are very costly), 3. administrative controls, 4. submission of documents from farmers when required.

PAs have shown active interest in employing EO technologies for monitoring farmers' performance, as well as other technologies apart from on-farm checks; for example, farmers have the option to provide evidence regarding their activities by using a mobile app, i.e. geotagged photos with captured coordinates, direction, azimuth value, and date stamp. Through this app,

1. farmers can inform PA about performed activities (e.g. grass mowing, grass removal, catch crop seeding, green fallow ploughing), and
2. all users, including citizens, can inform PA about bad farming practices (e.g. grassland areas that are not mowed)
3. PA officers evaluate the data and decide if they will perform on-farm-checks.

Through the ENVISION service, continuous and systematic remote monitoring of all of the abovementioned requirements will take place throughout the year. Moreover, ENVISION will allow PAs to simultaneously monitor different requirements, saving time and resources currently devoted to performing numerous on-farm checks to inspect multiple, different measures. The ENVISION data products that PAs will utilize to monitor farmers' practices include: grassland mowing/ploughing, cultivated crop type map, vegetation status indicator, phenology extraction, and soil erosion index.

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Monitoring the condition of soil (Flemish Paying Agency (LV) - Belgium Market drivers)
Current CAP's 6th GAEC requires the maintenance of soil organic matter level through appropriate agricultural practices. The objectives of the future CAP's GAECs include: maintenance of soil organic matter (GAEC 3), minimum land management reflecting site-specific conditions to limit erosion (GAEC 6), protection of soil in winter (GAEC 7) and preservation of soil potential (GAEC 8). Moreover, voluntary Eco-schemes on soils with different levels of ambition will be defined. In this context, the continuous spatial and temporal monitoring of the SOC content in agricultural soils becomes extremely important. Currently, the state of agricultural soils is checked by performing soil samplings and conducting laboratory examinations. However, these methods do not provide a continuous overview of the state of soils and they require significant effort, time, and resources to be committed. Consequently, these types of controls have to significantly reduced and replaced with a more automated process.

The use of EO-data and services together with ML techniques can increase the spatial cover, accuracy, and efficiency of PA's (Flemish Paying Agency named LV) checks concerning CAP's obligations related to soil management. PA will test the ENVISION service for SOC estimation at the parcel level. It will also provide archive data and data on agricultural parcels from its LPIS system. The envisioned service will be able to deliver information on SOC at the parcel level, per pixel, with high temporal frequency. The SOC information will be used by PA as an input for monitoring farmers' good agricultural performance in relation to current CAP's requirements related to the maintenance of soil organic matter level and the soil organic matter management as well as CAP post-2020. The case will focus on a particular data product of ENVISION for monitoring CAP's soil requirements (soil organic carbon) and the maintenance of soil organic matter level relative to the current and future CAP requirements.

Monitoring organic farming requirements (Organic Certification Body (OCS) – Serbia)
One business case will be implemented in Serbia (OCS) in relation to a CB. This case will demonstrate how the uptake of EO technology can improve the overall monitoring of organic certification requirements such as farmland expansion, biodiversity, GHG emissions, water and soil. The Serbian Organic Certification System (OCS), i.e. the authorized control body that deals with the control and certification of organic products, will be responsible for all activities related to the implementation of the developed EO service, and InoSens (i.e. an Agtech Consultancy Company) will be responsible for the creation of the overall infrastructure and framework of this Business case. It will be assisted by INOS, a Serbian SME with the mission to accelerate the transfer of innovative ICT technologies to the agricultural sector. The ENVISION data products that will be employed during this case are: crop growth monitoring and distinction between organic and conventional farming practices.

2.3.1 Lighthouse Customer cases

Apart from the pilots, the ENVISION aims to attract "Lighthouse" Customers who are not members of the consortium and are participating in ENVISION voluntarily. The related areas of activity will be the effective monitoring of CAP environmental requirements and agricultural certification requirements. They will test specific features of the services at a small scale. They will choose the level and type of their involvement in the project. They will further enhance the results of ENVISION by providing extra intelligence on the users' needs and requirements, and/or by participating in the (small scale) testing and evaluation of ENVISION's services. ENVISION will establish long-term Business Synergies with them, and business partnerships to deliver value to all stakeholders involved (PAs, CBs, farmers, developers, consultancies) through ENVISION.

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3 The Market

From the production of agricultural products at the farm level to the delivery of food, feed, fiber and biofuel to the end-consumers, the agricultural value chain is both complex and diverse. On one hand, it entails *farmers*, traders, food companies and retailers striving to meet global demand in terms of both quantity and quality. On the other hand, key actors in the middle stages of production are aiming to enable and assure conformance and compliance to quality rules:

- *Service Providers* assisting farmers in the uptake of sustainable and profitable farming practices through advice, infrastructure or even through *certification services* that provide assurance for lawful and correct adoption of practices
- *Legislation and policy bodies* that put forward measures and regulation towards sustainable, competitive, and environmentally friendly agricultural activities, and provide funding and support to producers.

Among the means to utilize in this environment, research and technology are having a significant role, including component and machinery manufacturers that provide the means to carry out highly mechanised processes, as well as input companies (fertilisers, seeds, etc.), specialised application developers and device vendors integrating different technologies in a single solution and R&D actors from farming groups to academia and industry. These actors operate at different scales, ranging from individual farmers and high-tech agro-holdings at the farm level to dealers and distributors offering solutions at the regional level, and from nation-wide solution providers and national agencies (e.g. paying agencies, auditing entities) to multinational corporations.

ENVISION focuses primarily to provide its products and services *to those who provide certification services and authoritative agencies that manage funding* according to National and European rules that *farmers* must comply with. This is the target market as it is being described below.

3.1 Target Market

One of the main objectives of the Common Agricultural Policy (CAP) for the period 2021-2027 is to move from the process of controlling the agricultural activity compliance with the requirements to the increase of operational efficiency as well as prevention of irregularities by applying innovative technologies that enable performing the assigned functions in the most efficient way, replacing human and administrative resources by automated processes, creating new and simpler services for farmers. ENVISION is proposing core data products to be utilized within such control and monitor procedures, applied by authorities and certifiers who need to check production on a continuous basis and with full land coverage abilities at parcel level.

For that, monitoring systems are required to put in place, joining satellite observation data (e.g. from Copernicus) with GIS data originating from territorial Land Parcel Identification Systems (LPIS). The fundamental role of these systems is the *Checks by Monitoring (CBM),* which are based on satellite data and photos sent by farmers about the carried out agricultural activities. CBM enables farmers and the public authorities to access data used in the processes of administration and control of the European Union (EU) and national support, thus ensuring overall transparency in decision-making. It allows to use the spatial data for more efficient farm management and, most importantly, for reduction of number of sanctions against farmers who want to follow the rules, since they will be immediately notified of any discrepancies, thus getting time for rectification. Irregularities can be early

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detected so that corrective actions can take place, and checks can be prioritized in order to focus early enough on those who are not keeping compliant to the eco-scheme or other ruleset that needs to be followed. ENVISION data products are core elements supporting CbM in various contexts with high – quality features.

The **Paying Agencies** are also exploring the possibilities to use the CbM data not only as a compliance check tool after the support application is submitted by the farmer, but also as a help tool for farmers to submit more correct applications by providing the suggestions on possible ineligible areas, summer/winter crop/grassland areas and other. This should ensure lower error rates and sanctions, which would be much welcomed by the farmers. Moreover, there is an interest of PAs to provide broader list of services to farmers, for example, estimation of crop yield including the identification of drought, flooded and burnt-out areas. Also, possibilities to provide better fast-track services for farmers are discovered through collaboration with land, forest, water and environment management agencies, insurance companies, advisory and farm management, including precision agriculture, service providers.

In addition to Paying Agencies, who need to perform checks, auditing entities are responsible to certify products and processes, in the various pre-production and post-production stages, to deserve carrying quality labels, mainly related to the level of environment friendliness and healthiness of the product. These are the **Certification Bodies** (CBs)

Their role becomes crucial as the CAP Strategic Plans target to achieve a coverage of 25% in organic land by 2030. CAP budget will be allocated to this target across Member States; every country needs to put effort into place to reach their potential national targets, which should fairly contribute to the EU average 25% target. The entities who have been assigned with the responsibility to monitor farmers' practices, are strongly demanding automation to increase their capacity, assurance based on digital means and remote sensing to achieve reliability and quality, as well as performance to reach intime preventive actions against bad practices and fraud.

Obviously, radical and disruptive reforms will take place in the agriculture industry, within the forthcoming years. In this versatile and demanding environment, the target of ENVISION focuses primarily on the following market composed by,

- *PAs – Payment Agencies and*
- *CBs – Certification Bodies,*

while it can also formulate proposals and offerings to agri-producers, namely the:

- *Farmers – either as individuals or as collective union entities*

Next sections below present some facts and figures for these market segments.

In parallel to addressing directly these markets, ENVISION foresees to build services that can be re-used by other developing entities; ENVISION can become a valuable part of a community ecosystem that works and builds applications that exploit remote sensing and processing applications in order to provide specific solutions addressing special requirements of PAs, CBs and producers.

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3.1.1 Payment Agencies

To ensure that CAP funds are spent appropriately, Member State Authorities have to comply with legal management and control mechanism. Each Member State is responsible for subsidy administration and control, which are carried out by **a National Control and Paying Agency (NCPA or PA).** Paying Agencies (PAs) are the bodies responsible within a Member State for the management and control of CAP expenditure, notably controls, calculation and payment of CAP aid to the beneficiaries and their reporting to the Commission. Part of a PA's work may be done by delegated bodies, but not payments to beneficiaries and their reporting to the Commission.

In order to obtain area-based financial support [direct payments], farmers are required to submit an application to their PA early in the year, where they declare the precise location of all of their agricultural parcels, as well as the crop type. The National Agency is responsible for controlling at least 5% of those declarations and penalizing farmers who submit incorrect information by performing so-called On-The-Spot (OTS) checks. For area-based subsidies, an agricultural parcel must be controlled at two different levels: both the declared crop and area must be correct. EC in turn audits the PAs. When discrepancies between the control result and the reality are found, a Member State is penalised and has to return to the EU part of the subsidies that were distributed to farmers.

The traditional system of aid claims and checks has been a sequential system, whereas checks by monitoring is an interactive system. The traditional ways of performing checks have obvious limitation in terms of coverage, number of checks that can be performed; sampling instead of full coverage is many times the option to follow, which is also a not a good practice that can lead to erroneous results. A strong strategy towards organic production and new, modern eco-schemes that target to accelerate environment friendly and climate push the need towards automated means with full coverage in terms of space and time (continuity).

The complex process of subsidy control requires computational tools: PAs rely on Integrated Administration and Control System (IACS), which includes a Land Parcel Identification System (LPIS). The main functions of those spatial databases are localization, identification and quantification of agricultural land via detailed geospatial data, in order to facilitate the distribution of CAP subsidies.

The checks by monitoring approach can take new information into account at any time during the growing season (such as newly acquired, more recent Sentinel data, geo-tagged photos, or other documents sent by the farmer), and it therefore provides more opportunities for farmers to rectify their claims before they are finalized. Paying agencies can also send warning messages to farmers, giving them the opportunity to take corrective action (e.g. mowing a field). Therefore, the monitoring approach can prevent non-compliance from occurring rather than penalising farmers afterwards.

Under the traditional approach using on-the-spot checks, paying agencies select small samples of farmers to check. If a sample field visit takes place, an inspector checks the parcel area and the crops grown against the information provided by the farmer in the aid claim. LPIS is subject to regular updates and was introduced as a response to findings of the annual on-the-spot inspections of a sample of around five percent of farmers; i.e. as a tool to prevent non-compliance and to support farmers. Under the on-the-spot-checking regime, a farmer is in theory only liable to be checked once in 20 years and 95% of the farmers receive little feedback on their application. Furthermore, the very term 'on-the-spot-check' implies a snapshot inspection (a single observation), but covering a year's worth of aid.

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The introduction of the payment for agricultural practices beneficial for the climate and environment (greening) required checks on agricultural activities - crops cultivated, maintenance of permanent grassland, ploughing, etc. – which are not feasible in a single visit. This is where the new approaches to monitoring come into play. Under this approach, all agricultural parcels in a region are subject to the same monitoring process. Field visits are carried out only if the outcome of the monitoring process is inconclusive and the potential financial impact of non-compliance exceeds a certain threshold. If this leads to fewer field visits, it reduces the burden on the farmer and the costs for the paying agency. Henceforth, automation, digitalization and new technologies for management and controls can help mitigate the costs of CAP administration. If the use of satellites means that field visits are targeting farms most likely to be non-compliant, this will improve their efficiency.

Payment agencies sharing the management of the CAP expenditure by DG AGRI, are listed in Annex I. They are 76 payment agencies in total, from 27 countries, as in the DG AGRI Annual Report list[2]. The complete list of Paying Agencies is in ANNEX A : Paying Agencies List

PAs have already started utilizing CBM practices based on Earth observation, GIS and modern ICT; the trends and moves aligned to this strategy are described in Section 3.4.1 Current Status and Trends for PAs and CBs.

3.1.2 Certification Bodies

Certification bodies are authorities and SMEs in charge of the control system for production practices (organic, climate protection compliant, etc). They may confer their control competences to one or more public control authorities or delegate control tasks to one or more private control bodies. Member States are regularly informing the Commission with the list of designated control authorities and approved control bodies. The Commission regularly publishes these lists.

For instance, **organic certification** allows a farm or processing facility to sell, label, and represent their products as organic. The organic brand provides consumers with more choices in the marketplace. EC accreditation protects consumer options by protecting the organic seal. Any organic operation violating the regulations faces enforcement actions, which can include financial penalties or suspension/revocation of their organic certificate. Certification bodies are responsible for making sure that organic products meet all organic standards. There are five basic steps to organic (or other type of) certification:

1. The farm or business adopts organic practices, selects a nation-wide accredited certifying agent, and submits an application and fees to the certifying agent.
2. The certifying agent reviews the application to verify that practices comply with organic regulations.
3. An inspector conducts an on-site inspection of the applicant's operation.
4. The certifying agent reviews the application and the inspector's report to determine if the applicant complies with the regulations.
5. The certifying agent issues organic certificate.

[2] Annex 7 in https://ec.europa.eu/info/system/files/annual-activity-report-2020-agriculture-and-rural-development-annexes_en.pdf

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To maintain organic certification, the certified organic farm or business goes through an annual review and inspection process.

Organic Accreditation authorizes private, foreign, or state organizations to certify farms or processing facilities. Certifying bodies are accredited by the National Authorities and International organisations and are responsible for making sure organic products meet all organic standards.

Obviously, the on-site visits and checks are not capable to deliver continuous monitoring of farms and farmers. Continuous monitoring is necessary; similar needs as the ones mentioned for the paying agencies are prevailing, as long as the organic action plan and the need for higher level of assurance will increase the workload in terms of parcels, monitoring duration, types of cultivation, land coverage and integration with logistics chain.

The accredited certification bodies currently in place in EU Member States are published:

- 266 certification bodies are active in the EU Member States
- They are all listed in the agriculture section[3] of the EC EUROPA site
- 11 of them have been also accredited by the USDA (United States Department of Agriculture), permitting them to certify farms and businesses according to the USDA organic regulations.

The trends and moves that show adoption of ICT and EO-enabled monitoring in use by Certification Bodies, are described in Section 3.4 Current Status and Trends

3.1.3 Farmers

Farmers are not the primary focused targeted market by ENVISION. However, it is a potential market, which will be highly dependent on the productization results and achievements of ENVISION into the PAs and CBs market field. The most important benefits for them through the CbM approach, are related to:

1. Avoidance of penalties; Farmers can early detect cases when their practices are violating (or are close to violate) rules which secure the necessary quality of product, healthiness and eco friendliness which is also related to funding or penalties in case of mis-compliance.
2. Improved management of their farms and production practices in order to efficiently comply with rules, secure funds and achieve sustainable and environment friendly labeled products. Availability of data useful for smart farming (using modern technology to increase the quantity and quality of agricultural products) can provide farmers with economic benefits. For example, satellite images can provide information about soil nitrogen content or drought stress, which could optimise fertiliser application or irrigation, cutting costs for the farmer and reducing the negative environmental impacts of the agricultural activity.

Therefore, it is important to check demographics of farmers in respect to their type and size, as well as in respect to the level they are dependent on subsidies and suffer from income loss due to penalising.

[3] https://ec.europa.eu/agriculture/ofis_public/actor_cbeu/ctrl.cfm?targetUrl=home

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Additionally, we should not underestimate the level of power and significancy in terms of policy making and requirements definition that is being driven by large number of farmers, grouped by unions and cooperatives. Henceforth, they do affect decisions of policy makers and certifying agencies, as long as they are formulating the needs, mainly the ones who are applying the practices that are being monitored.

Population & Sizes - There were 10.5 million farms in the EU in 2016 (Source: EUROSTAT)[4], with the vast majority of these (95.2 %) classified as family farms. EUROSTAT data will be updated in 2023. An analysis of farmers economical and population figures is available on EU country factsheets[5]. In 2016, family farms accounted for around 80 % of the labour force input and around 60 % of the total utilised agricultural area, of livestock units and of the value of the agricultural output. In 2016, around one third of the managers of family farms were aged 65 or over[6], which is a serious concern for their ICT literacy and the ability to adopt modern practices. This phenomenon poses a serious risk to the sustainable development of family farming.

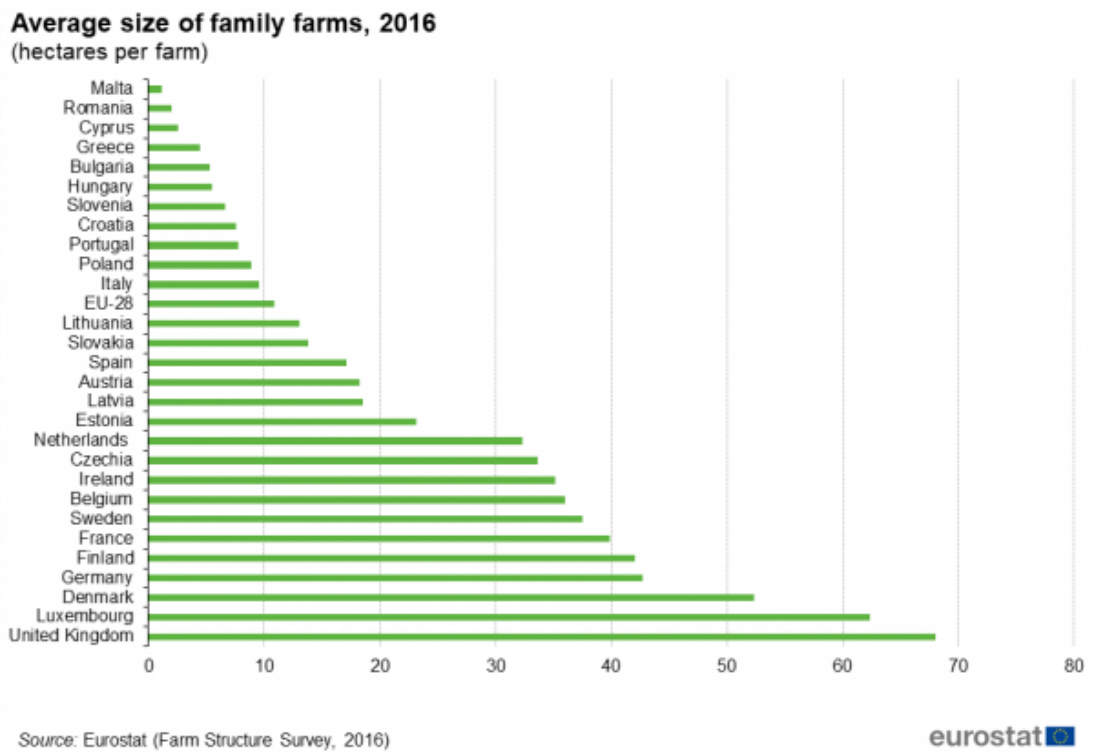

Figure 2 Average size of family farms, 2016 (hectares per farm) Source: Eurostat (Farm Structure Survey, 2016). EUROSTAT figures will be updated in 2023

Farm sizes vary from an average of less than 1 hectare to thousands of hectares. Family farms are, on average, largest in the United Kingdom (68 hectares per holding), followed by Luxembourg (62 hectares per holding) and Denmark (52 hectares per holding). In contrast, the smallest family farms, with an average size of between 1 and 2.5 hectares were in Malta, Cyprus and Romania (see Figure 2).

[4]https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agriculture_statistics_-_family_farming_in_the_EU
[5]https://ec.europa.eu/info/food-farming-fisheries/farming/facts-and-figures/performance-agricultural-policy/agriculture-country/eu-country-factsheets-0_en
[6] 3.3 million farm managers of family farms were aged 65 or over in the EU-28. This was more than one third of the total.

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The United Nations' Food and Agriculture Organisation (FAO) defines a family farm as '*… an agricultural holding which is managed and operated by a household and where farm labor is largely supplied by that household*'. Family farms are by far the most common type of farm in the European Union, encompassing a wide range of agriculture holdings (farms) from small, semi-subsistence farms with only family workers and farms which have to rely on other gainful activities for a diversified source of income, through to much larger, more productive farms which nevertheless are mostly managed by family members. Family farms dominate the structure of EU agriculture in terms of numbers, their contribution to agricultural employment and, to a lesser degree, the area of land that they cultivate and the value of the output they generate. There were 10.5 million farms in the EU in 2016, with the vast majority of them (95.2 %) classified as family farms. Across all the farms in the EU-28, family farms used 81.4 % of the regular agricultural labor force. Non-family farms represented less than 5% of the EU total number of farms in 2016 but cultivated just over one third of the total utilised agricultural area. In 2016, there were about 509 000 farms in the EU that were not classified as family farms in 2016. Family farms are, on average, consistently smaller than non-family farms in terms of the utilised agricultural area; this is particularly true for farms with only family workers. Farms with no family labour force cultivate an average area that is almost 8 times larger than the average area cultivated by farms with only family workers. The farms with no family labour force have the largest average area.

Dependency on Aids – According to June 2021 Statistical Factsheet [7] 6.158.000 beneficiaries are receiving financial aid of 38MEuros.

Distribution of direct aids to producers in financial year 2019*

Size-class of aid (all direct payments)	Financial year 2019			
	Beneficiaries		Payments in EUR	
	x 1 000	% of total	x 1 000	% of total
< 0 €	2	0.0%	- 2 308	0.0%
≥ 0 and < 500 €	1 368	22.2%	447 566	1.2%
≥ 500 and < 1 250 €	1 595	25.9%	1 282 783	3.4%
≥ 1 250 and < 2 000 €	660	10.7%	1 049 320	2.7%
≥ 2 000 and < 5 000 €	1 051	17.1%	3 357 392	8.8%
≥ 5 000 and < 10 000 €	596	9.7%	4 223 279	11.1%
≥ 10 000 and < 20 000 €	439	7.1%	6 221 012	16.3%
≥ 20 000 and < 50 000 €	342	5.5%	10 436 020	27.3%
≥ 50 000 and < 100 000 €	78	1.3%	5 199 637	13.6%
≥ 100 000 and < 150 000 €	14	0.2%	1 689 877	4.4%
≥ 150 000 and < 200 000 €	5	0.1%	917 808	2.4%
≥ 200 000 and < 250 000 €	3	0.0%	682 657	1.8%
≥ 250 000 and < 300 000 €	2	0.0%	501 592	1.3%
≥ 300 000 and < 500 000 €	3	0.0%	1 045 106	2.7%
≥ 500 000 €	1	0.0%	1 110 404	2.9%
Total	**6 158**	**100%**	**38 162 145**	**100%**

*Notes:
1. Figures for financial year 2020 will become available during the second half of 2021.
2. Negative values represent beneficiaries that in total reimbursed money to the EAGF (recoveries, corrections, etc.)

Figure 3 Distribution of Financial Aids to producers

The Annual activity report 2020[8] - Agriculture and Rural Development shows that penalties and corrections are a serious burden – as well as a reason for income loss – for farmers and policy makers, putting also money at risk. A an adjusted error rate of 1.93 has been observed, which however for

[7] https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/agri-statistical-factsheet-eu_en.pdf

[8] https://ec.europa.eu/info/publications/annual-activity-report-2020-agriculture-and-rural-development_en

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certain country cases reaches and exceeds 5%. Therefore, the smoother intime and accurate monitoring is valuable.

Ageing - One of the crucial issues related to family farming is the ageing of farm managers. On farms with only family workers, the share of managers aged 65 or over (34.3 %) was much higher than in farms without any family labor (9.3 %). These figures suggest that farm managers working for corporations and cooperatives were much more likely to have stopped managing farms by the age of 65.

However, the percentage of managers aged between 55 and 64 accounted for around one quarter of the total managers in all types of farms. There were relatively few young farm managers in the EU-28 in 2016. Managers younger than 40 years old accounted for about 10 % of all managers on farms with only family workers, although this share rose to 17 % in non-family farms.

Young farm managers (aged under 40) of family farms were more common in Luxembourg (26.0 %); Austria (21.7 %) and Poland (20.0 %) than in most Member States. They were far scarcer in Cyprus (2.9 % of all family farm managers) and Portugal (3.3 %), where family farm managers aged 65 or over were relatively common (43.7 % and 50.1 % respectively).

Farm managers by age class and type of farm labour, 2016
(thousands)

	All managers on farms	Managers on family farms of any type				Managers on non-family farms of any type			
		Of all ages	Less than 40	40 - 64	65 years or over	Of all ages	Less than 40	40 - 64	65 years or over
EU-28	10 306	9 823	1 022	5 474	3 325	483	81	336	66
Belgium	37	31	3	21	7	6	1	4	1
Bulgaria	202	191	26	93	72	11	3	7	1
Czechia	28	23	2	14	7	5	1	3	1
Denmark	33	30	2	20	8	3	0	3	0
Germany	277	251	36	194	21	26	5	19	2
Estonia	15	12	1	7	4	3	1	2	0
Ireland	137	135	17	78	40	2	0	1	1
Greece	685	677	56	394	227	8	1	5	2
Spain	942	824	66	489	269	118	15	78	25
France	455	312	43	208	61	143	28	108	7
Croatia	134	130	13	73	44	4	1	3	0
Italy	1 146	1 101	86	556	459	45	5	30	10
Cyprus	35	34	1	18	15	1	0	1	0
Latvia	70	68	6	41	21	2	0	2	0
Lithuania	150	147	18	83	46	3	1	2	0
Luxembourg	1	1	0	1	0	0	0	0	0
Hungary	430	418	52	236	130	12	2	8	2
Malta	10	10	1	6	3	0	0	0	0
Netherlands	57	50	4	36	10	7	1	5	1
Austria	130	124	28	87	9	6	1	4	1
Poland	1 410	1 393	282	948	163	17	4	12	1
Portugal	259	242	9	103	130	17	2	10	5
Romania	3 420	3 396	250	1 632	1 514	24	5	17	2
Slovenia	69	69	6	43	20	0	0	0	0
Slovakia	25	22	4	13	5	3	1	2	0
Finland	14	12	1	10	1	2	0	2	0
Sweden	23	18	2	11	5	5	1	3	1
United Kingdom	112	102	6	61	35	10	1	7	2

Source: Eurostat (Farm Structure Survey, 2016)

eurostat

Figure 4 Farm managers by age class and type of farm labour, 2016 (thousands) Source: Eurostat (Farm Structure Survey, 2016)

Challenges for family farmers - The main challenges facing family farms often reflect issues that are common for all types of small business: access to resources (such as land and capital) or access to markets (particularly in relation to the bargaining power of small farms in the food chain). Demographics provide a social challenge for family farms, as inter-generational succession issues may impact upon the sustainability of family farming. This challenge is further complicated in some of the

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EU Member States by legislation over inheritance (which may influence land consolidation/fragmentation).

Farmers Cooperatives - Being the prime user of technological solutions aiming at enhanced cultivation and sustainable farming practices, farmers stand at the epicentre of user requirement definition and evolution. These depend on a number of factors, including most notably farm size, crop type and level of sophistication (directly related to access to finance). Given that most farmers are smallholders (global average under 2 ha), *agricultural cooperatives and farmers' organisations* have come to play a significant role in supporting and economically empowering small agricultural producers. Cooperatives provide a wide range of services including improved access to markets, finance, natural resources, information and technologies. In addition, they facilitate smallholders' participation in decision-making at all levels, enable the purchase of (shared) equipment and help towards striking better deals for inputs.

In Europe, COGECA, the "General Confederation of Agricultural Cooperatives in the European Union", currently represents the interests of approx. 40,000 farmers' cooperatives employing around 660,000 people and with a global annual turnover over three hundred billion euros throughout the enlarged Europe. Joined together with COPA (Committee of Professional Agricultural Organisations), they constitute the main representative body for farmers at European level. COPA-COGECA's main role lies in lobbying the EU's public institutions to influence policy decisions affecting farmers and on facilitating exchanges that promote the uptake of solutions to common challenges. In that framework, they publish position papers and organise dedicated conferences such as "Big Data for Cooperatives and Farmers" that tried to shed light on aspects related to the uptake of precision farming solutions.

3.2 Potential Early Adopters

ENVISION envisages that a number of PAs and CBs will become early adopters of its services. The most obvious and prominent early adopters are expected to be the ones who are to participate in ENVISION business cases. ENVISION will be tested and validated in a pre-operational environment by potential future customers of its services. The two customer segments which are involved in the project are

- Paying Agencies using ENVISION to monitor environmental and climate requirements of EU policies related to agriculture, and
- Certification Bodies using ENVISION to monitor organic farming requirements.

Apart from those business cases, the prospective early adopters can be expanded to more actors through the active communication and marketing activities that will target mature organisations with already gained experience into the use of monitoring systems and with verified needs that lead them to the adoption of more modern and innovative solutions.

Henceforth, we categorize these early adopters based on the reasons that indicate them as most possible candidates to adopt ENVISION outcomes in their practices:

Category 1: PAs and CBs partners of ENVISION as business cases providers

National PAs participating in ENVISION

- National Paying Agency (NPA), Lithuania
- Vlaamse Gewest (LV), Belgium
- Organismos Agrotikon Pliromon (CAPO), Cyprus

CBs participating in ENVISION

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- Doo Organic Control System Subotica (OCS), Serbia
- Linking Environment and Farming LBG (LEAF), United Kingdom

The following three types of business cases are being developed as part of the project, with the abovementioned partners contributing to their implementation and validation

- Monitoring multiple environmental and climate requirements of CAP (Lithuania and Cyprus)
- Monitoring the condition of soil (Belgium)
- Monitoring organic farming practices (Serbia)

The business cases mentioned above are described in Section 2.3.

Category 2: Lighthouse customers plus more

The ENVISION Lighthouse Customers are not members of the consortium. They do not have a budget; they are participating in ENVISION voluntarily. They face issues relative to the effective monitoring of CAP environmental requirements and agricultural certification requirements. They will test specific features of the services at a small scale. Their contribution to the project is significant as they will further enhance the results of ENVISION by providing extra intelligence on the users' needs and requirements, and/or by participating in the (small scale) testing and evaluation of ENVISION's services. Depending on each Lighthouse Customer's specific needs, they will decide which ENVISION products and services they are interested in. ENVISION aims to establish long-term Business Synergies with them, and business partnerships to deliver value to all stakeholders involved (PAs, CBs, farmers, developers, consultancies) through ENVISION. Therefore, we classify them as potential early-adopters of ENVISION.

From the proposal phase, the Lighthouse Customers that have expressed their interest in using and testing the ENVISION solution are:

Payment Agencies

- the Agricultural Paying Agency of Slovakia (APA)
- the Swedish Board of Agriculture (SBA),
- the French Agency of Agricultural Services and Payments (ASP),
- the Danish Agricultural Agency (DAA),
- the State Agricultural Intervention Fund of the Czech Republic (SZIF),
- European Agricultural Funds of Bulgaria (CAAF),
- the Agency of Paying and Intervention for Agriculture of Romania (APIA)

Certification Bodies

- the Institute for Control and Certification in Agriculture and Forestry Maribor of Slovenia (KON)
- the Organic Certification Body ECOVIVENDI of Serbia (EV),
- the Inspection Institute for Organic Products "BIO Hellas" (BIO),
- the Inspection and Certification Organisation "TÜV HELLAS" (TUV)

Each of the eleven (11) Lighthouse Customers will decide which data products they are interested in and determine their level and type of involvement in the project. They will have the opportunity to contribute to the identification of users' requirements, and/or to test and validate the ENVISION service.

In addition to these 11 Lighthouse Customers, ENVISION considers also early adopters which are not in this group, who have gained significant experience in the past through research project and other innovation initiatives and they seek for solutions that could overcome significant obstacles which are now faced by ENVISION.

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Summary about early adopters of ENVISION - To summarise, the table below provides an indicative list of potential early adopters of ENVISION services:

Payment Agencies National PAs participating in ENVISION ○ National Paying Agency (NPA), Lithuania ○ Vlaamse Gewest (LV), Belgium ○ Organismos Agrotikon Pliromon (CAPO), Cyprus Lighthouse Customers: ○ the Agricultural Paying Agency of Slovakia (APA) ○ the Swedish Board of Agriculture (SBA), ○ the French Agency of Agricultural Services and Payments (ASP), ○ the Danish Agricultural Agency (DAA), ○ the State Agricultural Intervention Fund of the Czech Republic (SZIF), ○ European Agricultural Funds of Bulgaria (CAAF), ○ the Agency of Paying and Intervention for Agriculture of Romania (APIA) Other: ○ Netherlands Enterprise Agency (RVO) of Netherlands ○ Instituto Tecnológico Agrario de Castilla y León (ITACyL) in Spain ○ Fondo Español de Garantía Agraria (FEGA) - Spanish coordination body ○ Agenzia per le Erogazioni in Agricoltura (AGEA) - Italian Coordinating Body
Certification Bodies CBs participating in ENVISION ○ Doo Organic Control System Subotica (OCS), Serbia ○ Linking Environment and Farming LBG (LEAF), United Kingdom *Lighthouse customers* ○ the Institute for Control and Certification in Agriculture and Forestry Maribor of Slovenia (KON) ○ the Organic Certification Body ECOVIVENDI of Serbia (EV), ○ the Inspection Institute for Organic Products "BIO Hellas" (BIO), Greece ○ the Inspection and Certification Organisation "TÜV HELLAS" (TUV), Greece

Table 1 ENVISION Early Adopters

The number of countries where the initial business cases and first targeted customer references will come from allow for validating the pre-commercial and startup ENVISION services in a multitude of different environments and climates. ENVISION can achieve early operation with success in Northern (Lithuania, Sweden, Denmark), Western (Belgium, France), Southern (Cyprus, Greece), Eastern (Serbia, Bulgaria, Romania), and Central (Czech Republic, Slovenia, Slovakia) Europe, where diverse conditions are present; for example, cloud-cover is more prominent in northern regions than in southern, thus by

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building the project's cases in such different settings its services can be designed according to the needs of each region across the spectrum of numerous environments.

All countries are part of the EU (except Serbia) and are thus required to follow the same legislation in regards to the environment, climate, and agriculture. Serbia on the other hand, is not obliged to follow this legislation but, as it's mainly involved in trade with EU Member States, the country's relevant laws are fully in line with the EU rules in respect to the conservation of the environment as a vital objective of organic agriculture.

Therefore, it is expected that early adopters are critical to achieve, as they will drive and attract other market actors to follow and will show a successful path to wider expansion of ENVISION services.

3.2.1 Fostering Expansion of Potential Customers Base

In addition, to the most potential early adopters for ENVISION, we should count also on the outcome of dissemination activities that will exploit the professional networks of all partners. The project partners will make use of their existing channels and networks for reaching the target audiences, aiming to raise market awareness about ENVISION services. Dissemination actions will definitely contribute to achieve wider base of potential customers, some of them possibly to become actual customers at early deployment phases. To be more specific,

- Technological, research and other partners (URDG, DRAXIS, NOA, ETAM, INOS, AgroApps, ITC, EV ILVO) and certification bodies (OCS, LEAF) have built Networks of Interest through their participation in European and National projects (such as RECAP, GEO-CRADLE H2020) that are dealing with the integration of state-of-the-art EO activities - in the thematic areas of food security, agri-production, energy, raw materials and climate change. Networks include groups and individuals (more than 10.000) representing major stakeholders including paying agencies, agri-consultants, farmers' organisations and unions, governmental and non-governmental organizations, private companies and academic / research institutions, collective bodies and scientific communities at a local, regional, national and European level, that share a common interest related to the CAP and environmental protection, remote sensing and ICT.
- Partners will bring these networks to ENVISION and will utilise their dissemination channels (websites, newsletter, agricultural press, research conferences and papers, network projects, etc.).
- Certification bodies (CBs_ work also closely with other CBs who conduct audits, to which they can share the success stories resulting from the project. They attend a number of meetings and conferences of their alliances where ENVISION outcomes can be disseminated, and have stakeholder networks which includes producers, food service providers and brands.
- Participating paying agencies are leading or actively contributing to national rural policy building and relevant development, participating into committees related to Rural Development, Direct Payments and Agricultural Funds. They participate into IACS and ENRD workshops and in expert groups for Direct Payments and Rural Development.
- Paying agencies have a database of all the aid applicants which is constantly updated and maintained. All the entities in this database, receive information from PAs regarding their application process stage, errors found in their aid applications, and other relevant information, via mail, email or SMS.
- Paying agencies and certification bodies (NPA, LV, LEAF, CAPO, OCS) are also networking with partners via Panta Rhei Platform, which is the main channel of sharing experience, discussing daily issues as regards IT/computerisation aspects related to the implementation and development of the future CAP. It is an informal group for exchanging ideas and experiences between the

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accredited Paying Agencies in the sector of the EAGGF[9] and EAFRD within the EU; it holds biannual conferences.

- They are also using Learning Network Platform for the Directors of the accredited Paying Agencies and Coordination Bodies – another tool of community building and networking on a wide variety of relevant issues as regards measures under EAGGF and EAFRD, incl. dissemination of information about the introduced innovations/digitisation, related news in the EU and national legislation, sharing experience and consulting on possibilities to simplify and ensure more efficient procedures/workflows, with informal group meetings throughout the year.

3.3 Drivers

Driving forces are making the market more mature and eager to utilize services like ENVISION. These drivers are including the CAP, the country policies, the plan towards organic farming and the EC programs orientation that formulate a motivating environment with legal and financial support measures. Market drivers are also the functional and technological features of the upcoming solutions and market characteristics plus the adoption and the experience gained by existing pilots addressing the creation and assessment of Area Monitoring Systems.

A brief overview of these drivers is given below.

⇨ **CAP pushing towards automation -** The European Union (EU) Common Agricultural Policy (CAP) is the overarching system of subsidies and payment programmes for agriculture and rural areas. The CAP pursues a range of objectives and accounts for over 40% of the European Union's annual budget. The Commission adopted a number of legal provisions and provided the technical guidance to enable Member States to take advantage of freely available satellite data (the Copernicus program) to monitor areas claimed for aid as an alternative to carry out often costly on-the-spot-checks (OSTC). Several Member States have decided to introduce 'checks by monitoring' for part of the aid schemes and/or areas as from 2019. This choice of the monitoring approach will equally deliver also on the assurance. The monitoring approach is expected to offer great potential for simplification of administrative and control-related tasks, but also for monitoring of the CAP's performance in a much wider sense.

Following the 2013 CAP reform, payments are intended to act as a safety net in the form of a basic income support. Cross-compliance and Greening are two mechanisms (referring to specific obligations) that are linked to this payment to ensure more environmentally friendly farming approaches and deliver continued food security and safety in Europe. The introduction of cross-compliance and greening measures brought additional complexity for programme administrators, that push towards more and improved automation and exploitation of remote sensing and GIS and ICT-enabled solutions. Data samples need to be collected from many different sources, to be correlated and analysed within time, and checked in terms of compliance with complex rules scheme.

For instance, ENVISION key drivers caused by CAP include the following very specific motivation for key services to support:

- The inspection of Cross-compliance, Greening, and RDP's climate- environmental-requirements, including "Agri-environment and climate", "Organic farming" and "Natura 2000 and water framework directive payments", is currently a challenge to

[9] European Agriculture Guidance and Guarantee Funds

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PAs because they consist of *many different rules with different inspection dates*. These requirements necessitate actions such as the verification of 1. crop types, 2. land abandonment, 3. use or not of herbicides, or mechanical weed control. The option to monitor the requirements remotely will reduce control costs for PAs and the administrative burden on farmers, thus ensuring faster and more efficient controls and faster delivery of payments to farmers.

- Current CAP's 6th GAEC requires the *maintenance of soil organic matter level* through appropriate agricultural practices. The objectives of the future CAP's GAECs include: maintenance of soil organic matter (GAEC 3), minimum land management reflecting site-specific conditions to limit erosion (GAEC 6), protection of soil in winter (GAEC 7) and preservation of soil potential (GAEC 8). Moreover, Member States can define in their Strategic Plans voluntary Eco-schemes on soils with different levels of ambition. In this context, the continuous spatial and temporal monitoring of the SOC content in agricultural soils becomes extremely important, not only from the environmental perspective -to limit soil degradation- but also in economic terms to ensure that the beneficiaries of the CAP follow the obligations under the conditionalities and voluntary schemes.

The context caused by the current and future CAP brought the need and urgency of monitoring systems, as described below: *the Area Monitoring Systems (AMS)*.

⇨ **The Farm to Fork and Biodiversity strategies –** These two strategies are at the heart of the European Green Deal aiming to make food systems fair, healthy and environmentally-friendly. Food systems cannot be resilient to crises such as the COVID-19 pandemic if they are not sustainable. Food systems are being redesigned. Today they account for nearly one-third of global GHG emissions, consume large amounts of natural resources, result in biodiversity loss and negative health impacts (due to both under- and over-nutrition) and do not allow fair economic returns and livelihoods for all actors, in particular for primary producers.

A set of measurable targets is driving policies, decisions and support mechanisms. The Farm to Fork and Biodiversity Strategies include a range of ambitious targets intended to put the EU food system on a transformative path to greater sustainability. Those with the greatest relevance to agricultural production include the following:

- agriculture to contribute to a reduction of at least 55 % in net GHG emissions by 2030;
- reduction by 50 % of the use and risk of chemical pesticides and the use of more hazardous pesticides by 50 % by 2030;
- a reduction of nutrient losses by at least 50% while ensuring that there is no deterioration in soil fertility. This will reduce the use of fertilisers by at least 20 % by 2030;
- a reduction by 50 % of sales of antimicrobials for farmed animals and in aquaculture by 2030;
- reaching 25 % of agricultural land under organic farming by 2030;
- a minimum 10 % area under high diversity landscape features; and
- 100 % access to fast broadband internet in rural areas by 2025, so that to enable IoT sensing and continuous filed monitoring

Member States will need to measure the level of coherence to these strategies. Remote sensing technologies and compliance rules are the driving forces for modern monitoring practices.

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⇨ **Advent of Area Monitoring Systems -** One of the main drivers of the Market will be the establishment and selection of Area Monitoring Systems within areas and types of agriculture activities. *The AMS will become the single point of electronic facilitation, audit support, certification, clearing, guidance, for the PAs and CBs to monitor farmers. AMS is defined as a procedure of regular and systematic observation, tracking and assessment of agricultural activities and practices on agricultural areas by Copernicus Sentinels satellite data or other data with at least equivalent value.*

The role of AMS will be of primary importance in the certification and auditing process of farmer activities, to check their compliance with rules and eco-schemes' requirements. Therefore, EC will regulate and ask for annual AMS quality assessment according to a common methodology at Union level.

AMS will basically support Performance Monitoring and Evaluation Framework (PMEF) procedures, through the following:

- It gives reliable and verifiable information on the status of area-based interventions (and conditionality)
- AMS information permits management to address remedy mismatches between declared and observed agricultural conditions/practices
- It enables the increase of reliability of reported area-related output and results indicator values.

The great potential of AMS is positioned into many different roles:

- Realize the claimless application system
- Recognise cases of force majeure
- Support environment/climate policy objectives and statistical purposes
- *Support farmer to fulfil eligibility and conditionality requirements*
- *Support reporting obligations*
- *Support PAs to carry out systematic checks to make decision on payments*
- Support agricultural resources management (at parcel, farm or regional level)
- Permits targeted LPIS (Land-parcel Identification System) update strategy

AMS role will be strong into monitoring EU progress towards CAP objectives. The playing field that is enabled will be area-specific, reporting on area-related PMEF indicators. This monitoring progress towards CAP objectives, ensures availability of information on the quality of the reported area-related PMEF indicators. *The ambition of AMS is to cover all area-related PMEF indicators to improve and quantify the reliability of the values that are reported annually.* Therefore, AMSs require to be gradually expandable into indicators with new features and interventions.

The trend for PAs and CBs is to start early enough with an AMS, at least covering a minimum set of indicators that cover an integral number of areas and correspond to well-defined and substantial monetary schemes. Then, a steadily growing number and spread of indicators covered to get in-line with broader areas and widened requirements.
AMS analysis as ordered by PMEF is to detect monitorable phenomena and then determine one of the following facts, for each one:

- Conclusive presence
- Conclusive absence

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- Non-conclusive

The conclusive results are compared with the expected outcome (given the criteria) for interventions and/or conditionality, which finally will be either matches or mismatches:

- Matches: findings confirm expected outcome
- Mismatches: findings do not confirm expected outcome.

The development of ambitious AMS that support efforts in addressing environmental and climate-specific objectives is encouraged by the EU Green Deal, the European Court of Auditors and the Farm to Fork strategy. Therefore, AMS should integrate:

- Automatic monitoring of phenomena with Sentinel or other sensing infrastructure
- 2-way communication system interface with beneficiary farmers

AMS brings tangible benefits, as below:

- PAs and CBs will be automated, modernized without needing follow-ups
- Farmers to avoid penalties through the enabling prevention
- Area-related output and results indicators will be of high quality and reliability
- Farmers get services of many different types, enabling them to monitor their activity-specific indicators consistently
- Agencies and management bodies get statistics, indicators and realize a reliable system, a claimless system.

The benefits drive Commission to push efforts towards preparing relevant legislation and providing continuous guidance and technical support.

ENVISION services are matching the features and services covered by an AMS at startup steps. Its overall architecture should prove the ability to scale and expand to more services, as well as to integrate within processes that involve all actors and their respective interfaces: authorities, certifiers, farmers. Moreover, AMS build-up will employ other developers and service providers who can also utilise ENVISION services in order to build new services on top of ENVISION data products.

⇨ **Member States Strategic Plans -** The level of power that each country's agricultural decisions give towards policies that contribute to the CAP is definitely affecting the maturity at each national market, for PAs and CBs. The European Green Deal and its related strategies have set ambitious targets when it comes to agricultural policies. These ambitions must be addressed by the new CAP, following the political agreement on the future CAP reached by the Council and Parliament at the end of June 2021. While the overall aim of the what – climate neutrality by 2050 – is now legally binding, the how of realizing these ambitions remains open.

The new CAP legislative framework proposes a new delivery model that provides Member States with greater flexibility, and a new green architecture with mandatory standards, aimed at promoting environment and climate friendly practices by farmers. However, not all the Commission's proposals to strengthen the mandatory standards were adopted and related eco-schemes run the risk to be used as income support. *Much will depend on the Member States' Strategic Plans, which will set out their intervention strategies to achieve the CAP goals. There are concerns related to Member State's capacity to design such strategies, the extent of their ambitions, and the availability of data to monitor implementation.* The latter also relates to the CAP governance structure. It is not yet defined, whether the Commission before approving national plans will prefer to enter into structured dialogues with Member States in order to negotiate special measures and roadmaps or will apply enforcement measures to

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Member States based on financial withholding threatening actions. The Commission has levers such as the 'no backsliding' principle and has requested Member States to provide national targets in their Plans for six of the most important objectives in the Farm to Fork Strategy, but the CAP political agreement is clear that approval can only be based on legally binding obligations. Member States consider the pre-allocated CAP budget envelopes as their money, regardless of quality delivered. Monitoring tools should provide insights and possible adjustments. The countries should find the ways and models to tackle the negative effects of Green Deal targets on farmers' income.

- **Plan towards organic farming -** Recent production and market trends show the importance that organics has gained over the last decade. Organic farming responds to a specific consumer demand for sustainable food products, promoting more sustainable farming practices and contributing to the protection of the environment and improved animal welfare. The Farm to Fork Strategy and the Biodiversity Strategy set a very ambitious target for the development of the organic sector, as a tool to contribute to the creation of a sustainable food system, while at the same time contributing to the preservation of the biodiversity. The Commission is working on an Organic Action Plan that aims at boosting consumption to trigger an increase of surfaces. Moreover, it is also important to present organics as a model for conventional agriculture to move a step forward in the transition to sustainability.

  Organic farmers are required to comply with the national **Laws on Organic Production**; the. Laws are designed to be fully in line with environmental EU legislation in respect to the conservation of the environment as a vital objective of organic agriculture. To that end, there are several requirements that farmers need to follow (limits to fertilization, mandatory buffer strips, soil erosion prevention, nutrient management etc.) to acquire and maintain an organic certification. Organic certification bodies are responsible for evaluating their performance and compliance to the environmental rules by performing on-farm checks.

  The roadmap towards organic farming opens a challenging era for CBs with higher workloads and major responsibilities against authorities. They will definitely speedup into adopting and integrating improved solutions for monitoring compliance that exploit satellite sensing and precision agriculture practices; the process is already in place through pilots which are expected to turn from experimentation to long term production and expansion.

- **Horizon Europe Cluster 6 Programme -** The newly launched Horizon Europe programme includes Cluster 6, dedicated to Food, Bioeconomy, Natural Resources, Agriculture and Environment. It aims at reducing environmental degradation, halting and reversing the decline of biodiversity on land and better managing natural resources through transformative changes of the economy and society in rural areas. Research and innovation activities under cluster 6 will contribute to the objectives of the European Green Deal related to the Biodiversity Strategy to 2030, the Farm to Fork strategy, the European Climate Pact and initiatives under sustainable industry and eliminating pollution, as well as the long-term vision for rural areas, and the Sustainable Development Goals.

  A new generation of projects will continue and add value to previous Horizon 2020 achievements. Higher technology readiness level outcome is expected that will be closely accompany and support CAP requirements and strategic targets. 1.000 MEuros and 900

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MEuros are budgeted as described in the relevant workprogramme[10] for projects in this top priority area.

⇨ **Technology Solutions & Market Features (qualitative and quantitative) -** As already presented in the previous chapters there is a great diversity of applications in agriculture for which GNSS, GIS, 5G, HPC are the main enablers or key components in the processing chains. New technologies for continuous and territory-wide remote monitoring of environmentally friendly practices arise with the availability of Copernicus and GEOSS data. EO technology provides the fastest, most objective, straightforward, and cost-effective solution to successfully monitor farmers' performance in relation to environmentally-friendly practices. Through the use of this technology the entire area of agricultural land under the jurisdiction of PAs and CBs can be monitored continuously, instead of a small sample of farm land once a year. This data can be coupled with other sources of data, such as:

- Validated compliance decisions from on-farm checks from past years, acquired from PAs
- in-situ data acquired through sampling campaigns (i.e. soil data).

Through the use of Data Fusion and Machine Learning techniques, and supported by IT technology that can efficiently handle large amounts of data, this information can be used to train and validate models and algorithms for the delivery of data products that can serve the need for the identification of agricultural malpractices. In this way, information and knowledge of past years can be transposed into predictable observations or likely detections of the current year.

Applications can be broadly categorised into four categories: Guidance systems, Variable Rate Applications, Site-Specific Data Analysis applications and tracking/delineation. Each of these application groups has its own technology performance requirements, strongly affected by the efficiency of networks and computation resources. Therefore, the evolution of 5G network infrastructures at rural areas, as well as the exploitation of High-Performance Computing architectures, cloud and big data processing frameworks are main drivers towards achieving performance for intime and accurate results.

From the user point of view, these requirements must be satisfied in order to accept the proposed monitoring technology. Most in-field cultivation operations require a cm to sub-metre accuracy level (pass-to-pass). Certain in-field operations that require returning to exact locations at different times require in addition high-repeatability or otherwise very small drifts. On top of requirements strictly related to accuracy, users seek increased availability, reliability and, in the future, the authenticity of signals.

Apart from "quantitative" requirements, a number of "qualitative" requirements, mostly related to social or economic aspects are highly relevant for the adoption of the various solutions. For example, farmer education, age, income and geographic location, all play a key role in the adoption of technological solutions. Other key aspects, also underlined in include:

- Complexity - i.e. users seeking easy-to-use solutions;
- Interoperability/compatibility and standardisation - i.e. upgradeability of software to new versions and compatibility between different vendors solutions and between datasets;

[10] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-9-food-bioeconomy-natural-resources-agriculture-and-environment_horizon-2021-2022_en.pdf

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- Ruggedness and resilience gave that farmers often operate in varying climatic conditions;
- Product/Solution reliability, or in other words delivery of what is promised;
- Financial benefits.

⇨ **Proving Profitability –** It is very important to exhibit convincing cost-benefit cases justifying the initial investment. To that end, the need for the development of reliable precision farming calculator tools that can take into account geographic regions and socioeconomic variability across Europe has been strongly reported in the recent EIP Precision Farming report. This is particularly applicable to small-to-medium sized farms, for which tailored solutions are being developed. The **top most important parameter for the adoption of GNSS-based and EO-based solutions is increased profitability**. Besides that, however, there exist several key parameters acting as drivers for the adoption of an elaboration of user requirements on these solutions. This includes optimizing machine utilization (automatic machine setting, automatic steering); obtaining greater quantities of reliable site-specific information (yield mapping, soil sampling); minimising overlapping/skipping costs and reducing labour and stress (guidance systems); optimising input utilisation (nitrogen sensors, geo-referenced soil sampling, VR maps); and enabling integrated farm management solutions (machine monitoring); intime disease prevention.

3.4 Current Status and Trends

Increased and more sustainable agricultural production, being central in addressing a number of important societal and economic challenges, strongly relies on EO-enabled solutions in a number of applications. Satellite applications user requirements, strongly interlinked with the growing and evolving market trends, are driven by

- The need for increased profitability of agricultural operations, achieved primarily through machine utilization optimisation, acquisition of greater quantities of reliable site-specific information and optimisation of input costs (fertilisers, fuel, labour)
- The need to introduce solutions applicable (in terms of cost-benefits) to small and medium-sized farms, whilst overcoming socio-cultural barriers (lack of education, awareness, equipment ease-of-use, etc.)
- The need to comply with policy considerations related to the disbursement of agricultural subsidies and other regulatory aspects for environmentally friendly agricultural practices
- Significant improvements in High-Accuracy solutions (e.g. multi-constellation, multi-frequency, Galileo High Accuracy Service, coupled with increased availability of low-cost equipment
- Combination of navigation technologies with other complementary technologies such as Remote Sensing, proximal sensors, IoT and robotics, within integrated farm management solutions.

In this context, the need for a comprehensive global strategy of reducing the environmental impact of agricultural activities is absolutely critical. A key component in such a global strategy lies in the utilisation of science-based and, in particular, information technology-enabled solutions. In fact, over the past few decades, a number of solutions relying on technologies that have been developed for, or adapted to agricultural activities has emerged. GIS, remote sensing through satellites or RPAS, GNSS, optical sensors for nitrogen content and canopy condition, machine vision systems, gamma-radiometric soil sensors, etc. have been deployed across a wide range of applications.

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The markets of PAs and CBs have made their first steps but are still on their way to achieve more and to radically change their procedures and tools. ENVISION 's outlook on the market needs to identify those facts and trends that highlight the direction for the uptake of new services and platforms.

3.4.1 Current Status and Trends for PAs and CBs

The statements below are describing the progress and tendency that is being created, in terms of facts about the current status, the conclusions derived from past and ongoing work and the willingness of PAs and CBs in respect to priorities and desires:

- **EC & National Strategies -** Actions and decisions that realise and support strategies aligned to the Green Deal, Biodiversity enhancement, organic plans, Farm to Fork, etc. lead PAs and CBs to automation, intelligence, precision and remote sensing. So far, the outcome of this strategic move has been realized through participation into projects and initiatives that are working to set requirements for new systems, foster design and development and utilize in real scenarios in order to provide valuable assessment and conclusions for future work.

- **Growing use of digital data -** The trend has already triggered certain actions - either within a systematic roadmap or through occasional experimentation - and achievements have been reached by some actors. The Paying Agencies (PAs) in their approach for launching the CAP monitoring systems on time are investigating implementation solutions for Copernicus and commercial satellite data access as well as its processing. Many projects are contributing extensively to the implementation of AMS through modernisation of the Integrated administration and control system (IACS) by making efficient use of digital solutions and e-tools, creating reliable methodologies and harmonised data sets for monitoring agricultural performance while reducing administrative burden for farmers, paying agencies and other stakeholders. The objective will be achieved by providing a suite of digital solutions, e-tools and good practices for e-governance and initiates an innovation ecosystem to support further development of IACS that will facilitate data and information flows.

  Currently, the Sentinel data is more often used for execution of on-the-spot checks (OTSC). Progress has been noted on using Sentinel data for LPIS update. NPA's survey over 27 PAs in 26 Member States has shown significant increase of number of PAs using Sentinel a. for LPIs update (6 PAs in 2019, 14 PAs in 2020) and b. as a help tool to farmer (3 PAs in 2019, 7 PAs in 2020).

  Sentinel 2 data is widely used by PAs (24 PAs in 2019; 29 PAs in 2020). Bigger progress has been observed for Sentinel 1 data update (15 PAs in 2019; 23 PAs in 2020).

- **CBM uptake is steadily growing; however concerns still to address -** Many PAs are running multiple internally/externally funded technical projects and planning that CBM will substitute physical on the spot checks (OTSC) in coming years, however the PA's are still facing certain difficulties to do this faster because of small parcels, complex subsidy system with few monitorable eligibility criteria, doubts about the future audit approach, lack of skills, funding, infrastructure etc. PA's would like to get stronger leadership and a common strategy developed by the European Commission (EC) to help in dealing with the above problems, also a more tangible input from the EC as regards technical solutions:

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- provision of all needed algorithms for AMS (crop type detection, grass mowing date, crop harvest etc.) by the EC and
- increasing the spatial resolution from 10-20 to 5 meters

The indicator 3.5 below is showing the area under satellite monitoring, according to 2020 Annual Report of DG AGRI:

Result indicator 3.5: Area under Satellite Monitoring [for BPS/SAPS] **Explanation:** This indicator aims at measuring the uptake of new technology and digitalisation by CAP administrations in Member States: share of area receiving direct support (through the basic payment scheme (BPS)/single area payment scheme (SAPS)) that is covered by Checks-by-Monitoring or by the Area Monitoring System (AMS). **Unit of measurement**: ratio between the BPS/SAPS hectares covered with Checks-by-Monitoring or AMS and the latest available data on the total area under BPS/SAPS in the EU **Source of data:** Member States notifications on Checks-by-Monitoring; European Commission, DG Agriculture and Rural Development			
Baseline (2019)	**Interim milestone** (2022)	**Target** (2024)	**Latest known results** (2020)
3%	10%	50%	5.69%

Table 2 Indicator for Satellite Monitored Area coverage

⇨ **PAs and CBs to provide services as help tools to farmers -** The PAs are also exploring the possibilities to use the CBM data not only as a compliance check tool after the support application is submitted by farmer, but also as a help tool for farmers to submit more correct applications by providing the suggestions on possible ineligible areas, summer/winter crop/grassland areas and other. This should ensure lower error rates and sanctions, which would be much welcomed by the farmers. Moreover, there is an interest of PAs to provide broader list of services to farmers, for example, estimation of crop yield including the identification of drought, flooded and burnt-out areas. Also, possibilities to provide better fast-track services for farmers are discovered through collaboration with land, forest, water and environment management agencies, insurance companies, advisory and farm management, including precision agriculture, service providers.

⇨ **Usability awareness for Copernicus products -** Majority of PA's are aware about Copernicus Core service products, though there is still a need of learning how these products could be used for CAP. On the other hand, PAs already tested or plan to test in the near future the EC-funded five cloud-based Data and Information Access Services (DIAS) platforms, which provide centralised access to Copernicus data and information, as well as to processing tools. DIAS should be cheaper and faster solution for PAs to implement the AMS approach. Moreover, the PAs are keen to use the Free & Open-Source Software (FOSS) and open-source algorithms, developed by European Space Agency (ESA), EC and others (through Sen4CAP, NIVA, DIONE and other projects), but still not decided whether they will use the e-tools/platforms, which could help with AMS and which are developed through other EU H2020 programme projects (for example, RECAP, DIONE, ENVISION).

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- **Ongoing AMS development with allocated budgets –** AMS are being developed or decisions have been taken towards implementing them. Internal AMS projects dominate over international oner as the number of projects increased from 2019 to 2020 (doubled from 6 to 12). However, it is still not clear how the PAs are planning to test all the tools and Free and Open-Source Software (FOSS) that will be developed by international projects. Costs allocated for AMS developments range from 1 to 3 MEuros.

- ***The error rates should decrease –*** More efforts will be needed in the first years to deal with error rates. In the short-term they are expected to increase, but algorithmic optimisation will soon tackle the issue to reach acceptable levels for CBs and PAs. The service where accuracy is mostly desired is crop identification. The reason for this, is the fundamental role of the service itself. The crop type classification accuracy, and hence the usefulness of the remote sensing component for CAP administrative decisions for which crop-type is relevant, depends on three parameters:
  - Percentage of truthful declarations
  - Cloud coverage
  - Parcel size

  In certain case studies of the RECAP[11] project—i.e. Navarra, Spain—where 90% thematic accuracy was achieved, all these parameters were optimal. This means more than 97% of truthful declarations, limited cloud coverage, and an average parcel size of 2 ha, which is considered sufficiently large for a Sentinel-2 based classification. When a considerable percentage of declarations are not truthful, then similar crop types, both in spectral characteristics and phenology—e.g. wheat, barley, oats—might not be well discriminated. Hence, merging of such crop types into spectral coherent clusters (e.g. cereals) would be necessary for an adequately accurate result. Therefore, the thematic accuracy of the crop identification products depends on the type of information one is aiming for. For example, the usefulness of the clusters in assessing a crop rotation requirement depends on the degree to which farmers could implement a crop rotation *within*, as opposed to *across*, clusters.

  Crop classification accuracy also depends on the size and shape of the parcel, with classifications for larger parcels and parcels with straighter borders tending to have higher accuracy than smaller parcels or parcels with more irregularly-shaped boundaries. The parcel area is important since accuracy depends on the number of image pixels that fall within the parcel boundaries. Sentinel-2's 10 m pixel size equates to 50 image pixels in 0.5 ha of land. An analysis conducted, comparing the accuracy of classification in conjunction with the parcels' size, showed that having 50 pixels of information provides accurate results, whereas for smaller parcels the decision is both less confident and less accurate.

- ***Open Data Publishing –*** PAs and CBs access to data and production to processes data enables them to provide Open Government Data. 14 out of 29 PAs responded in NPA's survey that they already provide full open data, while 6 out of 29 are planning to do also. Others are only providing metadata; obviously data availability will be enriched through the role of PAs and CBs, enabling them also to participate into other business opportunities.

[11] RECAP—Personalised Public Services in Support for the implementation of the Common Agriculture Policy (CAP*), an Horizon 2020 project funded under the* ICT-enabled open government *(H2020-INSO-2015-CNECT) call (Grant Agreement 693171)*

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⇨ **The EU-funded cloud-based services were used for testing rather than for operational monitoring - The case of DIAS) -** Copernicus is the largest space data provider in the world, currently producing 12 terabytes per day. To facilitate and standardise access to this data, the European Commission has been funding the deployment of five digital cloud-based platforms providing centralised access to Copernicus data and information, as well as to processing tools. These platforms are known as the Data and Information Access Services (DIAS). Four of them offer services relevant to agriculture in 2019. They must meet various technical requirements and provide the Copernicus data free of charge, but they can charge for extra services (such as data processing, data storage, and combining Copernicus data with other datasets). The DIAS providers' services became available during 2018. In autumn 2018, the Commission decided to support the paying agencies implementing the checks by monitoring approach by subsidising their individual access to one of the four DIAS platforms for 2019. The subsidy amounted to €120 000 per DIAS provider to cover three phases: technical readiness review of DIAS providers by the Commission, onboarding of paying agencies on one of the DIAS provider and operational use of the DIAS by the paying agencies in 2019. Although the paying agencies had found it useful to test for free a DIAS platform, most of them used their existing infrastructure or contracts as primary processing solutions for checks by monitoring in 2019. Consequently, the value added by the Commission's expenditure of €480 000 is yet to be established. According to recent surveys, many paying agencies (~50%) do not intend to move to a DIAS platform soon and in the long run. Discussions with the paying agencies and expert panel between April and September 2019 highlighted the following uncertainties, delaying the move to DIAS providers:

- The cost of DIAS services now and in the future. Due to the technicalities and the pay-per-use business models, most paying agencies do not know how much it would cost them to run checks by monitoring on DIAS platforms in their country or region.
- Having four DIAS providers available, each with a different technology and structure, complicates decision-making by the paying agencies. While the Commission claims to have a solution for transferability of data from one DIAS platform to another, the paying agencies are not yet aware of it. This is complicated further by the uncertainty around the service continuity of some or all of the DIAS providers after the end of their contracts.

The main driver for possible use of DIAS is the cost savings at startup and the fact that it is faster than in house.

⇨ **Outsourcing is preferred-** The development of necessary algorithms is mostly outsourced and run inhouse, at the 3rd party providers or on DIAS

⇨ **Most Valuable (desirable) Products –** The most valuable products according to PAs and CBs opinion are (sorted by preference):

1. Crop Identification
2. Grass mowing
3. Crop Harvest
4. Biodiversity
5. Burnt out area
6. Drought areas
7. Crop yield estimation
8. Crop loss estimation in case of disasters

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9. Soil erosion
10. Flooded areas

Preference ranking is expected to change as new solutions will emerge that resolve fundamental services (such as crop identification) and conditions by legislation and new eco-schemes will change.

⇨ **The results of research projects are yet to be exploited -** Under its Horizon 2020 Research and Innovation programme the Commission has granted some €94 million to a range of research projects aiming to monitor agriculture using Copernicus Sentinel data. Among these projects, those which contributed directly to ongoing developments in CAP monitoring were identified and are described in the next section. PAs and CBs participating into these projects have gained experience and maturity into the use and evaluation of systems promising CBM with accuracy and reliability. Significant projects took place and achieved important results. Key partnerships with PAs and CBs show the significant role of these entities in order to match results with actual needs and prepare themselves for the next generation way of committing their role. These projects are described in ANNEX B : Projects in Brief.

3.4.2 CBM uptake and related conclusions

Some Member States took action to deploy the new technologies for direct payments. It was expected that Member States would take adequate steps for deploying new imaging technologies for CAP monitoring. Consequently, reviews focused on whether the paying agencies:

- implemented checks by monitoring in recent years (2019 onwards);
- used the Copernicus Sentinel data systematically to check some of the aid requirements;
- used geo-tagged photos or drones;
- participated in EU or ESA-funded research projects concerning the use of the new technologies; and
- carried out pilot projects to test the use of the new technologies.

15 paying agencies made selective use of checks by monitoring in 2019 - *For* the 2019 claim year, 15 out of 66 paying agencies in five Member States have implemented checks by monitoring on all or part of the area for which they are responsible, for all or some aid scheme. Seven Member States are participating in ESA project Sen4CAP[12] which has been followed by the DIONE[13] project that builds on top of SEN4CAP outcome. Taking into account the technical guidelines drafted by the JRC, these 15 paying agencies have developed diverse methodologies for monitoring the different aid scheme requirements applicable in their regions. Crop types, agricultural practices and agro-climatic conditions are important factors that come into play.

[12] Sen4CAP (Sentinels for Common Agriculture Policy) is a project that has been setup by **ESA** in direct collaboration and on request from **DG-Agri**, **DG-Grow** and **DG-JRC. The** project aims at providing to the European and national stakeholders of the CAP validated algorithms, products, workflows and best practices for agriculture monitoring relevant for the management of the CAP (http://esa-sen4cap.org/)

[13] DIONE is a H2020 project (www.dione-project.eu) that offers a unique fusion of innovative technologies to improve the workflow of agricultural monitoring. It is developing a direct payment controlling toolbox for paying agencies to abide by the modernised CAP (Common Agricultural Policy) 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 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.

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Representative examples of methodologies and use of Sentinel data for checks by monitoring in 2019, are described below:

- **In Belgium (Flanders)**, the paying agency monitors the eligibility requirements for three schemes. For those schemes, farmers have to show use of their land for some form of agricultural activity. An AI algorithm, trained using a time series of Sentinel 1 and 2 images (in combination with the information contained in the farmers' declarations), predicts the probability that each parcel belongs to one of five classes (arable land, grassland, leguminous crops, fallow and non-eligible). Parcels where the outcome of the algorithm does not match the farmer's declaration are flagged red and followed up with a field visit. Where the outcome of the algorithm is inconclusive (yellow flag), parcels are followed up on screen and, if necessary, with a field visit. In 2019, permanent crops are excluded from this process, as they are verified using an update of the LPIS.

- **In Spain (Castile and Leon)**, the paying agency monitors the requirements for nine schemes. For the basic schemes, it is sufficient to check whether the use of land is as arable land, as grassland or for permanent crops. More precise crop identification is required for greening and voluntary coupled support (VCS). The paying agency thus performs a classification (26 crop classes and 9 non-crop classes) using a machine-learning algorithm trained with the farmers' declarations for crop classes and using other data sources to identify non-crop classes. The classification is performed with time series of Sentinel 2 images (in combination with climate data, and information on elevation, aspect and slope). Other types of markers have been developed also, e.g. related to crop type, or to detect certain events (for example, the preparation of land for growing crops). All inconclusive parcels or parcels with possible non-compliance are flagged yellow. Parcels above a certain financial threshold are followed up in the office and if still inconclusive, then with a field visit.

Although radar data from Sentinel-1 are not impaired by the presence of **cloud cover**, they are used less often by paying agencies because they are more difficult to process and interpret. However, some paying agencies (Belgium-Flanders and Denmark) have integrated them successfully in their machine learning algorithms while others use them for detecting grassland mowing (Italy).

Paying agencies end up with different proportions of yellow and red parcels for possible further follow-up. The variations between the proportions of red/yellow flagged parcels are mainly due to the size of parcels farmed, type of the parcels/activities monitored (mowing activity is easier to detect than grazing) and the methodologies applied (e.g. the number and accuracy of markers). Nevertheless, the maximum proportion of parcels requiring field inspection for these paying agencies is 1 %.

RECAP platform was tested and validated in an operational environment in five countries—Greece, Lithuania, Serbia, Spain and the United Kingdom—with the active participation of public organisations, agricultural consultants, and farmers. The platform was comprised of five different workflows (one for each country pilot), due to the differences between the pilots and the CAP rules interpretation. Based on this, the RECAP platform is developed as an integrated system, composed of core functionalities that are commonly shared across the pilots, with additional pilot-specific functionalities are built on top of these core functionalities. Pilot implementations in Spain, Greece, and Lithuania focused on *delivery of public services*, with the participation of four public organisations (Paying Agencies and Agricultural Advisory Services) which are members of the project consortium (INTIA, OPEKEPE, NMA,

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and LAAS). In the United Kingdom, the pilot implementation focuses on *delivery of personalised services from agricultural consultants* (partners STRUTT & PARKER).

The Serbian Pilot (INO) case in RECAP project focused on *organic agriculture*, with organic certification bodies, organic farmers and public bodies to overlook that organic certification is in line with legal requirements. The RECAP platform supported the entire process of subsidy provision for organic farmers, certification agencies, agricultural consultants and for the public authorities tasked with implementing, managing and controlling this payment scheme. Serbia being an EU candidate country (2012), has started accession negotiations in 2014 and is committed to transpose and implement the acquis on agriculture and rural development by the date of accession. RECAP platform will be positioned to support monitoring aspects of relevant subsidies within the Instrument Pre-Accession Assistance in Rural Development (IPARD) and providing assistance for the implementation of the acquis concerning the CAP.

Upon completion of the RECAP pilot, participants were surveyed about their perceptions about the extent to which the RECAP platform reduces administrative burden and facilitates compliance. Selected results from this survey (RECAP Consortium, 2018) are:

- 61% of farmers participating in the RECAP pilot somewhat agreed or strongly agreed that the RECAP platform *increases their understanding* of CAP Cross-Compliance (CC) rules, and 55% somewhat or strongly agreed that the platform *decreases the likelihood of their breaking CC rules*.
- 42% of agricultural consultants participating in the pilot reported that the *necessary time for preparing Basic Payment Scheme (BPS) application will be shorter using the platform*; and the corresponding time reduction is >25% for 60% of this subset; the remaining 44% considered that time spent preparing applications would not change. Similar results were found in relation to time spent checking adherence to CC rules.
- 51% of participating farmers considered that their necessary *time for preparing a Basic Payment Scheme (BPS) application would be shorter using the platform* (and 64% of this subset of farmers considered that the corresponding time reduction would be greater than 25%); compared to 44% of farmers who considered the time spent would not change, and 5% who considered their time spent making an application would be longer. Similar results were found in relation to time spent checking adherence to CC rules.
- 82% of organic farmers somewhat or strongly agree that the platform increases their understanding of compliance with Organic Certification and Organic Subsidies; 77% believe it will help them to follow organic certification requirements, and 91% believe that using the system will reduce time for presenting evidence of compliance with Organic Certification requirements.
- 74% of inspectors somewhat or strongly agree that the platform makes the CC procedure more transparent, while 68% believe the platform increases the accuracy of OTSC for CC;
- 62% of inspectors consider the time spent inspecting a farmer would be shorter using RECAP-like platforms, and of these, 60% considered the time reduction would be greater than 25%. Similar results were found in relation to the number of plots inspected per day.
- 58% of inspectors somewhat or strongly agree that the platform allows for the reduction of administrative burden for inspectors.

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- 100% of certification bodies somewhat or strongly agree that the platform will assist them with Organic Certification and that it reduces administrative burden.

Overall, the crop classification algorithm was assessed to provide satisfactory results: 75-85% accuracy, even for datasets that include satellite imagery only until mid-late June. This is very important, since paying agencies require accurate information at the time of the farmers' applications, in order to better target their sampled on-the-spot inspections to parcels that constitute potential breaches of compliance.

Crop classification from the RS component was provided also with the crop type as declared by the farmers. This functionality is key for paying agencies, as (together with the ground-truthing accuracy); it allows probabilistic identification of potential non-compliance. The RECAP team developed a "traffic light system" to convey this probabilistic assessment in an intuitive way. Where the ground-truthing accuracy of the RS classification is high, but the RS classification disagreed with the declared classification, this indicates potential non-compliance (untruthful declaration).

RECAP case study participants commented on the practicalities of using remote sensing information and machine learning to successfully classify crop types and identify compliance with environmental requirements (e.g. GAEC, greening):

> *"Different description of crop types would imply different spectral signatures for the crop classes and thereby different classification results. Additionally there are differences in the percentage of correctly declared cultivated crop types that accordingly affect the training of the machine learning algorithms. In Navarra, Spain declarations are almost completely correct and therefore results are excellent. In Greece, however, there is a significant percentage of falsely declared crop types that affects the classification accuracy. Nonetheless, the algorithm is indeed robust; in the sense that if 20% of declarations are wrongly stated this would roughly mean only 5% reduction in accuracy. Finally, in countries such as Lithuania, where cloud coverage is significant throughout the year algorithmic modifications are necessary. For example, it was found that a different machine learning algorithm performed best for the Lithuanian case.*
>
> *The main pillar of the agriculture monitoring scheme is the accurate crop type classification. The practicality of the classification is straightforward. However, RECAP attempted to specifically address the compliance of farmers to their actual CAP obligations (GAECs, SMRs, Greening). For some CAP obligations, such as Greening 1, crop classification is indeed all that is needed to decide on the compliance of the farmers. Now, for other obligations such SMR 1 (Reduce water pollution in nitrate vulnerable zones), the RS component of the RECAP platform provides a risk assessment on the soil loss and runoff to nearby watercourses, for each parcel. This is indeed a prerequisite for the farmers in order to comply with SMR 1, but the rule also extends to manure spreading obligations that cannot be addressed by remote sensing. Therefore, even though the remote sensing information provided with respect to SMR 1 is useful, it is not complete for compliance decision making."*

The above mentioned facts are showing with evidence that the move towards technology-enabled CBM will be strong and the need for sophisticated high quality data products, as the ones of ENVISION,

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opens opportunities for wider adoption by prospective AMS and other nationwide or areawide systems.

3.4.3 Farmers – Future and Now

Though farmers are featured by the majority of aged ones who are not enthusiasts about changes applied into their practices and it is not so easy for them to adopt new ones, it is important to mention features which will dominate the younger ones and the new ones. These are driven by their upcoming willingness to perform and follow moves, such as:

- *Farmers to join financing eco-schemes*- Eco-schemes will unlock new funding and additional incentives for climate- and environment-friendly farming practices. Schemes will be voluntary for farmers but will secure funding and support. These schemes can for example finance organic farming, agro-ecological practices, precision farming, agro-forestry or carbon farming.

- *Environmentally – friendly farming* - Farmers, as any other users of land and water, shall respect EU law, notably the nitrates directive and the Water Framework Directive. This is essential for protection of river courses against pollution, for sustainable management of nutrients (avoiding run-offs) and avoiding increasing irrigation in areas marked by water scarcity. The proposal for a Farm Sustainability Tool for Nutrients to be made available to farmers is particularly important to help farmers sustainably manage their nutrient cycle and comply with legal obligations. Moreover, farmers will tend to use systems that monitor resources consumption, mainly water and soil.

- *More farmers to become genuine* - Farmers who depend solely on farming to earn their living will be the ones eligible into financial schemes that will fund and support modernized farming, according to EC targets. The Commission will support direct support targeted to genuine farmers. Those, whose agricultural activity is an insignificant part of their overall economic activities will be excluded from financial support opportunities. Hence, it is expected that genuine farmers will be the ones to evolve in the market.

- *Biodiversity sensitive* - Farmers will tend to be sensitive in biodiversity matters. A precondition for more biodiversity on farmland is the creation of refuges in the form of hedges, trees, ponds and other landscape features. More farmers will be concerned with the preservation of biodiversity. Expanding landscape features and “non-productive” areas for biodiversity as a basic requirement for support should lead to real change in the service of biodiversity, not simply be a near-photocopy of the status-quo. It should apply to all agricultural land, require an ambitious minimum share of area and lead to high diversity areas that effectively contribute to reversing loss of biodiversity. Nature patches in farms will be among the farmers interests to protect and preserve. New policies will also motivate farmers to adopt biodiversity sensitive practices in ways that should be easily certified through sensing technology.

- *Adopting Precision Farming Practices and ICT Innovation* – The utilization of the various different enabling technologies and the combination of the different types of data they generate, has given rise to Precision Agriculture. More farmers will become familiar to precision agriculture benefits and practices. The adoption rate will strongly depend on policy measures and agriculture suppliers push along with satellite and 5G/6G networking. The global precision farming market size is anticipated to reach USD 16.35 billion by 2028, according to a new report by Grand View Research, Inc. Precision farming, also known as site-

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specific crop management or satellite farming, is a farm management concept that uses information technology to ensure optimum health and productivity of crops. The precision farming technique largely depends on specialized equipment such as sensing devices, antennas and access points, and automation and control systems. It also involves maintenance services and managed services. Additionally, it incorporates a broad range of technologies such as bio-engineering, robotics and automation, imagery and sensors, and big data. The growing number of applications for telematics in agriculture is anticipated to drive demand for precision farming over the projected period. Telematics services include tracking devices using the Global Navigation Satellite System (GNSS) to show the position of the equipment for management purposes. Major manufacturers of agriculture equipment are adopting telematics services for their equipment to improve farm efficiency, thereby reducing the cost of agricultural operations and maximizing profitability. Additionally, improved management can help reduce environmental impact. Telematics technology is used to capture and transfer data from the farm equipment through sensors installed on tractors and other field monitoring equipment. The increasing adoption of telematics systems by agricultural equipment companies is expected to drive market growth.

Defined as a farming management concept that enables the observation, measurement and response to site-specific aspects and variabilities in crops and animal-rearing aspects, precision agriculture has demonstrably contributed in increasing yield and productivity while controlling costs and reducing the environmental impact of agricultural activities. Precision Agriculture techniques essentially consist in the precise and effective application of inputs including fertilisers, pesticides, water resources, labour and machine hours. Their adoption depends on a number of different parameters including geographical location, climate, crop type, field and farm size, diversity of production/farming chains, available technical developments and social aspects. Thus far, PA solutions have been more widely and successfully adopted in arable land farming, especially in large farms of the main grain-growing areas of the USA and Europe. Apart from precision agriculture, a number of information technology-driven solutions have been targeting agri-logistic applications. The use of real-time information applications allows the efficient tracking and tracing of the farm assets, either in order to ensure their optimised utilisation (e.g. farm machinery monitoring, soil sampling) or to enable the geo-traceability of farm products.

Precision Agriculture and Agri-logistic applications lie at the core of an era when technology-based innovations have been increasingly contributing in ensuring efficient use of resources, maximising output and profitability and supporting sustainable, eco-friendly farm practices. Driven by the need to meet growing global demand for food, increased attention to crop health and yield, pressure on cost-effectiveness and reduced environmental impact, and supported by government incentives and subsidies, farmers have been increasingly taking up precision agriculture solutions. Furthermore, with advancements in GPS guidance and automation, drones are poised to transform the agriculture industry. The ability of drones to precisely analyze the soil at the beginning of the crop cycle and detect a plant infected with bacteria or fungus is anticipated to propel the growth of the drone segment.

⇨ *Foster farmers' maturity and ICT-literacy* - However, the rate of technology adoption among farmers is still low, and is likely to hamper market growth over the forecast period. This may be due to factors such as the absence of stringent standards and limitations on the exchange of data. Furthermore, farmers lack independent consulting and advisory services to make decisions on investments. Independent services are not linked to co-operatives, government

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bodies, and farmer associations where farmers can get additional information to make improved decisions.

⇨ *More Animal farmers will respect biosecurity and animal identification* - The Covid-19 pandemic has reminded us of the importance of biosecurity. More farms will seek sustainability criteria. This means that farm and food system must effectively manage risks of critical events in animal health and food safety. Precise identification of farm animals is the cornerstone to ensure public and animal health. Farmers not respecting basic requirements on animal identification are penalised under current rules (cross-compliance). This should continue to be the case, which will lead more farmers towards compliance.

⇨ *Adopt New business models and schemes to mitigate risks caused by income losses* - While the 2021-2027 CAP budget may not have decreased in nominal terms, Green Deal targets will initially have negative effects on farmers' incomes. Although politically sensitive, the classic negative externalities of farming for the environment and climate must be internalised for both farmers and consumers, which is also in farmers' own interests in the longer term. New income models can become a win-win situations both for farmers and environment, also with the aid of technology and innovation using both nature- based and high-tech solutions to address climate and food security concerns.

In this context, the critical role of farmers in providing their concrete user requirements, already at the level of the development of the technology as well as in relation to dissemination, has been recognised both in the framework of research projects but also at the institutional level.

3.4.4 Key Messages

The experience so far through projects and national initiatives have sent the following 5 key messages, that are forming the trends for upcoming moves:

1. ***Earth-observation tools powering accessible, user-specific platforms offer the opportunity to substantially reduce transactions costs of administering the Common Agricultural Policy*** - As the results from the surveys made after the end of projects (like RECAP, Sen4CAP, DIONE etc), pilot participants (agricultural consultants, inspectors, certification bodies and national paying agencies, farmers) all generally considered that the administrative burden is reduced. In some cases, reductions in administrative costs (generally measured as time spent on various administrative activities) were considered to be greater than 25%.

2. ***By using spatially-explicit earth observation and other data on a wide range of agricultural and environmental variables, project pilots pave the way for more nuanced, targeted agri-environmental policies*** = Beyond lowering the administrative costs of implementing existing CAP programmes and requirements, digital agri-platforms based on earth observation data enable public authorities to better monitor the implementation of agricultural and agri-environmental policies, and pave the way for more targeted policies in the future. In particular, the provision and availability of highly-differentiated spatial data (e.g. by parcel) on agricultural practices and landscape characteristics (e.g. slope, proximity to receiving waters, soil type, etc.) at high temporal frequencies will allow agencies to pursue more spatially and dynamically flexible policies that were previously infeasible due to data constraints.
3. ***Digital tools can increase the transparency of inspections and the accountability of public organisations, resulting in greater robustness of, and trust in, public agencies*** - All these platforms provide access to frequently updated satellite data and to functions for inspectors

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(PAs, CBs) or farmers so that they may upload geotagged, time-stamped images to support administrative checks of eligibility and compliance. Thereby, farmers have continuous access to further farm-related details within a secure and transparent framework. Further, farmers can use the images uploaded in a number of ways: e.g. share them with advisors and seek assistance or rectify non-compliance or prevent such a case occurring in the future. The tools assist fair, transparent and detailed inspections.

4. ***Services and platforms should use a co-operative approach to ensure the efficiency and effectiveness of their technical solutions, and interoperability with other solutions*** **-** Platforms and service providers should "build bridges" between public administrators and farmers through the use of innovative Earth Observation solutions and related tools. They should be based on a *user-driven approach* with solutions having to be designed and developed alongside the end-users and stakeholders, under a co-creation and co-production scheme. That's why, all these projects are work closely with users, PAs, CBs and farmers. The collaborative approach encourages *proactive participation of farmers in the overall monitoring procedure*, giving them an active role in the data collection process, enhancing close communication and co-operation with public administration. This innovative approach sets up a monitoring system that informs, guides and notifies farmers on their obligations towards the Basic Payment Schemes regulations, instead of penalising them for non-compliance when inspections take place. Finally, they need to offer Application Programming Interface (API) allowing other platforms to use data products or contribute data databases. This allows for *interoperability* and *interconnectivity* with other platforms or applications offered by PAs as well as ensures further integration with other systems developed (or to be developed) by agricultural consultants. In this way, project results will allow for the *"only once" principle*, according to which information submitted once by the farmers need not be asked for again by another service of the administration.

5. ***Innovative digital solutions such can underpin new private sector business models and opportunities -*** The innovative solutions that are provided to agricultural consultants give rise to new business opportunities. Agricultural consultants are offered certain functionalities allowing them to search and use data stored; to integrate search results into their applications supporting farmers' claims. Platform services can be used as a tool to underpin the day-to-day work of agricultural consultants to provide valuable advice to farmers.

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4 The Environment

The environment for ENVISION is comprised by the competitive moves, either expressed through technological companies that develop services to facilitate CBM directly facing the same market with ENVISION or building technological components that could evolve to parallel service platforms competing with ENVISION or work together with ENVISION as a tech component contributing and addressing specific needs and gaps. Some cases are not even products or companies, but project initiatives funded by national or EU-funded projects.

Apart from the competition and similar activities field, ENVISION environment is affected by the legislation in place and the legislation that is being drafted.

Last but not least the advent of modern ICT many times respond to needs and resolve problems that accelerate market adoption and customer satisfaction. Accuracy and reliability is just a matter of achieving combining as many data sources as possible, time-series snapshots, sensing at rural areas, high performance computing and high capacity bandwidth everywhere. HPC, big data frameworks and 5G/6G with edge computing architectures are capitalising the value of huge data collections and updated assured from the space technologies.

4.1 Competition

Considering market progress so far, potential and emerging competition can be identified within players who are active into experimenting or even performing commercially similar activities that address the ENVISION market and goals. The evidence carried is either produced by their activities and saying so far, the outcome of their projects and the relations that they have already built in the market. As the GEOSS and Copernicus data have given rise to new practical solutions, the number of firms operating closely to the field that ENVISION aspires to succeed is increasing as the market potential of similar but largely differentiated services in niche segments, is high. In that sense, future potential competitors have been identified in some EU countries (e.g. Netherlands, Italy, Germany, Slovenia, Czech Republic, Finland and Austria) currently operating in the monitoring of changes of agricultural landscapes and practices relevant to the management of the CAP.

An analysis and review of similar services so far, has already been already described in D2.1 “Review of current services provision”. Further analysis on the positioning of these services and the window that is opened for newcomers to explore is also made. A list of activities and companies is being annexed to D2.1. Some of them and some additional ones have been identified as important ones to consider as potential emerging competition for ENVISION; a detailed view for each one is provided in the ANNEX C: Competition.

Examples of businesses (active in EU) with relatively favourable positioning are

1. NEO, Geomatics & Earth Observation
2. e-GEOS and its subsidiary GAF AG[14]

[14] February 2021: GAF AG has won the first European call for tenders for the operational implementation of the agricultural area monitoring system in Germany in 2021 stipulated by the European Common Agricultural Policy (CAP). The Paying Agency will make use of GAF’s sophisticated cloud-based solutions for the automatic monitoring of agricultural parcels. More details in Annex A.

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3. BASF Digital Farming[15]
4. EOX IT Services Gmbh
5. SINERGISE
6. KappaZeta
7. Geosys
8. AGRICOLUS
9. Neuropublic
10. Cloudeo
11. TerraNIS
12. GISAT (DROMAS service)
13. Quantis
14. SatAgro

More information about the abovementioned competitors (including others also in EU) along with descriptions of their profiles is given in ANNEX C: Competition. Relevant also activity takes place by non-EU industrial, such as Agrosmart (Brazil)[16], CropX[17] (USA, Isreal, New Zealand), RESSON[18] (Canada), Orbital Insight[19] (USA, UK), TARANIS[20] (Israel), Rangelands (USA)[21].

More examples include also successful project outcomes, such as:

- possible commercial exploitation of SEN4CAP which was initiated by both the DG AGRI and the JRC through a public tender,
- projects such as the Advanced Platform for Intelligent Inspections and the New IACS Vision in Action (NIVA)project

These projects and many more are being described in ANNEX A :

Within this operational environment, the interesting points to note are:

- the competitive advantage of ENVISION is that it is one step ahead in terms of its design as it is more targeted in the monitoring of specific rules instead of monitoring general changes in the agricultural landscape elements
- ENVISION emphasis on sustainability rules monitor positions its services one step ahead in terms of readiness to address upcoming needs of PAs and CBs
- the add-on component offers a great field for opening work threads towards greater functionality expansion. This dynamic, can move potential competitors to become partners and contributors into a wider strategy
- most competitors identified are
    - having expertise into geo-informatic applications development which has been utilised into developing tailor – made agriculture applications. Specialisation is not featured in all cases; not all actors are promising a structure that is totally oriented to

[15] Among the important recent market facts, Bosch and BASF smart farming have formed a new joint venture. The 50/50 joint venture (JV) between Bosch and BASF Digital Farming will globally market and sell smart farming technologies from a single source. The JV has been registered as Bosch BASF Smart Farming (BBSF) GmbH.

[16] https://agrosmart.com.br/tecnologia-de-ponta-agrosmart/

[17] https://www.cropx.com/technology/

[18] https://resson.com/technology/

[19] https://orbitalinsight.com/geospatial-technology

[20] https://taranis.ag/technologies/

[21] https://rangelands.app/

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support CBM and the organisations (PAs and CBs) who run inspection and monitoring processes

- mostly dealing with crop monitoring and classification; they are lacking soil monitoring functionality. They are mostly using Sentinel-1 only data without fusing data with other geo-sources. Most of their focus has been paid on the identification of image change detection signalling a change in crop status, disaster identification and other cultivation needs. Orientation so far, was mainly addressing the farmers and the ones who are working towards adopting precision agriculture practices.

- Some competitors' noted are already operating with paying agencies i.e. EOX Gmbh, Neuropublic, GAF

4.2 Regulation

The policy instruments that affect the market conditions for activities of ENVISION and other relevant initiatives and products, to address *economic* (food security, globalisation, declining rate of productivity growth and price volatility), *environmental* (resource efficiency, soil and water quality, etc.) and *territorial* (depopulation and relocation of businesses out of rural areas) challenges, the EU Common Agricultural Policy (CAP) sets forth three high-level policy objectives:

- Viable food production
- Sustainable management of natural resources and climate action
- Balanced territorial development

In meeting these objectives, cases of successful farm management paradigm (precision agriculture, soil sampling, environmental protection measures) can prove to be a key tool. Such solutions contribute not only to enhanced competitiveness of the agricultural sector (increased crop yield and profitability) but also to sustainable utilisation of resources and minimisation of environmental impact. In that context, the specific policy measures and regulation put forward to ensure the fulfilment of long-term objectives, not only benefit from the uptake of innovative technologies such as earth observation solutions but also act as a key driver for innovation.

The main framing regulation and the policy trends are :

- The current CAP in place
- The new CAP (under consultation
- The policies supporting plans for organic farming

4.2.1 Current CAP

The Common Agricultural Policy (CAP) (2014-2020 and beyond) establishes the legislative framework around a system of subsidies and other support programs for agricultural activities in the European Union. Since 1962, and throughout a series of reforms, the CAP has not only supported farmers in their efforts to supply EU citizens with good quality and safe food; it has also been guiding the implementation of sustainable agriculture across the EU. The recent CAP reform maintained the two-pillar structure that was in place since 1999:

(1) direct payments and market measures, and

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(2) rural development.

Both pillars are aimed at meeting all three long-term CAP objectives more effectively, through an integration of the first pillar instruments with the regionally tailor-made and voluntary measures of the second pillar. The first pillar concerns direct payments to farmers that respect certain agricultural production and land use standards, whilst a new "green" direct payment that rewards farmers for respecting three mandatory agricultural practices (maintenance of permanent grassland, ecological focus areas and crop diversification), has been introduced. Financial support under the second pillar is implemented through national and/or regional rural development programs (RDP). Alongside these two pillars, a number of objectives that are relevant for precision agriculture have been introduced. This includes "improving agricultural competitiveness", "fostering innovation", "enhancing farm income", "providing environmental public goods" and "pursuing climate change mitigation and adaptation". On top of that, a number of articles of the CAP, describe measures that either benefit already today or could so in the future from EO-enabled or supported applications.

For instance, Article 17 concerns measures related to farm modernisation and intensification, as well as agri-environment- climate measures. In the first case, EO-based applications such as farm machinery guidance and automatic steering support increased crop yield, reduced carbon footprints and soil compaction (CTF). On the other hand, VRA can assist farmers in complying with the environment-related regulation. This applies, for example, to controlling and reducing the amount of nitrogen in the so-called Nitrate.

Article 28 puts forward measures to support farmers that undertake operations related to the agro-environment-climate commitments such as environmentally favorable extensification of farming; management of low-intensity pasture systems and integrated farm management and organic agriculture. In this scheme, farmers commit for a minimum period of five years, to apply environmentally friendly farming practices, over and above legal obligations. GNSS-enabled precision agriculture solutions can support farmers in participating in this scheme.

Article 35 supports cooperation between at least two entities on joint pilot projects related to environmentally- friendly farming practices, e.g. efficient water management. Here too, precision agriculture and water resources preservation practices can contribute to the corresponding requirements.

Finally, Articles 14 and 15 foresee measures related to the uptake of innovative technologies in real farming practices. This includes training and knowledge transfer actions (Art. 14) to farmers to develop technical and environmental skills; and Farm Advisory Services (FAS) under article 15 for the delivery of best agronomic practices and uptake of innovative solutions. A prime example of such Farm Advisory Service is the "Be PRECISE" cost-benefit calculator developed by the UK-HGCA to help growers weigh the costs and benefits of using precision farming technology on their farms. The need for robust advice that can be provided via FAS, and especially for cost-benefit backed advocacy on the uptake of precision farming techniques has been underlined as a top recommendation by the EIP-FG on Precision Agriculture.

Finally, precision agriculture supported by GNSS-based, GIS and satellite observation applications can contribute in meeting the requirements put forward within the greening measures. Under this new element (that accounts for 30% of direct payments), farmers receiving an area-based payment are obliged to undertake various straightforward, non-contractual practices that benefit the environment and the climate. Thus, farmers with more than 10 ha of arable land have to comply with crop diversification requirements:

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- Up to 30 ha: farmers have to grow at least 2 crops and the main crop cannot cover more than 75% of the land.
- Over 30 ha: farmers have to grow at least 3 crops, the main crop covering at most 75% of the land and the 2 main crops at most 95%.

In addition, farmers must maintain the ratio of permanent grassland to the total agricultural area, and must also ensure that at least 5% of arable areas (over 15 ha) is designated as an 'ecological focus area' dedicated to ecologically beneficial elements. Given that ENVISION related applications can contribute to all three measures, greater uptake can be foreseen in the (near) future.

In this context, the regulation introduced in May 2018, attempted to modernise the implementation of checks for area-based payments and for cross-compliance requirements. This landmark change foresees those modern solutions such as geo-tagged photos and data from Copernicus Sentinel satellites being used to carry out checks. This new "monitoring approach" promises significant benefits for farmers and administrations alike. The new rules will allow those member states that wish to do so to eventually replace or complement on-site checks with automated and less burdensome controls, as those enabled by ENVISION-like services. Several member states have already indicated their intention to immediately start using new technologies such as geo-tagged photos. This modern approach is further reflected in the legislative proposals of the European Commission for the future of the common agricultural policy. These are organised around 9 clear objectives and consider technology (including Galileo, EGNOS and Copernicus Sentinels) as a key enabler for CAP2020+.

Apart from the policy framework directly related to the CAP, a number of other directives and policy schemes are of relevance for the uptake of modern EO and GNSS solutions in agricultural activities. This is particularly relevant, in expectation of the authentication services of Galileo, ensuring better robustness against spoofing.

Thus, additional policy and regulation-driven applications are currently at work or can be anticipated in the near future. A brief overview is provided below:

- **Geo-traceability:** As described in the applications' section, the Regulation (EC) No 1/2005 foresees that road vehicles transporting livestock must be equipped with GNSS trackers. In addition, GNSS solutions make it possible to monitor environmental and location-based variables, communicate them to databases for analysis, and comply with food safety and traceability standards, as described for example in Directive 2001/18/EC on Genetically Modified Crops.
- **Environmental directives:** By enabling the exact measurement of field boundaries, regulating the use of inputs and geo-referencing site-specific crop data, GNSS can support farmers in complying with environmental directives such as Natura 2000, the Nitrates Directive and the Water Framework Directive. In addition, GNSS (in combination with Earth Observation) can support a number of environmental monitoring applications. Finally, with the advent of fully autonomous farm machinery being expected in the near future, regulation may be expected to set the requirements for their operation (accuracy, availability, continuous connectivity, etc.).

4.2.2 The Future CAP

Background - The Commission presented its proposals for the CAP reform in 2018, introducing a more flexible, performance and results-based approach that takes into account local conditions and needs,

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while increasing EU level ambitions in terms of sustainability. The European Parliament and Council agreed on their negotiating positions on the reform of the CAP respectively on 23 and 21 October 2020, leading to the start of the trilogues on 10 November 2020. The Commission published the Farm to Fork and Biodiversity strategies in May 2020. These two strategies were presented in the context of the European Green Deal to enable the transition towards increased sustainability of our food systems and to tackle the key drivers of biodiversity loss.

Agreement Reached - The provisional political agreement was reached on the 25th June 2021 by the European Parliament and Council on the new Common Agricultural Policy that introduces a fairer, greener, more animal friendly and flexible CAP. Higher environmental and climate ambitions, aligned with Green Deal objectives, are to be implemented from January 2023. The new CAP will also ensure a fairer distribution of CAP support, especially to small and medium-sized family farms and young farmers. Based on simpler rules set up at EU level, each Member State will prepare a strategic plan to implement the policy over the next five years. This will allow them to take local conditions into account and to focus on performance.

A fairer CAP - For the first time, the CAP will include *social conditionality***,** meaning that CAP beneficiaries will have to respect elements of European social and labour law to receive CAP funds.

Redistribution of income support will be mandatory. Member States will redistribute at least 10% to the benefit of smaller farms, and must describe in their strategic plan how they plan to do this. Support for *young farmers* will have a new mandatory minimum level of 3% of Member States' budgets for CAP income support to young farmers (farmers up to 40). This could cover income support, investment or start-up aid for young farmers.

Addressing more and newer beneficiaries of lower size adds complexity and volume size to workloads for certification bodies and payment agencies. Automation and digitisation are providing the means to respond to higher demand.

A greener CAP - The new CAP will support the transition towards more sustainable agriculture with increased ambition for climate, environment, and animal welfare. This will enable implementation through the National Strategic Plans in line with the Green Deal and its Farm to Fork and Biodiversity strategies. It also introduces new tools that, combined with the new way of working, will enable a more efficient and better-targeted environmental, climate and animal welfare performance:

- *Consistency with the European Green Deal:* The new CAP will fully integrate EU environmental and climate legislation. CAP Plans will contribute to the targets of the Farm to Fork and Biodiversity Strategies, and will be updated to take into account the changes in the climate and environmental legislation from the European Green Deal.
- *Conditionality***:** the minimum requirements CAP beneficiaries have to comply with to receive support are now more ambitious. For example, on every farm at least 3% of arable land will be dedicated to biodiversity and non-productive elements, with a possibility to receive a support via eco-schemes to achieve 7% . All wetlands and peatlands will be protected.
- *Eco-schemes* will be mandatory for Member States to offer. This new voluntary instrument will reward farmers for implementing climate and environmentally-friendly practices (organic farming, agroecology, integrated pest management, etc.) as well as animal welfare improvements. Member States must allocate at least 25% of their income support budget to eco-schemes, a total of €48 billion of the direct payments budget.
- *At least 35% of rural development* funds will be allocated to agri-environment commitments, which promote environmental, climate and animal welfare practices.

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- The CAP budget must contribute significantly to the Union's overall climate spending. To ensure a realistic and robust calculation, by 2025 the Commission will propose a new, differentiated approach that moves beyond the existing methods.

Financial support, to be reliable and assured, is demanding ICT and digital data products to support compliance and certification according to eco-schemes and rules. ENVISION-like services' main target is to support Payment agencies and Certification Bodies to commit an increased workload that the new CAP will set.

A more flexible CAP - The new CAP introduces a new way of working, where each Member State will draft a national CAP strategic plan describing how the CAP objectives as well as and Green Deal objectives as described in the Farm to Fork and Biodiversity Strategies will be achieved. In addition, the new CAP focuses on performance thanks to:

- *Simpler rules* at EU level.
- An *annual performance report* to be submitted by Member States to the Commission from 2024 onwards, complemented by an annual review meeting.
- The Commission will *review the performance of the CAP strategic plans* in 2025 and 2027, to be followed up, when necessary, by a request for action to Member States by the Commission.
- A *set of common indicators* to monitor the implementation of the CAP and assess the performance of CAP strategic plans.

High performance will be strongly dependent on the use of Earth observation and remote sensing technology in the context of area monitoring systems empowered by ENVISION-like services.

Strengthening the position of farmers in a competitive agri-food sector - The new CAP maintains an overall *market orientation*, with EU farms operating according to market signals while taking advantage of opportunities outside the EU resulting from trade. It also *reinforces the position of farmers* in the food supply chain by expanding the possibilities for farmers to join forces, including by means of certain exceptions from competition law. A new *agricultural reserve* will be introduced to fund market measures in times of crises, with an annual budget of at least €450 million.

Next steps - The new CAP, covering three regulations (Horizontal, Strategic Plan and Common Market Organisation regulations), has to be formally approved by the European Parliament and adopted by the Council before it can enter into force. As for the CAP strategic plans, *Member States have until the 31 December 2021* to submit their draft plans. The Commission will then have six months to assess and approve the plans, which will then enter into force beginning of 2023.

4.2.3 The Organic Action Plan

An overview of the 2021-2027 action plan that is specific into addressing policy and regulation acts supporting organic farming, is given below. New organic legislation will enter into force on 1 January 2022, further to the postponement of its implementation for a year. The rules will reflect the changing nature of this rapidly growing sector. The new regulation is designed to ensure fair competition for farmers whilst preventing fraud and maintaining consumer trust through the following:

- production rules will be simplified through the phasing out of a number of exceptions and opt outs;
- *the control system will be strengthened thanks to tighter precautionary measures and robust checks along the entire supply chain;*

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- producers in third countries will have to comply with the same set of rules as those producing in the EU;
- organic rules will cover a wider list of products (e.g. salt, cork, beeswax, maté, vine leaves, palm hearts) and will have additional production rules (e.g. deer, rabbits and poultry);
- certification will be easier for small farmers thanks to a new system of group certification;
- there will be a more uniform approach to reducing the risk of accidental contamination from pesticides;
- exemptions for production in demarcated beds in greenhouses will be phased out.

In May 2020, the European Commission published its 'farm to fork' strategy – 'for a fair, healthy and environmentally friendly food system' – along with the EU biodiversity strategy, as part of the implementation of the European Green Deal. In those strategies the Commission set a target of 25 % of the EU's agricultural land to be under organic farming by 2030, as well as a significant increase in organic aquaculture. These targets aim to contribute to improving the sustainability of the food system, to reverse biodiversity loss and to reduce the use of chemical substances in the form of pesticides and fertilisers. The Commission's 2021 work programme set out its intention to prepare an action plan for the development of organic production for the 2021 to 2027 period, and the action plan was published on 25 March 2021. Offering an initial analysis of the action plan, this briefing outlines the measures envisaged and the implications for different stages of the food chain in the EU. It also examines the results of the public consultation launched by the Commission in September 2020 to gather stakeholders' views on the challenges and opportunities for the organic sector. The views of key stakeholders in response to the publication of the action plan are also covered, along with the initial views expressed by the advisory committees.

The Commission's communication on the development of organic production outlines the outcomes of the public consultation held between September and November 2020 along with projections for the organic sector for the next decade. It builds on the previous 2014-2020 action plan and takes into consideration the entry into force of the new regulatory framework for organic production (Regulation (EU) 2018/848) in January 2022, which will reinforce legal certainty for organic production, distribution and consumption.

The communication outlines a number of key features of the organic sector within the EU, providing a policy context for the actions that follow. In particular, the communication underscores that:

- organic farming currently accounts for 8.5% of the EU's total utilised agricultural area (UAA). This represents an increase in the area under organic farming by almost 66 % in the period between 2009 and 2019;
- organic retail sales have doubled in value over the same period; current projections based on existing policies and trends predict growth in the organic sector over the next decade, reaching 15 % to 18 % of agricultural land by 2030;
- land farmed organically is claimed to have about 30% more biodiversity than land farmed conventionally.

Another notable observation included in the Commission's analysis is that organic farming is more costly, as organic farmers use natural processes and avoid the use of synthetic products. It also states that although yields are lower, organic farmers often enjoy better incomes as organic products are usually sold at higher prices that conventional ones. On the consumption side, findings from the Eurobarometer 2020 special report indicate that 56 % of those surveyed stated that they were aware

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of the EU organic logo, while 66 % of respondents declared that they were ready to pay up to 10 % more for agricultural products produced with a limited carbon footprint.

In March 2021, the Commission launched the organic action plan for the European Union. The action plan lists 23 actions structured around three axes as summarised in *Table 3 Organic Action Plan – 23 actions in 3 axes* .

- Axis 1: stimulate demand and ensure consumer trust
- Axis 2: stimulate conversion and reinforce the entire value chain
- Axis 3: organics leading by example: improve the contribution of organic farming to environmental sustainability

Axis 1 – Stimulating demand and securing consumer trust - This axis focuses on stimulating demand for organic products, in order to provide an incentive for farmers to switch to organic production. This will involve, for example, making use of the EU's agricultural promotion policy, where already 27 % of its budget is allocated to organic production. Other actions highlighted include: the role played by public canteens in favouring organic food; the potential offered by green public procurement when organising public procurements, and action to reinforce the EU school scheme by identifying ways to increase the distribution of organic products; the review of this scheme is not planned until 2023. Other actions include efforts to: prevent food fraud, strengthen traceability and transparency by for example developing a database of certificates of all EU operators, and establish partnerships with businesses willing to promote the use of organic products as part of their corporate social responsibility.

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Axis 1	Axis 2	Axis 3
Stimulating demand and ensuring consumer trust	**Stimulating conversion / reinforcing the value chain**	**Improving the contribution of organic farming to sustainability**
Information and communication	Optimal use of new CAP and CFP instruments; national strategic plans for aquaculture	Pilot network of climate positive organic holdings, carbon farming (2022)
Agricultural promotion (EU organic logo)	Sector analysis to increase market transparency	Genetic biodiversity and higher yields: demonstration farm networks, AKIS, EIP-AGRI
Promotion of organic products in public canteens and green public procurement (GPP)	Stepping up of collection of market data and extension to EU market observatories' analysis.	Alternatives to contentious inputs and other plant protection products.
Reinforcement of organic school schemes and study on real price of food	Organisation of the food chain, including protection against unfair trading practices	Enhanced animal welfare in the context of the Animal Welfare Platform
Fight against fraudulent practices at all levels	Better information on group certification	Efficient use of resources: bio-degradable plastic
Database of certificates of all EU operators	Small-volume processing and short trade circuit: bio-districts	Efficient and sustainable use of water, increased use of renewable energy and clean transport
Action to improve traceability	Fostering of social inclusion in rural areas that promote gender equality and young farmers	
Efforts to engage the private sector: retailers, wholesalers, catering services, etc.	Organic animal nutrition: alternative protein and vitamin sources and organic feed additives	
	Reinforcing organic aquaculture	

Notes to Table 1: CAP: common agricultural policy; CFP: common fisheries policy; AKIS-agriculture knowledge and innovation system; EIP-AGRI: agricultural European innovation partnership.

Table 3 Organic Action Plan – 23 actions in 3 axes

Axis 2 – Stimulating conversion and reinforcing the value chain - Although not the only one, the common agricultural policy (CAP) is considered a key tool for supporting conversion to organic farming. The action plan encourages Member States to make full use of the instruments available under the new CAP in their national strategic plans to accelerate this transition, including the new eco-schemes and rural development funds. To attain this objective the Commission will, starting in 2023, assess the specific circumstances and needs of each Member State and provide specific support accordingly through technical assistance, the exchange of best practices and the strengthening of farm advisory services to promote relevant knowledge exchange. EU demonstration farm networks will be set up to promote the dissemination of best practices enabling education providers to develop courses on organic farming. Efforts will also be made to improve the availability of market data on organic production. To encourage short organic supply chains, the Commission will encourage Member States to support the development and implementation of 'bio-districts'. These are geographical areas where farmers, the public and tourist operators and public authorities enter into agreement for the sustainable management of local resources based on organic principles and practices. Other elements under this axis include actions to help Member States design measures for organic farming in rural areas that promote gender equality and the inclusion of young farmers. The Commission

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will also support research and innovation on alternative sources of protein for organic livestock farming, including the adoption of an algae initiative.

Axis 3– Improving the contribution of organic farming to sustainability Recognising the potential offered by organic farming in relation to climate change mitigation, the Commission will set up a pilot network of climate positive organic holdings to share best practices. In order to increase the contribution that organic farming can make to sustainability, the Commission intends to dedicate at least 30 % of the next calls relating to intervention area 3 Agriculture, forestry and rural areas' of Cluster 6 of Horizon Europe to topics specific to or relevant for the organic sector. This funding will be used to support the preservation of plant genetic resources, the availability of organic seeds and the development of organic heterogeneous plant reproduction material, while also boosting rural research and innovation in improving organic yields and in developing alternatives to 'contentious inputs' in organic farming. Other actions relate to finding ways to improve animal welfare in organic production and to promote the more efficient and sustainable use of water and the increased use of renewable energy, including reduced nutrient release. The Commission will also be adopting a framework for bio-based, compostable and biodegradable plastic for uses in all types of agriculture.

Progress Made - The European Commission presented its action plan on organic farming to the meeting of the Agriculture and Fisheries Council on 26-27 May 2021. At their meeting on 19 July 2021, EU agriculture ministers adopted the Council's conclusions on this plan, expressing their overall support. Council recognised the contribution that organic farming can make to the protection of the environment and biodiversity, including the fight against climate change and the improvement of animal welfare. Recognising that Member States were at different points in relation to the development of organic farming, it noted that each Member State should make its contribution to the collective effort to achieve the target of 25 % of EU agricultural land under organic farming. The Council conclusions noted that organic farming and production will have an important role to play in the national strategic plans. They also emphasised however that the adoption of national organic action plans by Members States should remain a voluntary decision.

Organic agriculture forms a key part of the European Green deal, involving the implementation of both the 'farm to fork' and biodiversity strategies. In its resolution of 15 January 2020 on the European Green Deal, the European Parliament highlighted how agriculture has the potential to help the EU reduce its emissions through sustainable practices such as organic farming. *A major achievement of the last parliamentary term was the new regulatory framework for organic production (Regulation (EU) 2018/848). In light of the coronavirus pandemic, and in order to ensure the smooth functioning of the organic sector, the date of entry into force of the regulation was deferred until 1 January 2022 (see Regulation (EU) 2020/1693).*

The European Commission presented its action plan to the European Parliament Committee on Agriculture and Rural Development at its meeting on 14-15 April 2021. Members welcomed the proposals but also expressed concerns regarding the implementation of the plan by farmers, raising several issues. These included for example,

- how to reach the target of 25 % of the EU's agricultural land dedicated to organic farming;
- production costs;
- the challenges facing different Member States, the role of innovation;
- and issues relating to distribution and markets outside the EU.

Parliament is set to prepare an own-initiative report on the action plan on organic agriculture. Looking to the future, much will depend on the extent to which Member States will make provision for organic agriculture and production by implementing the action plan through their national CAP

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strategic plans, following the provisional agreement reached between the Council and Parliament on CAP reform on 28 June 2021.

Other factors will also have an influence, such as the response from the farming community and changes in consumer behaviour. This analysis of the action plan has highlighted the range of policies impacting on the future of the organic sector. They include policies pertinent to all elements of the food system: sustainability, health, climate, agricultural promotion, public procurement, the EU schools scheme, training and education, research and innovation (including the role played by agricultural knowledge and innovation systems), taxation and environment and biodiversity. Set in the context of the Commission's action plan, these point to the interdependency across policy areas. There is also a time dimension to the actions listed, with different actions to be initiated over the years 2021 to 2023. A time lag can be expected in terms of implementation of the action plan measures and their impact on the ground. *A mid-term evaluation of the plan is scheduled for 2024*

Findings from the public consultation The Commission held a public consultation between 4 September and 27 November 2020 to gather stakeholders' views on challenges and opportunities for the development of organic production and consumption in the EU. A synopsis of the 840 responses to the consultation (originating from 41 countries representing all EU countries and 14 non-EU countries) from organisations, stakeholders and citizens, was published by the Commission on 3 March 2021. The synopsis showed **a broad consensus on actions needed to stimulate the production of organic products,** for instance:

- the provision of training and advice to stimulate conversion to organic farming (91 % of respondents);
- the need to strengthen local and small scale processing and short food supply chains (90 %);
- support for improving the bargaining power of organic producers;
- the need to improve information and data on developing the organic market;
- and, finally, the need for support from the CAP.

There was also a high level of agreement (91 %) that information on organic products should be transparent and available to consumers. There was recognition of the need for public authorities to ensure compliance with the rules of organic production and for more information campaigns to promote the EU organic logo and organic products. In the case of the latter, more than half of respondents (59 %) considered national authorities to be mainly responsible for promoting organic production.

4.2.4 Policy and Regulatory Stakeholders

Policies falling under the CAP or other directives are shaping the requirements for the use of modern (GNSS-enables, satellite observation) solutions by farmers trying to comply with the specific measures. These policies are driven by strategic objectives set at EU level and are implemented through nationally or regionally established organisations of the Member States. Alongside European and national institutions, new structures such as the European Innovation Partnership “Agricultural Productivity and Sustainability” have been established with the aim to foster competitive and sustainable farming. A brief description of the various institutional actors follows.

At **European Leve**l, the Directorate-General for Agriculture and Rural Development (DG AGRI) is responsible for the implementation of agriculture and rural development policy, the latter being

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managed in conjunction with the other DGs which deal with structural policies. Specific Other DG's and associated agencies have specific responsibilities on subjects related to the implementation of precision agriculture. This includes:

The **EIP-AGRI**, funded under the EU Rural Development Policy, and aiming at catalysing the innovation process in the agricultural sector by bringing research and practice closer together. To this end, the EIP-AGRI has set up a specific **Focus Group working on the topic of mainstreaming precision farming**. The purpose of the group is to: take stock of the state of the art of practice and research in the field of its activity; identify needs from practice and propose R&D and innovation directions, through operational groups or other project formats to test solutions and opportunities. The group, which consists of 20 experts from research, farming and industry has recently published a report on precision farming.

- **DG GROW and GSA** managing the E-GNSS programmes and promoting the uptake of their applications in agriculture respectively
- **DG CONNECT** established the **"Smart farming and food security"** working group that explores how IoT scenarios/ use cases could allow monitoring and control of the plant and animal products life cycle from farm to fork.
- The **JRC MARS** unit develops methods, tools and systems for use within agricultural monitoring activities applied to Europe, sub-Saharan Africa and other areas of the world. It provides scientific and technical support for the Integrated Administration and Control System's (IACS) implementation, cross-compliance implementation and information management linked to the CAP regulations. Crop yield forecasting is undertaken to provide monthly bulletins forecasting crop yields to support the CAP and issue early warnings in case of crop shortages.
- At **National Level**, Member State National administrations, in particular, accredited paying agencies are responsible for the appropriate administration of direct payments to farmers applying for CAP aid and for the technical control of compliance with the specific measures. This includes the performance of the "on the spot" checks verifying the accuracy of field boundary measurements, for which as described earlier accuracy requirements differ between Member States (and thus the correction by GNSS and EO solution is used). It also concerns the implementation at national level of the IACS and in particular the Land Parcel Identification System (LPIS) that covers all agricultural areas.

Other stakeholders are also raising their voice, especially in respect to the new EU decisions and policy making acts in respect to new CAP and Organic Plan. Their positions on the new EU planning and targets are described below:

- **IFOAM – It is the European umbrella organisation for organic food and farming.** IFOAM Organics Europe welcomed the EU action for the new CAP and the Organic farming plan shortly after its publication, highlighting 'its push-pull approach, aimed at balancing increases in production and demand for organic producers'. It welcomed the funds dedicated to the promotion of organic products, the allocation of 30 % from Cluster 6 research and innovation funds to the organic sector, and the involvement of national, regional and local actors, including the implementation of bio-districts. The organisation considered the new action plan to be a net improvement on its predecessor, as it included more specific actions with a timeline for most of them. A subsequent in-depth analysis by IFOAM looked into the challenges and implications of the targets set by the organic action plan for the CAP and Member States' expenditure. It concluded that the Commission should increase its overall CAP expenditure on organic farming three to five fold, raising it from the current 3 % to 9-15 % of farm spending. As for the Member States, the study predicted that those with lower levels of support for organic farming would need to consider a 5-10 fold increase in expenditure

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dedicated to the organic sector, depending on their baselines, in order to deliver a fair contribution to the 25 % overall EU target.

- **Copa Cogeca**, representing farmers and agri-cooperatives, after broadly welcoming the 'market-driven strategy' of the EU action plan, subsequently published a more detailed position paper outlining the main challenges from the farmers' and producers' points of view. In order to meet the 'very ambitious target' set in the action plan, Copa Cogeca emphasised among other points that organic farmers and agri-cooperatives would need public policy support, such as through a promotion policy, and also investment in research and innovation to enhance organic seed and plant protection and increase European production of organic protein feed for livestock and European organic inputs for aquaculture.
- **Eurocommerce,** representing national retail, wholesale and international trade sectors, welcomed the action plan, pointing out that consumer sales of organic production had grown over 120 % over the last 10 years, and would continue to do so if appropriate accompanying measures were taken.
- The **Organic Processing and Trade Association Europe (OPTA)** welcomed the action plan points focusing on a demand-driven approach, including financial support for promotion and for organic in the public procurement, as well as the focus on national organic plans for each Member State. In a paper published in September 2020, OPTA set out its own list of 20 actions for a successful transition to 25 % organic by 2030. A key message from its analysis was the need to reduce the price gap between organic and conventional food by internalising environmental costs into food prices.
- **The European Landowners Organization (ELO)** made the point that a dramatic shift from conventional to organic farming could have unintended consequences. It felt that increasing competition in organic food production could challenge the existing price premium on organic products leading to increased income instability for farms. It also pointed out that in order to equal EU current food production under the target of 25 % of organic farms, a shift in land use would be necessary, implying that untouched areas could be required to be used for farming.

4.3 Technology

The technological environment (mainly ICT) is continuously being improved to enable more services with advanced quality at rural areas. Technology facts and achievements to note are either generic technology trends and infrastructure availability, or agriculture-specific technology achievements.

4.3.1 Digital trends overview

While COVID-19 has dominated the headlines throughout 2020, consistent development and deployment of ICT infrastructure and its concomitant services has meant a continued trend towards digital transformation for societies, businesses and governments alike.

ITU data show that

- in 2019 Internet use surpassed the 50 per cent mark (51.4 per cent globally by the end 2019),
- 75 per cent of the total world population had an active mobile broadband subscription, and
- fixed broadband subscription had grown to just over 15 per cent,
- Over 57 per cent of households today have Internet access at home.

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Moreover, given the increase in demand for data due to increasingly bandwidth-intensive services, international bandwidth has, on average, grown at a compound annual growth rate ("CAGR") of 36 per cent between 2017 and 2020, with a CAGR for international bandwidth per Internet user of 26 per cent between 2017 and 2019. Yet, the digital divide persists.

While almost all urban areas in the world are covered by a mobile broadband network, many gaps persist in rural areas.

As most countries across the world grapple with the effects of the COVID-19 pandemic, the role of ICTs and services, and the digital infrastructure that they ride and scale on has become central to continued economic and societal activity and to lessening the pandemic's impact. Overall, the impact of the pandemic has been to accelerate digital transformation, as businesses move towards distributed models of employment and digital delivery of services and products. Individuals forego travel and socializing and turn towards digital entertainment and communication platforms but also, increasingly, to e-commerce. Schools move to online learning and digital classrooms, and governments increasingly rely on and need data on citizens, health, and economic indicators to establish policies. While research on the contribution of digitization to soften the impact of pandemics is limited, emerging evidence is compelling about its accelerating effects across all areas of people's lives and sectors of the economy.

Generally, the pandemic has forced a greater demand for digital reliance and this outcome is here to stay in the "new normal" as the utility of more abundant data and the lowering transaction costs of using that data impact how entrepreneurs, policy-makers and professionals make decisions. The pandemic, however, is just one driver of current trends. Climate responsibility, continued economic development, demographic shifts and social wellbeing are also other key drivers.

In the light of these global trends, policy development focused on inclusion, access, security, skills and sustainability in terms of emerging technologies and their benefits is poised to become one of the defining characteristics of the 2020s. This is mirrored in the ITU thematic priorities for Europe that remain highly relevant going forward.

Artificial intelligence, the Internet of Things, cloud computing, distributed ledger technology, precision medicine, digital trade, autonomous mobility, and many more evolving technological arenas will shape the future of the world, and Europe in it. Europe has the opportunity to set an example for the world in policy development and implementation, given its top spot in many ICT indicator rankings and considering that it also leads other regions in the ITU G5 Benchmark for regulatory excellence.

For example, the increasing demand for digital transformation affects a broad range of stakeholders, and a collaborative regulatory response could set a responsible policy development approach not only for ICT regulation, but also for all emerging technologies that depend on the ICT infrastructure foundation. Ultimately, at the heart of this historical transformation, ICT infrastructure is the predominant enabler, along with fit-for-purpose policy, of Europe's future competitiveness and global leadership. We cannot lose sight of the fact that improving ICT infrastructure is more than a goal for operators and consumers. It does much more than facilitate mobile and broadband connections. It facilitates the backbone for global supply chain integration, the innovative use of critical health information, the opportunity for citizens to improve their options in the workforce, the ability for students to gain skillsets previously unavailable to them, and many more positive externalities that are changing the course of history. Indeed, it will be history that looks back at this early era of technological development to see how policies and governance approaches reinforced the resilience and responsiveness of societies, all the while assessing for risks, protecting consumers and enabling positive outcomes for citizens.

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Focusing within EU, Europe region has seen continued growth in most areas of ICT infrastructure, access, and use and leads globally across all ICT indicators:

- Mobile network coverage is just shy of 100 per cent,
- Internet use by individuals is above 80 per cent, \Internet access at home is nearing 90 per cent and
- almost 100 per cent of 15- to 24-year-olds are using the Internet.

In addition,

- Europe has the most affordable ICT prices, ahead of the CIS region.
- While a digital divide persists, rural Internet access by household has increased to 78 per cent
- the gender gap has decreased, with a five-percentage-point difference remaining between women's and men's Internet use.

Most European countries have achieved levels of basic ICT skills above 40 per cent, but great variation remains in relation to standard and advanced skills.

Europe has progressed significantly in the area of cybersecurity, with all countries having cybercriminal legislation and cybersecurity regulation in place.

In terms of ICT infrastructure developments and integrated technologies, there is still ample room with regard to AI capability and capacity development that can be fostered through advancing standardization to achieve the necessary scale.

While in the area of IoT, Europe is well-positioned and at the forefront of adoption across a number of countries, a fragmented policy environment stands in the way of accelerated progress. On the other hand, Europe is leading the way in cloud technology governance and policy development, a key enabler of IoT and other ICTs.

The COVID-19 pandemic has had a profound impact on Europe and has pushed consumers and businesses alike in the adoption of digital services and technologies, accelerating digital transformation of some areas of business by several years. Most network operators were able to cope with the increased demand on their networks, providing a good stress test for the future and highlighting areas that require increased attention. The positive ICT developments and trends have been underpinned and accompanied by state-of-the-art G5 regulatory frameworks that are based on a new regulatory paradigm of collaborative regulation.

Europe is at the forefront of this new regulatory paradigm and leads other regions by far with 28 fourth generation and 10 fifth generation regulators. Many projects, programmes and initiatives have been undertaken jointly by ITU-D and Member States across all of the ITU Office for Europe's five thematic priorities, including broadband infrastructure, e-government services, digital inclusion and accessibility, cybersecurity and trust in ICTs and innovation.

The outlook for the European ICT market is positive and the Europe region together with the ITU Office for Europe stand ready to build on the progress achieved and to address challenges where these persist.

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More analysis on these technology trends are described in ITU Publications, 'Digital trends in Europe 2021 ICT trends and developments in Europe, 2017-2020'[22]

4.3.2 Agri-specific technology

Sentinel-2 Data enable Check By Monitoring - Assessing its Spatial Limits on Arable Crops is surveyed
The European Copernicus program operates its own constellation of Earth observation satellites and produces an immense amount of satellite data. Together with the fast development of cloud processing platform services, it gave rise to an impulse to exploit these resources and technology advances within the EU's Common Agriculture Policy (CAP).

The availability of large amounts of Sentinel-2 data has been a trigger for its increasing exploitation in various types of applications. The Sentinel-2 imagery is promising to support checks by monitoring, a newly introduced control approach within the European Common Agriculture Policy framework.

As the CbM approach is based upon the use of Copernicus Sentinel data (Sentinel-1/2), its application scope is limited by the radiometric and geometric characteristics of these satellites. While the revisit time of Sentinel satellites provides an unprecedented temporal resolution, the ground sampling distance (GSD) and geometric positional accuracy could be too coarse for smaller spatial features. The CbM faces a tradeoff between the large amount of free data and its medium spatial resolution.

It is, therefore, of importance to understand the limits above which these data still guarantee a meaningful outcome. Current OTSC image data have a spatial resolution of no more than 2.2 m for a panchromatic band. As a result, one of the major concerns of the EU Member States regarding the operational implementation of monitoring is the perceived inadequacy of the Sentinel sources for small fields. Cases where conclusion cannot be made regarding the eligibility of Sentinel imagery due to the size of the field (or other observed features) require alternative data sources, such as a higher resolution data stack, geotagged photographs, or field inspections. Inevitably, these alternative sources and processes have a higher cost than the automated processing of free Sentinel data, so managing them is essential.

The introduction of the checks by monitoring approach in the framework of the European Common Agriculture Policy gave an impulse to explore and assess the ability of Sentinel-2 data to detect a parcel's behavior in terms of the geometry of that parcel. Recent research[23] demonstrated that the size of the parcel is not an appropriate measure for the evaluation of Sentinel-2 data suitability for CbM. The number of full pixels and the ratio of pixels lost after the application of a half-pixel-wide negative buffer emerged as more appropriate parameters. Research findings also suggest that the surrounding land use or land cover is a relevant factor that needs to be duly taken into account.
For the majority of tested parcels, the Sentinel-2 data provided the same or similar information about the state and the activity on the field. Considering the deliberate small size of the parcels in the studied samples, the results proved the high potential of Sentinel-2 imagery. Thus, for the checks by

[22] https://www.itu.int/en/ITU-D/Regional-Presence/Europe/Documents/Publications/Digital-Trends_Europe-E.pdf

[23] https://ec.europa.eu/jrc/en/publication/assessing-spatial-limits-sentinel-2-data-arable-crops-context-checks-monitoring

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monitoring, the study provided evidence of a good design strategy involving the trade-off between the temporal and spatial resolution of the Sentinel-2 satellite.

The limiting criteria expressed by geospatial parcel parameters serve to identify a group of "vulnerable" agricultural parcels for which there is a high probability that Sentinel-2 might not be a suitable satellite to assess their state and related agricultural activity. Member states, therefore, need to adopt the definition of these spatial limits when designing their monitoring approaches.

Cloud-free crop maps foster sustainable farming - A new commercial service cleverly combines radar data from Copernicus Sentinel-1 and optical data from Copernicus Sentinel-2 to offer daily maps of field-scale crop biomass. Importantly, these maps are completely unimpeded by cloud cover. This new service allows farmers to better monitor and assess the growth of their produce, and, ultimately, make more effective decisions. The service is the result of a collaboration between VanderSat and BASF Digital Farming GmbH, and sees the integration of VanderSat's innovative Cloud-free Biomass product with BASF Digital Farming's xarvio™ Field Manager.

VanderSat incorporates satellite data into products and services focused on the management of crops and water resources. The BASF xarvio Field Manager, which is already used by more than 40 000 farms around the world, is a digital application that combines knowledge and data on fields and crops for plot-specific management.

The service (cloud-free Biomass) combines radar technology, both passive and active, with optical satellite images to continually measure biophysical parameters and water content in vegetation, which accurately calculates all stages of crop growth during the entire growing season It builds on the long-term cooperation between ESA and BASF to evaluate how satellite-derived data and images can be best used for agricultural purposes. Working closely with farmers, the goal was to translate this information into digital tools and services to optimise agricultural practices.

The way VanderSat and BASF Digital Farming have been able to combine different types of satellite data to achieve cloud-free coverage for the service is a game-changer – a prime example of science being turned into a commercial product. Images from satellites carrying optical 'camera-like' instruments can be used to measure spectral greenness and to subsequently derive a measure of 'normalised difference vegetation index', NDVI. However, these satellite images can only be captured during daylight and when the skies are free of cloud. In some parts of the world such as Western Europe, the daytime skies can be cloudy as much as 70% of the year. And, at times, it can take more than two weeks to receive cloud-free images of a particular area.

Also, growth underneath the crop canopy cannot always be detected. This is clearly less than optimum if you are a farmer trying to monitor crop conditions, which can change very quickly in the growing season. The beauty of the Cloud-free Biomass service is that it combines optical images from Sentinel-2 with radar images from Sentinel-1 mission, which has the advantage of being able to image regardless of daylight or cloud cover.

Satellite radar interferometry effective for mapping crops - Traditionally, optical, or 'camera-like', satellite images are used to map different crops from space, but a recent study shows that Copernicus Sentinel-1 radar data along with *interferometric processing* can make crop-type mapping even better. This, in turn, will help improve crop-yield forecasts, production statistics, drought and storm damage assessments, and more. The Sentinel-1 mission comprises two identical satellites, each carrying an advanced radar instrument to provide a day-and-night, all-weather supply of images of Earth's surface.

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These images are used for numerous applications such as monitoring sea ice and floods, as well as shifts in the land surface or ice surface through the process of interferometry (InSAR) – which is where images of the same place from consecutive satellite passes are compared to reveal differences that occurred between image acquisitions. Part of this research was carried out through ESA's SInCohMap[24] project, which is dedicated to exploring innovative methodologies for land-cover and vegetation mapping using Sentinel-1 multitemporal InSAR coherence data. The constellation of the two identical Sentinel-1 satellites orbiting Earth 180° apart allows most parts of the world to be imaged every six days. The satellites' radar instruments can transmit a signal in either horizontal (H) or vertical (V) polarisation, and then receive in both H and V polarisations.

Crop-type mapping using satellite imagery plays a key role in Europe's Common Agricultural Policy, in which 'checks by monitoring' are being established routinely to reduce field work and the associated bureaucracy. Moreover, it also helps monitor potential threats to ecosystems if new crops are introduced close to protected areas. During the development of the SInCohMap project, all the possible combinations of images acquired in one year were computed and analysed.

EOS to launch LEO system for digital precision agriculture - The satellite imagery analytics provider EOS plans to launch seven optical satellites into LEO by 2024 according to the Californian company saying. By launching its own satellite imaging constellation, the company aims to establish a full satellite data production vertical – from direct imagery collection to processing, analysis and delivery. One of the key objectives of the new satellite constellation will be monitoring of farmlands, making this project the first of its kind oriented towards agriculture according to the firm. With these new satellites, EOS Data Analytics will increase the accessibility and accuracy of satellite monitoring features, which will help address pressing global challenges, such as climate change, land degradation, environmental threats, and more. EOS offers Earth observation solutions for "smart decision-making" in agriculture, mining, oil, military, and other industries.

Easier Geotagging (with ABACO[25] Geophoto) - ABACO, a NIVA[26] project partner, has released in 2021 a new version of ABACO GEOPHOTO, the app for hand-held devices to collect photographic evidence with certified location data, built with and for farmers. ABACO GEOPHOTO is currently supporting for more than three years several national and regional Common Agricultural Policy (CAP) Paying Agencies. Farmers and surveyors are pro-actively involved in a variety of situations in CAP checks and management, including Rapid Field Visits (RFV), update of the Land Parcel Identification System (LPIS), ground truthing and supporting the Checks by Monitoring. The app fully responds to the current technical requirements and recommendations of the EU Commission. The app has included several additional capabilities, like a chat, a calendar, a task list, navigation to target, and much more. Beyond the app, the system includes backend management capabilities required to handle the large amount of data collected and to support decisions. It is also used to collect information in Farm Management Information Systems (FMIS), to collect documentation on crop growth, and to enable data exchange with Consultants and Farm Advisors. This is done alongside new capabilities to capture additional field data. The newer version of ABACO GEOPHOTO includes the EGNSS4CAP libraries from the European Space Agency (EUSPA, former GSA) to fully exploit the capabilities of the Galileo satellite constellation and becoming a perfect example on how a commercial provider has given continuity to a previous public investment in baseline technology.

[24] The project "Sentinel-1 Interferometric Coherence for Vegetation and Mapping" (http://www.sincohmap.org/)

[25] ABACO systems is a worldwide (www.abaco.com) leader, with 30+ years' experience, in modular, high performance, open architecture, standards-based rugged embedded computing for the most demanding applications in defense and industry.

[26] The NIVA project: New IACS Vision In Action (https://www.niva4cap.eu/)

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Advanced Cloud infrastructures enable the convergent use of HPC and big data in favor of demanding application including agriculture - The largest constraint to satellite-based model performance is now training data rather than imagery. While imagery has become abundant, the scarcity and frequent unreliability of ground data make both training and validation of satellite-based models difficult. Expanding the quantity and quality of such data will quickly accelerate progress in this field. Other opportunities for advancement include improvements in model interpretability, fusion of satellites with other nontraditional data that provide complementary information, and more-rigorous evaluation of satellite-based approaches (relative to available alternatives) in the context of specific use cases. Nevertheless, despite the current and future promise of satellite-based approaches, these approaches will amplify rather than replace existing ground-based data collection efforts in most settings. Many outcomes of interest will likely never be accurately estimated with satellites; for outcomes where satellites do have predictive power, high-quality local training data can nearly always improve model performance.

Therefore, the evolution of cloud platforms that can support the flexible deployment of data pipelines combining performance and easy adaptation to processing technologies such as big data processing systems (such as Spark, Kafka streaming, ..) while also exploiting HPC (GPUs, FPGAs), will respond to the increased need for many data sources with different processing patterns and high demanding data volumes and rates.

Environmental monitoring by JRC - Environmental monitoring can be described as a programme of recurring, systematic studies that reveals the state of the environment. The specific aspects of the environment to be studied are determined by environmental objectives and environmental legislation. The purpose of environmental monitoring is to assess the progress made to achieve given environmental objectives and to help detect new environmental issues. The results are of fundamental importance to environmental management in general, as the drafting and prioritisation of environmental policies is based on the findings of environmental monitoring.
The JRC's work supports Copernicus (the European Earth Observation Programme), the Water Framework Directive[27] , the Marine Strategy Framework Directive, EU Food Security policy, European Climate Policy, EU Strategy for Sustainable Development, the Directive on ambient air quality and the Clean Air For Europe programme.

The JRC is involved in numerous environmental monitoring activities that survey a steadily increasing number of environmental pollutants in our ecosystems, the shortage of food and water supplies, the rapidly evolving state of climate change, and natural disasters and hazards. The JRC supports the implementation of related EU and global policies, contributes to the exchange of best practice, and develops, implements and harmonises methods of testing.

- **Air monitoring -** The JRC supports long-term greenhouse gas (GHG) monitoring, in particular within the European 'Integrated Carbon Observation System' (ICOS) and through activities within Copernicus - the European Earth Observation Programme. The JRC monitors and evaluates the effects of air pollution and climate change policies on the Earth System to determine their effectiveness and provide early warnings of potential risks.
  The JRC maintains the Emissions Database for Global Atmospheric Research (EDGAR)[28]. This is an online inventory of emissions of GHGs and air pollutants. With this database the JRC shows global emission trends in a comparable and consistent manner to analyse energy, climate and air pollution policies for industrialised and developing countries.

[27] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:02000L0060-20090625:EN:NOT
[28] http://edgar.jrc.ec.europa.eu/index.php

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The JRC also supports the Climate Service of Copernicus, the European Earth Observation Programme[29], by working on the standardisation of Earth Observation products and services related to climate change. This involves making on-site measurements, developing and benchmarking new satellite products and assuring compliance with international standards.
Furthermore, the JRC supports the implementation of the Kyoto Protocol by controlling and reviewing the EU Member States' submissions and contributions to the European Union Greenhouse Gas Inventory report.
Through Greenhouse Gases in Agriculture, Forestry and Other Land Uses in Europe (AFOLU DATA) information system, the JRC provides data, models and other tools to promote transparent, complete and comparable greenhouse gas estimates for this sector in Europe.
The Air Quality Framework Directive and its daughter directive require the monitoring of a range of parameters. Examples of certified reference materials provided by the JRC in this field are polycyclic aromatic hydrocarbons (PAHs) and selected heavy metals in a PM_{10}-like dust, trace elements or dioxins in fly ash, and platinum group elements in road dust.

- **Water monitoring -** The JRC's work on water monitoring covers the monitoring of water quality and assessment of the impact of pollutants and chemicals, the monitoring of water and marine ecosystems, the provision of early warnings and risk management, the monitoring of floods and droughts and the monitoring of water quantity in Europe and worldwide.
  The Water Monitoring Service, set up in the context of the GEOLAND[30] research project, addresses water management issues in the context of the Water Framework Directive[31] and the Floods Directive[32] in Europe. Both directives require quality assured and harmonised information on water quality and quantity as well as tools for making predictions.
  The Water Monitoring Service provides a pan-European model that aims to compare country-specific models in order to address cross-border catchment issues and the integrated analysis of transnational water bodies.
  The models provide information on water balance, flows in all major streams and rivers, soil moisture level, lake/reservoir levels, snow water equivalents, and regional snow coverage.
  The system can be used for prediction of the current and future hydrological climate.
  In the context of water monitoring and acquisition of reliable and comparable analytical data, the JRC develops suitable reference materials for substances on the priority list in freshwater, seawater and related matrices such as biota and sediment.

- **Ecosystem services monitoring-** One of JRC's main roles in this area is to provide tools for the monitoring of ecosystems and agrosystems, and to contribute to the understanding of the interactions between development, environment, and security issues. It fulfils this role by engaging in near-real-time monitoring activities using satellite data and dedicated geospatial knowledge management systems.

[29] http://copernicus.eu/
[30] http://www.gmes-geoland.info/project-background/project-tasks/core-information-services/water-services.html
[31] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:02000L0060-20090625:EN:NOT
[32] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32007L0060:en:NOT

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- **Biodiversity monitoring -** The Digital Observatory for Protected Areas (DOPA)[33] is a biodiversity information system that functions as an assessment, monitoring and forecasting tool for biodiversity. It was developed to support the ambitious mission of the Convention on Biological Diversity (CBD) for 2020: to halt the loss of biodiversity and to share the values and benefits of biodiversity and ecosystem services equitably. DOPA is designed to provide decision makers with the most relevant, reliable and up-to-date scientific information obtained from ground and space observations in order to assess pressures on protected areas, as well as analytical tools to identify areas that are most suitable for conservation.

- **Fire, drought and flood monitoring -** The JRC focuses on the improvement of early warning, monitoring and damage assessment systems for weather-driven natural hazards. Modelling is a fundamental tool for assessing climate change effects and the occurrence of natural events such as forest fires, floods and droughts.

4.4 SWOT Analysis

The SWOT analysis made for ENVISION is a preliminary one, based on the envisaged goals and achievements; however, the definite identification, analysis and validation of all SWOT items, will be possible upon the completion of all data products and deliverables of the project. Current SWOT has been made based on a) findings described in D2.1 "Review of Current Services Provision" as it has been expressed by PAs and CBs who participated into relevant surveys and b) new items found through the analysis of the market outlook data, related to legal, political, technological and market environment and facts. The subsections below include all these points ; the ones replicated in the deliverable D2.1 are discriminated.

4.4.1 Strengths

Current market outlook views identify the following strengths for the ENVISION outcome and approach:

- Increased accuracy: The inability of current systems into addressing resolution and accuracy is addressed by an envisaged 3-5% increase in resolution / accuracy compared to the state-of-the-art. Spatial and temporal resolution of each data product (crop classification, grassland mowing and soil indices) will reach 10 and 20m at parcel level. ENVISION will deploy SOC[34] monitoring at high spatial and time resolution over a large area.
- Ability to expand and build more: ENVISION add-on development tool will enable the creation of an ecosystem of developers and engineers to build and adapt (or optimize) new services to evolving rules and standards
- Enhanced spatial and temporal inspection capacity with cost-efficiency- Through the use of EO technology the entire area of agricultural land under the jurisdiction of PAs and CBs can be

[33] https://dopa.jrc.ec.europa.eu/dopa/

[34] This is due to the selection algorithms that will be applied to every step of the process, in order to minimize the influence of all the disturbing factors (clouds, soil moisture, vegetation, etc.) and consequently improve the reliability of the SOC mapping. ENVISION exploits the short revisit time of the Sentinel-2 constellation to provide a SOC time trend, thus not only a static picture linked to a singular acquisition date. The continuous spatial and temporal monitoring of the SOC in croplands, will be extremely important not only from the environmental perspective to limit soil degradation, but from an economic perspective as well.

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monitored continuously in a cost-efficient way, instead of a small sample of farm land once a year.

- High fusion of multimodal data is a strong feature. ENVISION uses Feature Level fusion to combine multimodal satellite data and other agricultural practices relevant geospatial information, stacked in the ENVISION Data Cube[35].
- Emphasizing on sustainability - ENVISION brings in the first Sustainable Agricultural Practice Monitoring Data Cube, populated with all kinds of relevant datasets, including satellite, geospatial, meteorological and climatological data[36].

D2.1 findings:

- EO based remote monitoring services are identified as cost-effective solutions by greatly reducing the need for frequent on-farm inspections and minimising computational time, inspection time on-site, travel costs for the relevant assessments, particularly as more and more inspectors get familiar with these
- capacity to store data for more than 10 years and flexibility, where organisations can either implemented 'ready-to-use' systems or adapt and develop 'in-house' solutions, are reported as the strongest features of the remote monitoring services
- remote and continuous monitoring leaves less room for the farmers to not comply with relevant agri-environmental policies
- Remote monitoring helps organisations maintain safety of their employees during the Covid-19 pandemic while enabling continuity of services.

4.4.2 Weaknesses

Current market outlook views identify the following weaknesses, mainly because of difficulties that need to be faced by innovative monitoring and inspection systems:

- Difficulties in changing the working practices of public officers.
- Public officers are lacking shared understanding on how to make best use of EO-enabled technologies and the insights obtained from their processing.
- Public authorities are reluctant to replace their existing systems and start using EO enabled services to allow the scaleup of their systems.

[35] An indicative application of the approach is the creation of a downscaled Normalized Difference Vegetation Index (NDVI) product, a typical RS index that is used for crop growth monitoring and the computation of phenology metrics. Combining Sentinel-2 data at 10 meters resolution and with a 5- day revisit time, with MODIS data at 250 meters resolution and with at least two daily acquisitions, data fusion can improve both the spatial and the temporal resolution of NDVI. The fusion of information becomes more effective and efficient through the use of gridded, normalized and resampled datasets in the Data Cube. Another indicative application is the fusion of SAR Sentinel-1 and optical Sentinel-2 data, firstly to enhance the accuracy of the crop type mapping method in Northern, frequently clouded countries; and secondly to detect textural changes on the landscape that indicate ploughing or mowing.

[36] The Cube is designed specifically to serve the monitoring of sustainable agricultural practices. It updates and stores the relevant data, indices and products that in turn feed the alerting (compliance breach and event detection – i.e. mowing, harvesting etc) system at the knowledge tier. Another novelty of this foreseen monitoring approach is to enable multi-year compliance assessment for instance, looking at actual crop rotation for a given parcel rather than merely looking at crop diversification at the exploitation level. Such a monitoring approach is expected to simplify and enhance transparency for all parties and the nationwide coverage allows targeting major concerns rather than focusing on peculiar and marginal issues detected in specific control areas.

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ENVISION is addressing these weaknesses throughout the project duration; however, efficiency of its approach needs to be proved and concerns about the witnessed weaknesses will remain after the end of the project.

D2.1 findings for existing systems are raising concerns for new monitoring system, such as ENVISION. Concerns for weakness include the following for ENVISION to address:

- need for personnel to receive training and update knowledge regarding the newly developed IT systems
- current services are unable to detect many of the practices included in the CAP cross compliance measures, and they are not accurate enough to address the specific needs of many countries that are defined by high diversity in crops, high topographic variability and a system of small parcels. Because of these weaknesses, PAs cannot see remote monitoring as a replacement for on-farm inspections, but as a supplement for only a few specific services.
- it is difficult to address issues of privacy and confidentiality expressed by their members – claimants, when using such systems.

limitations such as the inability to collect and analyse crop, soil and water samples, observe and assess biodiversity, evaluate crop health, and estimate the usage of fertilisers and pesticides

4.4.3 Opportunities

Current market outlook views identify the following opportunities motivating ENVISION:

- New CAP has higher ambitions in respect to green rules compliance and sustainability practices[37]
- The increasing importance of the SOC content for the cross-compliance rules for CAP post-2020 opens new business opportunities. ENVISION emphasizes on SOC monitoring with high quality and accuracy
- New Eco-schemes[38] will be defined by each Member State, which need flexible and continuous monitoring[39]
- The developers' ecosystem of ENVISION can become the most powerful feature. Established agri-technology actors are potential development partners to exploit the add-on component, members of ENVISION ecosystem
- Workload of PAs and CBs will increase dramatically. Automation will be urgent to apply
- Complexity of rules associated with targets (biodiversity gas emissions, air quality, food security) require new technologies for continuous and territory wide remote monitoring

[37] Among the 9 objectives of the new CAP, environmental care and preserving landscapes and biodiversity are addressed and the Commission has set high ambitions on these issues. The "enhanced conditionality" is a new integral part of the CAP2020+ framework and replaces 'greening' and cross-compliance of the current CAP. The EU is seeking a dual benefit, on the one hand through the preservation of the environment given that substantial environmental challenges remain and on the other hand as data from the Copernicus Sentinels and other Earth observation missions can replace the physical visits to farms and the time-consuming checks and consequently realizing simplification.

[38] Particularly on organic farming, the legislative proposals indicate as an option for Member States, to be obliged to allocate 30% of pillar I payments to provide top ups for four schemes that would be voluntary for farmers, one of which is organic farming. Moreover it is indicated for Member States that they may decide to set up eco-schemes for agricultural practices such as, again among others, for organic farming, while as it always was through the years, organic farming is envisaged as one of the types of intervention in the rural development programmes of the post 2020 programming period.

[39] The CAP reform aims strongly to simplification, enhanced by using furthermore than in the past, remote sensing technology for continuous monitoring.

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- The availability of Copernicus and GEOSS data along with EO technology provides the fastest, most objective, straightforward, and cost-effective solution to successfully monitor farmers' performance in relation to environmentally-friendly practices

D2.1 findings:

- The provision of high quality, mobile internet connections to rural areas and farms across the countries. The enhancement of current internet-network provision will greatly benefit adoption of remote monitoring methods.
- PAs suggested that another avenue for research that could greatly increase adoption of remote monitoring systems is the improved accuracy of the services by updating the relevant algorithms and increasing spatiotemporal resolution of available data
- The use of a common platform for all services and a common data format, could further support the implementation of new IT systems

The increase of spatiotemporal resolution of relevant data products will facilitate observations of inaccessible plots for several critical growing periods throughout the year

4.4.4 Threats

Current market outlook views identify the following threats for ENVISION to address:

- Delays of Member States policy to deploy their national plans towards organic farming
- Emerging competition with established relations at national levels with national PAs are having advantage at certain countries for high penetration of crop types

D2.1 findings:

- potential increases in the cost of development and implementation of services
- cost of training of employees to use new services
- potential lack of consensus among developers about the uniformity of data and platforms between past, current and future system configurations
- complex IT services may not be adapted in time to accommodate changes in relevant legislation and policies, particularly when there is little available information and high uncertainty prior to these
- current regulations enforce on-farm inspections and therefore should be adapted to recognise and promote the use of remote auditing

4.5 PESTLE Analysis

The overall PESTLE review is summarised below:

Political – The CAP reform and the main actors (described in Section 4.2.4 Policy and Regulatory Stakeholders) are defining the political environment for ENVISION. The motivating policy that favours ENVISION exploitation is shaped by the new eco-schemes (schemes for the environment and climate). They are the main innovation in the green architecture of the CAP proposed by the Commission. As mandatory instruments, they will oblige Member States to allocate a proportion of their payments to schemes that would directly benefit the environment and climate. The Commission's notes that *"*Member States may decide to set up eco-schemes for agricultural practices such as the enhanced management of permanent pastures and landscape features, and organic farming. These schemes may also include 'entry-level schemes' which may be a condition for taking up more ambitious rural development commitments". Two things are worth highlighting. First, the practices mentioned vary from entry-level schemes through creation of or enhanced management of landscape features to organic farming. Second, it seems to give Member States the flexibility to design eco-schemes as the

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lower level of an implied hierarchy of ambition, with even the suggestion that participation in an eco-scheme might be a condition for participation in an agri-environment-climate measure (AECM), or to programme them as particular interventions working alongside AECMs in a complementary but independent way. In this way, eco-schemes could pay for practices that are even more ambitious and go beyond practices that are funded under AECMs.

Eco-schemes in the CAP will be a major new tool to support precision farming, organic farming, agro-ecology and agro-forestry – as well as other approaches or specific practices relevant to climate change, management of natural resources, and biodiversity. Eco-schemes will allow a large number of farms to improve their environmental performance. The main four flagship eco-schemes announced in the Farm to Fork Strategy were, in brief:

- **Agro-forestry**. While the flagship proposal defines agro-forestry as a particular type of land-use system and technology where woody perennials (trees, shrubs, etc.) are deliberately used on the same land management unit as agricultural crops and/or animals, there is no clear indication how eco-schemes might be used to promote agro-forestry. In the presentation to the Council Working Party, the agro-forestry flagship is confusingly re-interpreted as landscape and biodiversity on agricultural lands. Relevant eco-scheme practices suggested included land lying fallow and establishment and management of landscape features to improve their quality, which are defined as agro-ecology in the flagship proposal.
- **Agro-ecology**. The flagship proposal defines agro-ecology as practices that rely on, and maximize, ecological processes to support the production system. A relatively long list of possible eco-scheme practices are suggested, including organic farming; sustainable land management practices; enhanced crop rotation, for example, including leguminous crops; landscape features; land lying fallow; support for low to moderate grazing; and implementation of flower strips, margins strips and high diversity grassland strips.
- **Precision farming**. This is defined as a management concept focusing on observation, measurement and responses to inter- and intra-variability in crops, fields and animals using ICT-based sensor technologies and software. Support for a nutrient management plan is highlighted as a possible eco-scheme practice
- **Carbon farming.** This refers to farm activities having an effect on carbon pools in soils and vegetation. Again, there is a lengthy list of possible practices that could be supported by an eco-scheme: conservation agriculture, cover crops, afforestation, rewetting of peatlands, conversion of arable land to grassland, and grassland management (e.g. switching to multisward grasslands).

The most interesting aspect of the policy environment for ENVISION will be country-specific and dependent. Member States are currently engaged in the design of their CAP Strategic Plans. A key innovation in the green architecture in the future CAP are eco-schemes. Because of their novelty, there is a lot of uncertainty around how eco-schemes might work in practice, and how best they might be designed to contribute to the environmental and climate objectives of Member State Strategic Plans. Further uncertainty arises because amendments proposed by both the Council and Parliament could radically change the scope of eco-schemes from that envisaged in the Commission proposal.

In response to Member State requests, the Commission has provided guidance on how it sees eco-schemes operating. It has made clear that eco-schemes can be designed around multi-annual contracts, but they also provide additional flexibility in that they can also fund annual interventions. Member States will also be able to limit access to eco-schemes if the potential enrolment would require unit payment values to vary by more than provided for in the CAP Strategic Plan.

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The Commission has highlighted various eco-scheme flagships that it sees as particularly appropriate for eco-schemes. However, they are not the final ones and work is in progress as they might not fit perfectly the characteristics of eco-schemes. Alternative practices would seem to better fit the specific new characteristics of eco-schemes, suited where:

- the intention is to support existing agricultural management options that are environmentally beneficial but challenged by under-exploitation or even abandonment;
- an intended change in the farming practice is continuous in nature;
- the annual duration of eco-schemes has strong environmental advantages;
- the annual duration can open doors in the agricultural community and when the negative effects with respect to environmental efficacy are limited;
- they can mitigate problems of national administrative law

Further discussion to clarify these issues are required and the Commission itself has recognised this; therefore exchange sessions in expert groups or management committees have been organized in 2021 in this direction.

The environmental performance of the new green architecture in general and the eco-schemes in particular depends on three general aspects:

- The measures are effective on a unit base (i.e. per ha, per animal, …).
- The overall implementation level of the measure is sufficient to modify the picture on an aggregate scale.
- The payment levels are adequately related to the environmental output provided.

Much of the public debate around eco-schemes focuses on the selection of measures, while the remaining two aspects somehow fly under the radar. All in all, the design of eco-schemes remains a work in progress, and the final outcome as well as the actual deployment plan per Member State will affect ENVISION planning.

Economical – The economy factor is stressed by the payment agencies need to a. increase cost-efficiency of check procedures and b. reduce the risk of future financial corrections.

The cost-efficiency of CbM is obvious, as it targets to continuous monitoring off all land parcels without needing travel costs and on site visits for all cases. ENVISION fully complies to this objective; its orientation is strongly supported by the migration in progress, from OTSC to CbM.

However, although the Commission encourages the use of new technologies - especially for monitoring direct payment area aid - paying agencies are concerned about the possible outcomes of future Commission's audits, that might cause financial corrections and delay in the process. These concerns are being addressed by continuous revisits and discussions on the regulatory field, as described in the relevant PEST**L**E paragraphs.

Last but not least, the economic factor is important also for farmers to prefer checks by monitoring approach, as it generates data useful for smart farming which can provide them with economic benefits. For example,

a. satellite images can provide information about soil nitrogen content or drought stress, which could optimise fertiliser application or irrigation, cutting costs for the farmer and reducing the negative environmental impacts of the agricultural activity,

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b. early detection of non compliance enables them to apply corrective actions and avoid penalties, loss of funding. One of the decisive reasons to adopt checks by monitoring is the ability to prevent penalties by informing the beneficiary of potential non-compliances and allowing for remedial actions. With checks by monitoring, beneficiaries have the possibility to amend the aid application based on continuously updated information on the activities on the farm and a dialogue with the paying agency in charge. This option is not available with the classical control approach. After a classical field inspection, reductions and penalties are applied for non-compliances detected. ENVISION 's increased accuracy will improve trustworthiness of CbM results, thus avoiding need of extra visits and increasing assurance levels for both farmers and auditing entities.

Social - As ENVISION targets mainly PAs and CBs, the social factor might not sound so strong to consider; however, it affects a. the level of strength the society will demand high quality and sustainable farming and b. the ways to achieve trustworthy agriculture products for the society and the environment. Therefore, the social factor for ENVISION market remains important; it is featured the following three main items:

1. Aged farmers are more reluctant to adopt new practices.
2. COVID-19 impact on business models boosted telework practices
3. Consumer demand for organic, environment-friendly and healthy food

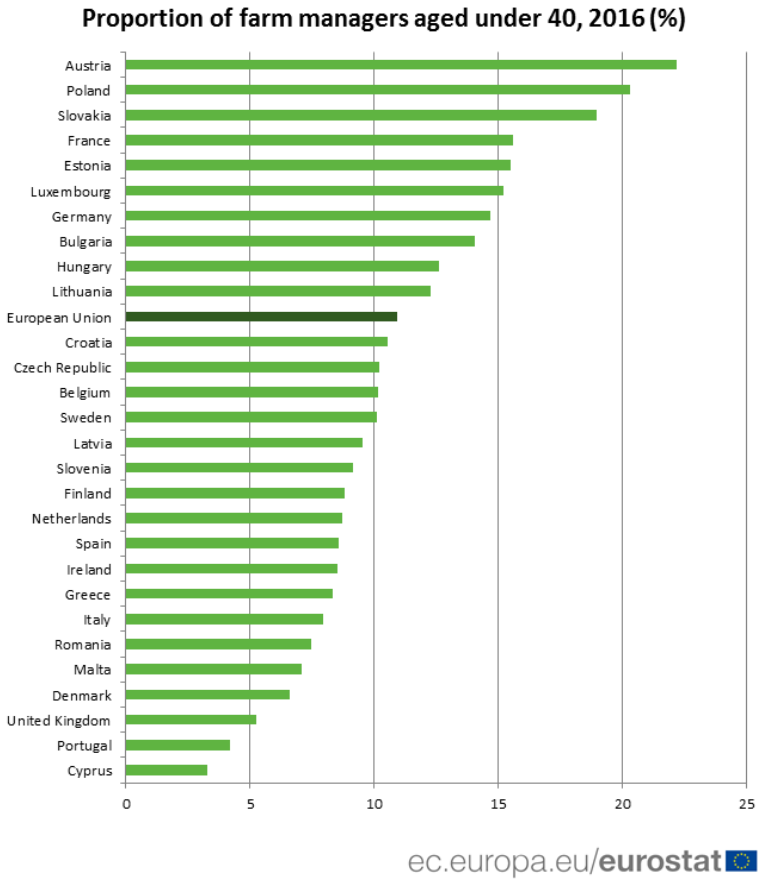

Figure 5 Aging of farmers across country (Eurostat, 2016)

ENVISION market demand will be higher, as long as farmers will migrate to new practices and adopt eco-schemes. However, the adoption rate is affected by the number of young farmers; it is not easy

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for aged farmers to change practices and employ more ICT-dependent and environment friendly practices. The figures so far (Figure 5) show that in most EU countries, farmers aged under 40% are less than 15%. This is significant obstacle for eco-schemes adoption and the efficient and quicker deployment of greening in agriculture. Being an obstacle, does not mean that it cannot be faced. Motivating measures, training and encouragement of new younger farmers to startup modern organic farming are expected to increase the participation of young people into farming within EU Member States.

The COVID-19 crisis has taken a terrible human toll and the necessary containment measures have battered OECD[40] economies and societies. Fortunately, digital technologies, business models and work practices are playing a crucial role in helping avoid a complete standstill. This is accelerating ongoing processes of technology proliferation and adoption across businesses, as well as the intensity and extent to which businesses use digital technologies to maintain operations. Broad and representative surveys of ICT usage in business will not deliver data covering the pandemic period until 2021. However, various evidence suggests that many firms (and other organisations) are taking up digital tools, or further deploying and making greater use of them. This is allowing them to operate during the pandemic. Businesses have rapidly altered their way of working to allow employees to telework. Estimates for various OECD countries suggest that a significant minority of jobs – between about one-quarter and one-third – can plausibly be performed from home. Others estimate that around 30% of North American and Western European workers are in occupations that allow home-based work. Only 10% to 15%, or fewer, of workers in OECD countries were estimated to have been home-based in 2019. Consequently, COVID-related restrictions on movement are likely to have incited a significant additional portion of workers to telework if they could. The potential for teleworking, and the extent of teleworking achieved during the pandemic, vary considerably between industries and countries. ENVISION services are by nature enable telework by fostering the continuous monitoring of rural activities without needing local presence and commuting across land parcels.

Last but not least, social trend for healthy food produced with sustainable and environment – sensitive practices will move the supply chain to assure product quality and transparency at all stages in the supply chain: from the land and the producer to the shop and the retail chain. ENVISION responds to this trend by empowering its prospect customers to monitor eco-friendliness of farmers' practices and end produces. However, there is a concern related to EU actions boosting organic production without increasing the demand; that might lead to price falls, disastrous market conditions for organic farmers and abandonment of green practices. This will harm the farmers, the consumers and the climate. Consumer uptake needs to be also motivated by the EU. The highest organic retail share is in Denmark (12%); henceforth, targeting 25% of the land to become organic needs to be accompanied with parallel consumer uptake towards organic products, remains a serious concern that needs to be tackled. The pandemic has pushed organic sales up over the course of the last year, and although there is an optimism that this growth may continue in 2021, other reports have shown that there will be challenges that may limit ongoing growth, including threats to consumer income, uncertain supply chains, livestock processing and imports.

Technological – Technological conditions of ENVISION are already mentioned within Section 4.3 and are related to both the technology uptake by citizens and professionals, the generic cloud, network and high-performance-computing infrastructure available and the progressing state-of-the-art, as well as the agri-specific technological achievements that empower ENVISION visionary market take-off.

[40] https://www.oecd-ilibrary.org/sites/bb167041-en/1/3/10/index.html?itemId=/content/publication/bb167041-en&_csp_=509e10cb8ea8559b6f9cc53015e8814d&itemIGO=oecd&itemContentType=book#section-209

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Obviously the technical environment is a great enabling factor for the services that ENVISION targets, as well as for improvements foreseen in respect to performance, quality and richness of services. Therefore, it is not the technology that counts but the conditions to deploy it.

Therefore, we highlight on the most important technological factor of environmental and land monitoring, which is the satellite monitoring and positioning infrastructure. The global navigation satellite system Galileo and the Copernicus Earth observation program are flagships of the EU space policy. They enable more accurate navigation and timing and deliver valuable data about the Earth, and help monitor the environment, land and oceans. The programs entail significant and long-term costs for the EU budget, which up to the end of 2020, totaled around €18 billion. However, the concern is not about the availability of technology but about the conditions and the requirements to fully exploit the potential of EU space programs.

A recent audit performed by the European Court of Auditors reports findings and concerns related to EU Space programs uptake. The audit assessed the effectiveness of the measures taken by the Commission since 2014 to promote the uptake of services derived from the EU space programs Galileo and Copernicus, towards achieving the expected economic and societal benefits.

According to the results, the EU space programs Galileo and Copernicus provide valuable services and data, which the Commission promoted in various ways but it has not done enough to harness the full potential of the programs and capitalise on the significant investment made to achieve the expected benefits.

Galileo services already enhance the accuracy of navigation and there is good use of Copernicus data in monitoring of some EU policies, but the Commission has no comprehensive strategy yet for promoting the uptake of the EU space programs that includes all relevant actors and entities at EU and Member State level.

Furthermore, its approaches for supporting the uptake are only partly linked to specific, measurable, accepted, realistic and time-bound strategic objectives that clearly explain what should be achieved. The Commission has not addressed the fragmented nature of the services markets in its own approach and has only received little information on the significantly diverging Member State strategies and approaches in using the services in their administrations and in supporting uptake.

There is no generally recognised conceptual statistical framework in the EU for estimating the benefits of space services and the Commission’s estimations have shortcomings in terms of methodology and coverage. This makes it challenging to reliably estimate the benefits of the programs. Key performance indicators used provide only basic information and do not measure the achievement of main objectives of the programs.

The Commission’s actions aimed at supporting the development of new technologies in navigation, access to and use of Copernicus data, raising awareness about the programs, and market uptake. However, the objectives and the impact of several key actions were not clear and the potential for synergies is not being exploited yet. Moreover, key features of Galileo are not yet available, which may hamper its ability to gain the market for these services. The Commission adopted regulations in road safety and emergency services to facilitate the uptake of Galileo, but there is still little action in other areas or market segments. There is also no comprehensive analysis conducted yet to identify where the use of Copernicus could be better promoted in EU legislation. The Commission and Member States have also no systematic overview of regulatory or administrative barriers that may inhibit the use of space services.

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In order to better exploit the potential of the EU's space programs, the Commission should:

(a) develop a comprehensive strategy for supporting the uptake of EU space services.

(b) develop a conceptual framework for estimating the benefits of the EU space programs and improve performance measurement;

(c) ensure full readiness of Galileo, and better targeted action on uptake of the EU space services; and

(d) use the regulatory framework better to support the uptake of EU space services

It is expected that these audit results and recommendation will add value by helping the Commission to promote effectively the uptake of EU space services in the new multiannual financial framework 2021-2027, and to monitor better the achievement of the programs' objectives. All detail of audit results and significant recommendations made are described within the audit report EU Special Report[41] "EU space programmes Galileo and Copernicus: services launched, but the uptake needs a further boost."

Legal - The legislation environment has already been described within Section 4.2 Regulation. However, the most important aspect to highlight is that the legal framework for checks by monitoring has become clearer.

The legal framework allowing the use of Sentinel data for checking farmers' area aid applications entered into force early enough in May 2018. The legislative changes made in October 2019 clarified many areas of the new monitoring approach, but the rules for the new approach were not as detailed as those for the traditional checks. While this provides scope for innovation and the Commission has expressed its readiness to hold discussions and find solutions if major issues arise, paying agencies expect further guidance from the Commission in order to take the right decisions and reduce the risk of future financial corrections. Another issue is the complexity of the current CAP aid measures, as some requirements cannot always be monitored remotely and need cross checking of satellite data with local samplings.

Although the Commission has attempted to remove or mitigate some of these obstacles, paying agencies expect further guidance from the Commission in order to take the right decisions and reduce the risk of future financial corrections. The Special report 04/2020: New-Tech in agri-monitoring of the European Court of Auditors shows that for 52 out of 59 paying agencies, one important obstacle **is** uncertainty about the Commission's conformity clearance procedure in the context of the new approach. While, in the case of traditional checks, detailed rules exist on how to carry out on the spot or remote sensing checks, there are no such rules for checks by monitoring. Paying agencies are thus concerned that the Commission may later question their approach and the decisions taken, and apply financial corrections.

The Commission understood this concern and took steps to clarify how checks by monitoring will be audited in the future. Changes in the legislation as well as guidance provided to Member States were prepared in close cooperation between the policy and audit experts of the Commission. Hence, the need to provide flexibility was balanced with ensuring minimum risk of potential financial corrections, through through:

- assessing each notification of checks by monitoring against a set of legal and technical elements;

[41] https://www.eca.europa.eu/Lists/ECADocuments/SR21_07/SR_EUs-space-assets_EN.pdf

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- communicating the results of these assessments to the paying agencies; and
- sending a letter to all paying agencies implementing checks by monitoring in 2019, expressing its readiness to hold discussions and find a solution if major issues arise.

Under the new approach, all agricultural parcels in a region are subject to the same monitoring process. Field visits are carried out only if the outcome of the monitoring process is inconclusive and the potential financial impact of non-compliance exceeds a certain threshold. This means that field visits are targeting farms most likely to be non-compliant, which improves their efficiency by reducing the burden on the farmer and the costs for the paying agency.

Environmental – The urgency for environment-friendly farming is materialised through the Biodiversity strategy and its applicable measures that the new CAP will deploy. ENVISION fits perfectly to this strategy. The ENVISION monitoring service will identify whether a declared agricultural parcel can be considered to comply with the sustainable agricultural practices stemming from EU policies by verifying conditions related to an agricultural activity or a crop type. Indicative practices that will be monitored will be: Rotating crops and embracing diversity, planting cover crops during off-season, applying integrated pest management, etc. Such practices can result to the following interrelated environmental impacts of unsustainable agriculture which will be addressed through the ENVISION monitoring service:

1. Water pollution - Water pollution is realised due to the presence of nitrates and phosphates from agricultural sources and can lead to eutrophication and the development of harmful algal blooms in water bodies adjacent to agricultural lands.
2. Soil degradation - Farm soil degradation is a result of practices such as unsustainable crop harvesting, unbalanced fertilization, and overgrazing, and can lead to soil erosion and loss of soil fertility and structure.
3. Biodiversity loss - Biodiversity is lost because of practices such as monoculture, which causes the loss of crop genetic diversity and reduces climate change resilience, and the destruction of critical habitats for the creation of arable land.
4. Landscape degradation - Landscape degradation can be the result of the conversion of forests, grasslands and other habitats to agricultural land. This can augment the impacts of climate change, lead to the annihilation of important habitats, and affect the water cycle.
5. GHG emissions - Large quantities of agriculture-sourced GHGs are emitted mainly due to deforestation, unsustainable management of croplands & grasslands, extensive soil disturbance, and conversion of grassland to arable land.

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5 Conclusions

ENVISION builds a set of services which will be appealing to payment agencies and policy makers/certification bodies by providing new service components and processing stages supporting demanding scenarios participating in the audit and monitor processes which are deployed within check procedures of farming practices that need to comply to certain criteria (eco-related or other types of criteria that assure compliance to CAP and are tight to target monetary subsidies)

The main service concepts of ENVISION to address the market mentioned are:

- Cultivated crop type maps - A service for payment agencies to deliver a number of EO derived products for cultivated crop type maps consisting of crop type maps, crop compliance with greening rules and alert mechanisms for smart sampling
- Data Fusion – A service to provide, as a backend a fully-automated Machine Learning module, aiming to assist in the enrichment of the Sentinel feature space for the rest of ENVISION services providing full time series of observations (no gaps due to clouds). The main goal of this service is to tackle the problem of cloudy observations of Sentinel-2 images, taking into consideration information coming from Sentinel-1 and the rest of cloudless Sentinel-2 cases.
- Sentinel Data Preprocess – A micro-service aiming at the generation of spectral, spatial and temporal features of Synthetic-aperture radar (SAR) data derived from Sentinel-1 (S1) satellites. The service will be a backend module, easy to be exploited by other modules of a potential AMS.
- Analytics on Vegetation and Soil Index Time Series – The Analytics on Vegetation and Soil Index Time-series (AVSIT) is an Earth Observation (EO) monitoring module that exploits satellite data along with the usage of Machine Learning algorithms on top of Datacube platform in order to provide into users' realistic indications related to the field activities and the control of cross-compliance policies. More specifically, this module will take advantage of numerous potentials of Datacube introducing an innovative Big Data framework in the field of CAP monitoring from Paying Agencies (PAs). The provided services address to paying agencies and policy makers
- Identification of Organic Farming Practices - This service will 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.
- 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. The service will contribute into the direct supervision of the Paying Agencies (PAs) of the compliancy of grasslands farmers to the respective regulation of pilot countries regulations and indication of possible declination from them. The provided service addresses to paying agencies and policy makers.
- Soil Organic Carbon monitoring – The Soil Organic Carbon service (SOC micro-service) is part of ENVISION and will deliver several EO-based services able to support the implementation SOC business cases (Soil Condition). The SOC service will deliver image tiles that present the SOC spatial distribution, estimated SOC mean values per agricultural parcel and per area of interest

The services mentioned are either provide integral end-to-end implementation of specific indicators check or implement a data process pipeline stage that could support other services, either ENVISION services or other processes within the check by monitoring ecosystem.

76 payment agencies and 266 certification bodies in total from 27 countries are addressed by ENVISION. The new CAP and the action plan towards organic need to deploy check by monitoring to

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wider scale, tight to variant demanding eco-schemes that ask for combinatory indicators. The conventional on the spot checks will not be sufficient to assure quick and correct audits to larger areas with more complex criteria. Additionally to the core target market of ENVISION, one should also consider the role of farmers in the market. Their need to reduce the risk of being penalized and to exploit new eco-schemes that will secure funding and product value in terms of product quality is driving and motivating the market to migrate its procedures towards check by monitoring.

PAs and CBs have already started utilizing CBM practices to certain extent based on Earth observation, GIS and modern ICT; the trends and moves aligned to their strategy are described in Section 3.4 Current Status and Trends, mainly driven by experience gains through EU and ESA projects.

ENVISION envisages that a number of PAs and CBs will become early adopters of its services either because they are already involved in the project, or they are having the role of lighthouse customers. 15 PAs and 6 CBs from 17 countries are listed in Table 1 ENVISION Early Adopters. The number of countries where the initial business cases and first targeted customer references will come from allow for validating the pre-commercial and startup ENVISION services in a multitude of different environments and climates. ENVISION can achieve early operation with success in Northern (Lithuania, Sweden, Denmark), Western (Belgium, France), Southern (Cyprus, Greece), Eastern (Serbia, Bulgaria, Romania), and Central (Czech Republic, Slovenia, Slovakia) Europe, where diverse conditions are present; for example, cloud-cover is more prominent in northern regions than in southern, thus by building the project's cases in such different settings its services can be designed according to the needs of each region across the spectrum of numerous environments. Early adopters are critical to achieve, as they will drive and attract other market actors to follow and will show a successful path to wider expansion of ENVISION services.

The overall startup and development environment for ENVISION is shaped by the following significant factors in respect to policies, regulation, technology, economy, social and competition matters:

- CAP reform is magnifying the level of effort that is needed by PAs and CBs to monitor compliance of farmers. Therefore, continuous checks by monitoring, powered by ENVISION-like services, are becoming a major priority for them.
- Still on the policy side, Member States national programs to apply EU directives and CAP goal strategy, will be among the most critical factors for ENVISION into addressing the EU market expansion
- Social trends will increase the demand for healthier, eco-friendly products that should be accompanied with qualification criteria assurance based on reliable, trustworthy and well defined procedures for monitoring and auditing. Organic planning will not be just a set of targets by EU policy, but will be driven by market demand
- A continuously innovating field with technologies related to data gathering (EO) achieved through the EU Space Programme and data processing based on modern cloud and high performance computing setups is enabling ENVISION to be performant and to adapt to upcoming growing needs. Moreover, other services are being developed by other actors, which can exploit also ENVISION add-on component in order to participate into integrated CbM approach
- A wide spectrum of prospective competitors are taking positions towards addressing the same market, however with different priorities and tech components;

As the GEOSS and Copernicus data have given rise to new practical solutions, the number of firms operating closely to the field that ENVISION aspires to succeed is increasing as the market potential of similar but largely differentiated services in niche segments, is high. In that sense, future potential competitors have been identified in some EU countries (e.g. Netherlands, Italy, Germany, Slovenia,

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Czech Republic, Finland and Austria) currently operating in the monitoring of changes of agricultural landscapes and practices relevant to the management of the CAP. A detailed view on these companies is provided in the ANNEX C: Competition. Examples of businesses (active in EU) with relatively favourable positioning include NEO, Geomatics & Earth Observation, e-GEOS and its subsidiary GAF AG[42]BASF Digital Farming[43], EOX IT Services Gmbh, SINERGISE KappaZeta, Geosys, AGRICOLUS, Neuropublic, TerraNIS and others. Interesting examples include also successful project outcomes, such as:

- possible commercial exploitation of SEN4CAP which was initiated by both the DG AGRI and the JRC through a public tender,
- projects such as the Advanced Platform for Intelligent Inspections and the New IACS Vision in Action (NIVA)project

The interesting point items to highlight are the following:

- the competitive advantage of ENVISION is that it is one step ahead in terms of its design as it is more targeted in the monitoring of specific rules instead of monitoring general changes in the agricultural landscape elements
- ENVISION emphasis on sustainability rules monitor positions its services one step ahead in terms of readiness to address upcoming needs of PAs and CBs
- the add-on component offers a great field for opening work threads towards greater functionality expansion. This dynamic, can move potential competitors to become partners and contributors into a wider strategy
- most competitors identified are
    - having expertise into geo-informatic applications development which has been utilised into developing tailor – made agriculture applications. Specialisation is not featured in all cases; not all actors are promising a structure that is totally oriented to support CBM and the organisations (PAs and CBs)
    - mostly dealing with crop monitoring and classification; they are lacking soil monitoring functionality. They are mostly using Sentinel-1 only data without fusing data with other geo-sources. Their focus has been on the identification of image change detection signalling a change in crop status, disaster identification and other cultivation needs. Orientation so far, was mainly addressing the farmers and the ones who are working towards adopting precision agriculture practices.
- Some competitors' noted are already operating with paying agencies i.e. EOX Gmbh, Neuropublic, GAF

ENVISION Market Outook has shown that conditions for market expansion are featured by:

- *Positivity* – Critical environment factors favors development and startup of ENVISION into addressing PAs and CBs needs of their current and upcoming practices. ENVISION fits to fill gaps that might be faced due to the CAP reform, the organic plans and the eco-schemes which are being defined

[42] February 2021: GAF AG has won the first European call for tenders for the operational implementation of the agricultural area monitoring system in Germany in 2021 stipulated by the European Common Agricultural Policy (CAP). The Paying Agency will make use of GAF's sophisticated cloud-based solutions for the automatic monitoring of agricultural parcels. More details in Annex A.

[43] Among the important recent market facts, Bosch and BASF smart farming have formed a new joint venture. The 50/50 joint venture (JV) between Bosch and BASF Digital Farming will globally market and sell smart farming technologies from a single source. The JV has been registered as Bosch BASF Smart Farming (BBSF) GmbH.

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- *Complexity / Uncertainty*– Requirements are changeable; criteria and measures are still under development and negotiation. National Member States plans will also affect the timeliness and orientation for market expansion. Eco-schemes are demanding combinatory data pipelines where the technological factor has a key role to play in terms of performance and completence. ENVISION aims not just to be a service provider but an enabler of a total ecosystem; this is one more factor of complexity, as potential competition brings also partnership opportunities

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7 ANNEX A : Paying Agencies List

1. AT01 Agrarmarkt Austria
2. AT03 Zollamt Salzburg, Zahlstelle Ausfuhrerstattungen (ZOSA) [Salzburg Customs Office, Export Refunds Paying Agency]
3. BE02 Agentschap voor Landbouw en Visserij [Agency for Agriculture and Fishery]
4. BE03 Département des Aides de la Direction générale opérationnelle Agriculture, Resources naturelles et Environnement
5. BG01 State Fund Agriculture
6. CY01 Κυπριακός Οργανισμός Αγροτικών Πληρωμών [Cyprus Agricultural Payments Organization]
7. CZ01 Státní zemědělský intervenční fond [State Agricultural Intervention Fund]
8. DE01 Bundesanstalt für Landwirtschaft und Ernährung [German Federal Office for Agriculture and Food]
9. DE02 Hauptzollamt Hamburg-Jonas [Hamburg-Jonas Main Customs Office]
10. DE03 Baden-Württemberg
11. DE04 Abteilung P „Förderung und Zahlstelle" im Bayerischen Staatsministerium für Ernährung, Landwirtschaft
    und Forsten
12. DE07 Brandenburg und Berlin
13. DE09 EU-Zahlstelle der Freien und Hansestadt Hamburg
14. DE11 Mecklenburg-Vorpommern
15. DE12 EU-Zahlstelle Niedersachsen / Bremen
16. DE15 Der Direktor der Landwirtschaftskammer Nordrhein-Westfalen als Landesbeauftragter [The Director of the North Rhine-Westphalia Chamber of Agriculture as authorised state representative]
17. DE17 EGFL- und ELER-Zahlstelle Rheinland-Pfalz
18. DE18 Zahlstelle ELER/EGFL des Saarlandes
19. DE19 Zahlstelle des Sächsischen Staatsministeriums für Umwelt und Landwirtschaft
20. DE20 Zahlstelle des Landes Sachsen-Anhalt [Paying Agency of Saxony-Anhalt]
21. DE21 Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume (MELUR) des Landes Schleswig-Holstein
22. DE23 Freistaat Thüringen [Free State of Thuringia]
23. DE26 Landesbank Hessen-Thüringen Girozentrale (WIBank) - Geschäftsbereich „Wirtschafts- und Infrastrukturbank Hessen“
24. DK02 NaturEhrvervstyrelsen [Danish AgriFish Agency (DAFA)]
25. EE01 Põllumajanduse Registrite ja Informatsiooni Amet [Estonian Agricultural Registers and Information Board]
26. ES01 Dirección General de Fondos Agrarios de la Consejería de Agricultura, Pesca y Medio Ambiente de la Junta de Andalucía
27. ES02 Departamento de Agricultura, Ganadería y Medio Ambiente del Gobierno de Aragón
28. ES03 Organismo Pagador de la Comunidad Autónoma del Principado de Asturias
29. ES04 Fondo de Garantía Agraria y Pesquera de las Islas Baleares (FOGAIBA)
30. ES05 Organismo Pagador de Fondos Agrícolas Europeos de la Comunidad Autónoma de Canarias
31. ES06 Organismo Pagador de la Comunidad Autónoma de Cantabria
32. ES07 Consejería de Agricultura de la Junta de Comunidades de Castilla-La Mancha
33. ES08 Consejería de Agricultura y Ganadería de la Junta de Castilla y León
34. ES09 Departamento de Agricultura, Ganadería, Pesca, Alimentación y Medio Natural de la Generalidad de Cataluña
35. ES10 Consejería de Agricultura, Desarrollo Rural, Medio Ambiente y Energía de la Junta de Extremadura
36. ES11 Fondo Galego de Garantía Agraria (FOGGA)
37. ES12 Consejería de Medio Ambiente y Ordenación del Territorio de la Comunidad de Madrid
38. ES13 Consejería de Agricultura y Agua de la Región de Murcia
39. ES14 Departamento de Desarrollo Rural, Medio Ambiente y Administración Local del Gobierno de Navarra (DRMAyAL)
40. ES15 Departamento de Desarrollo Económico y Competitividad del Gobierno Vasco

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41. ES16 Consejería de Agricultura, Ganadería y Medio Ambiente del Gobierno de la Rioja
42. ES17 Agencia Valenciana de Fomento y Garantía Agraria (AVFGA)
43. ES18 Fondo Español de Garantía Agraria
44. FI01 Maaseutuvirasto [Agency for Rural Affairs]
45. FR05 Office de Développement de l'Economie Agricole des Départements d'Outre-Mer
46. FR18 Office du Développement Agricole et Rural de Corse
47. FR19 Agence de services et de paiement
48. FR20 Etablissement national des produits de l'agriculture et de la mer
49. GR01 Payment and Control Agency for Guidance and Guarantee Community Aids
50. HR01 Agencija za plaćanja u poljoprivredi, ribarstvu i ruralnom razvoju [Paying Agency for Agriculture, Fisheries and Rural Development]
51. HU02 Hungarian State Treasury
52. IE01 Department of Agriculture, Food and the Marine
53. IT01 Agenzia per le Erogazioni in Agricoltura
54. IT02 Servizio Autonomo Interventi Settore Agricolo
55. IT03 Ente Nazionale Risi
56. IT05 Agenzia Veneta per i Pagamenti in Agricoltura
57. IT07 Agenzia Regionale Toscana per le Erogazioni in Agricoltura
58. IT08 Agenzia Regionale per le Erogazioni in Agricoltura per l'Emilia-Romagna
59. IT10 Agenzia Regionale Piemontese per l'Erogazione in Agricoltura
60. IT23 Organismo Pagatore Regionale Regione Lombardia
61. IT24 Organismo Pagatore della Provincia Autonoma di Bolzano
62. IT25 Agenzia Provinciale Pagamenti della Provincia di Trento
63. IT26 Agenzia della regione Calabria per le Erogazioni in Agricoltura
64. LT01 Nacionalinė mokėjimo agentūra [National Paying Agency]
65. LU01 Ministère de l'Agriculture, de la Viticulture et du Développement Rural
66. LV01 Rural Support Service
67. MT01 Agriculture and Rural Payments Agency
68. NL04 Rijksdienst voor Ondernemend Nederland [Netherlands Enterprise Agency]
69. PL01 Agencja Restrukturyzacji i Modernizacji Rolnictwa [Agency for Restructuring and Modernization of Agriculture]
70. PL02 Agencja Rynku Rolnego [Agricultural Market Agency]
71. PT03 Instituto de Financiamento da Agricultura, Desenvolvimento Rural e Pescas
72. RO01 Agenţia pentru Finanţarea Investiţiilor Rurale [Rural Investment Financing Agency]
73. RO02 Paying and Intervention Agency for Agriculture
74. SE01 Statens jordbruksverk [The Swedish Board of Agriculture]
75. SI01 Agencija Republike Slovenije za kmetijske trge in razvoj podeželja [Agency of the Republic of Slovenia for Agricultural Markets and Rural Development]
76. SK01 Pôdohospodárska platobná agentúra [Agricultural Paying Agency]

UK PAs

- GB05 The Department of Agriculture and Rural Development
- GB06 The Scottish Government Rural Payments and Inspectorate Directorate
- GB07 The Welsh Assembly Government
- GB09 The Rural Payments Agency

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8 ANNEX B : Projects in Brief

DIONE

www.dione-project.eu

The EU-funded DIONE project 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 (Common Agricultural Policy) 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 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.

DIONE will

- Capitalise on recent results of ESA's SEN4CAP project that showcased the capability of Sentinel data to monitor the crop diversification rules.
- Include in the analysis the so far neglected EFA types (fallow land of all sizes, buffer strips, hedges, trees), by making use of super-resolution technology that improves the 10-20m Sentinel resolution to an improved resolution range (5-10m).
- Complement the use of EO data with a system of reliable, **ground-based geo-tagged photos**, captured by the farmers that exploits (a) advances that allow for improved positional accuracy, (b) low-footprint encryption techniques for improved data security and reliability and (c) image detecting manipulation techniques (image forensics).
- Implement a Green Compliance toolbox integrated with the paying agencies' aforementioned tools.

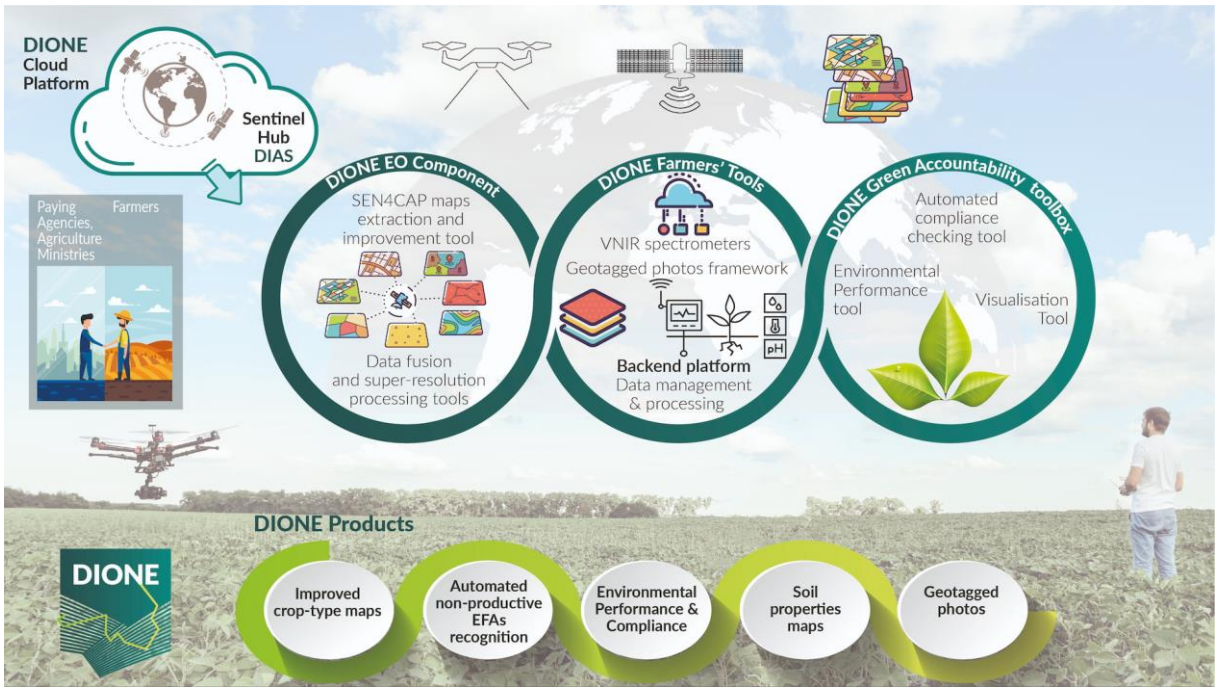

Figure 6 DIONE at a glance

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The integrated EO-based DIONE' toolbox delivers clear economic value to key targeted customers, estimating to lower administrative and operational costs to 30% of the current ones related to CAP area-based compliance checks and assessment of respective environmental impacts

NIVA - 'New IACS Vision in Action' (NIVA)
https://www.niva4cap.eu

It is a key project that started in June 2019, for which EU funding is expected to amount almost to €10 million. It aims to modernise the integrated administration and control system used by paying agencies, by making efficient use of digital solutions and e-tools to reduce administrative burden and improve environmental performance. NIVA modernises 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. After 2 years of NIVA implementation have passed the main achievements towards the main challenges and objectives, are summarized below.

Challenge	Baseline (project start) situation	NIVA achievements up to date
Absorbing innovations to simplify the governance	Innovations implemented separately in the 41 different IACS systems in Europe Only 2 to 3 open source solutions covering small parts of IACS systems	• More than 30 components have been developed and are being tested in cross-boundary collaboration • Working modes to learn from each other in an active way and start relying on developments implemented in different PA systems • Methodologies for Multi-Actor development and innovation deployment in IACS specified
Reducing socio-economic and administrative burden to farmers	Digital innovations offer potential to reduce the burdens to farmers and PA's Digital innovation being tested in some research projects	• Different aspects of implementing digital solutions have been aligned through an 'As-is' analysis • Wider adoption of research products in innovations and field testing ongoing • Pilots being tested specifically focused on lowering administrative burden through technology
Reducing the gap between IACS data use and potential broader uses	IACS derived data are shared in some member states on an 'As-is' basis Lack of standardization across claim years and common lists of relevant attributes (e.g. parcels, crops, vegetation types)	• Operational testing of IACS data use in pilots for other purposes • Standardization issues in IACS highlighted and recommendations provided in a stakeholder oriented way

Table 4 NIVA Project : Overview of NIVA progress on main challenges

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As shown in Table 1, NIVA made good progress towards the challenges from a technical implementation point of view in getting components delivered and making technical

Objective	Baseline (project start) situation	NIVA achievements up to date
Integrate and reuse IACS evolutions based on open standards and common services	Lack of standardisation across IACS systems Largely independent development within MS borders	• Raised awareness on need and pressure points for harmonisation and shared services • IACS evolution based on components developed in different trials and experiences with testing • Joint learning on potential IACS evolution through digital innovations through cross-collaboration
Build on farmers' acceptance of the Smart Monitoring methodology	Testing panels in different Member states Demands in new CAP for more monitoring data raising challenges with farmers	• Methodologies for joint development in a co-design and multi-actor approach • Active participation of farmer and farmer representatives in developing new monitoring approaches • Active participation of farmers in NIVA events
Reducing the gap between IACS data use and potential broader uses**	IACS derived data are shared in some member states on an 'As-is' basis lack of standardisation across years and common issues	• Operational testing of IACS data use in pilots for other purposes • Standardisation issues in IACS highlighted and recommendations provided in a stakeholder oriented way
Create a permanent exchange platform for discussion and exchange	Knowledge flow largely passive through presentation sessions at annual events EC DG JRC as a knowledge partner for both EC services and MS PAs	• Joint collaboration and working modes between MS on diverse aspects of IACS systems • NIVA providing knowledge products and briefs complementary to EC DG JRC • Increasing participation across stakeholder groups in NIVA stakeholder events

Table 5 NIVA Project : Overview of NIVA progress on main objectives

Among others, the following organisations participate in NIVA:
Paying agencies

- Lithuania : NPA - National Paying Agency
- Greece : OPEKEPE - ORGANISMOS PLIROMON KE ELEGHOU KINOTIKON ENISHYSEON PROSANATOLISMOU
- France : ASP - AGENCE DE SERVICES ET PAIEMENT
- Spain: Italy, FEGA
- Italy : AGEA
- Estonia: ESTONIAN AGRICULTURAL REGISTERS AND INFORMATION BOARD

Industry:
SINERGISE, NEROPUBLIC, eGEOS, …

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Sen4CAP - The *Sentinels for Common Agricultural Policy (Sen4CAP) project*, http://esa-sen4cap.org/

The project paid particular attention to provide evidence how Sentinel derived information can support the modernization and simplification of the CAP in the post 2020 timeframe. Sen4CAP has been set up by ESA in direct collaboration and on request from DG-Agri, DG-Grow and DG-JRC." The main SEN4CAP objectives were:

- identify and specify EO products and services suitable to increase the efficiency, traceability as well as reducing the costs of the IACS,
- develop Algorithm Theoretical Basis Documents along with open source code for agricultural EO products based on Sentinel-1 & -2 responding to the user requirements,
- demonstrate and validate the developed agricultural EO products up to national scale,
- Provide evidence for the utility of Sentinel products within IACS procedures at EU and national level for 6 national Paying Agencies, representative for the heterogeneous agricultural practices, landscape and climate within the EU, as well as to identify the associated limits and conditions of applications,
- prepare and facilitate the transfer of developed EO products and services to the PAs including capacity building and demonstrating cloud computing capabilities.

The SEN4CAP project relied on the guidance of a steering committee composed of the EC actors of the CAP, namely representatives from DG-Agri (Unit D.3), DG-JRC (Food Security unit) and DG-Grow (Copernicus). The steering committee provided advice on the evolving CAP policy and legal framework, the technical guidelines of the IACS implementation and the Copernicus context.

The Sentinels for Common Agricultural Policy - Sen4CAP project aimed at providing to the European and national stakeholders of the CAP validated algorithms, products, workflows and best practices for agriculture monitoring relevant for the management of the CAP. The project paid particular attention to provide evidence how Sentinel derived information can support the modernization and simplification of the CAP in the post 2020 timeframe. The overall approach proposed for the Sen4CAP project was completely user-oriented to ensure responding very concrete user needs and requirements. A Sen4CAP user group included Paying Agencies (PA) from 6 selected Pilot Countries, as well as a set of Champion Users belonging to the Conference of Directors of EU PAs, the Panta Rhei Platform and the Copernicus Agriculture Expert Group. Furthermore, the Steering Committee composed of representatives of the DG-Agri, DG-JRC and DG-Grow and chaired by ESA will provide guidance throughout the course of the project.

The project started in July 2017 and lasted 30 months, organized in two distinct phases. The first phase of 14 months delivered a Proof of Concept. During the second phase (16 months), the full value of the developed EO products and processing system will be assessed through a national-scale demonstration during the years 2018 and 2019. This demonstration was carried out in the operational environment of the engaged Paying Agencies. This phase included the necessary training and capacity building activities for the transfer of the developed EO products and services to the Paying Agencies. Participating Paying Agencies were the following:

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Czech Republic State Agricultural Intervention Fund (SZIF) https://www.szif.cz/cs	**Netherlands** Netherlands Enterprise Agency (RVO) www.RVO.nl
Spain, Castilla y León Instituto Tecnológico Agrario de Castilla y León (ITACyL) - Castilla I Léon Paying Agency http://www.itacyl.es/opencms_wf/opencms/index.html Fondo Español de Garantía Agraria (FEGA) - Spanish coordination body Ministry of Agriculture, Fisheries, Food and Environment https://www.fega.es/	**Lithuania** National Paying Agency under the Ministry of Agriculture http://www.nma.lt
Romania Agency for Payments and Intervention in Agriculture (APIA) https://lpis.apia.org.ro/	**Italy** Agenzia per le Erogazioni in Agricoltura (AGEA) - Italian Coordinating Body http://www.agea.gov.it/

Table 6 SEN4CAP Project : Participating PAs

RECAP* - Personalised Public Services in Support for the implementation of the Common Agriculture Policy (CAP*)

RECAP is an Horizon 2020 project funded under the *ICT-enabled open government* (H2020-INSO-2015-CNECT) call (Grant Agreement 693171). The initiative commenced in May 2016 with 30 months duration, involving 12 partners.. The overall budget of the project was EUR 2.7 million (EUR 2.1 million requested EU contribution). The project aimed to exhibit benefits based on the following interrelated objectives:

- improved e-public services that enable a better implementation of the CAP and simplify administrative procedures, integrating open and user-generated data.
- personalised public services that support farmers to better comply with CAP requirements.
- increased transparency of compliance monitoring procedures related to CAP.
- reuse of data (open and user-generated) by agricultural consultants and developers for delivering their own added value services for farmers.
- pilot test the services in an operational environment with the participation of end users in five countries (Greece, Lithuania, Serbia, Spain and the United Kingdom).
- assess the usability, effectiveness and impact of the proposed services in delivering the public administrations' goals, and provide feedback into a set of recommendations for future use of these approaches to deliver more effective and applied public administration.

RECAP is a commercial platform (cloud-based Software as a Service (SaaS)) that integrates satellite remote sensing and user-generated data into added value services for public authorities (administrators and inspectors), farmers and agricultural consultants, to improve the processes for implementing and monitoring the BPS. RECAP had three interrelated results indicators:

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- Increasing the efficiency and transparency of public authorities' procedures implementing and monitoring the CAP by enabling *effective and efficient remote monitoring of farmers' obligations* (including automation of compliance checks for some requirements) through the use of open earth observation (EO), user-generated data (geotagged and timestamped photos) and purpose-built algorithms. The RECAP pilots aimed to reduce administrator costs by at least 25%
- Providing *personalized services to farmers for their better compliance with the CAP environmental standards* (Cross Compliance (CC) and Greening Measures). The RECAP pilots aimed to reduce farmer administration costs related to BPS claims by at least 25%
- *Stimulating the development of new added value services by agricultural consultants* and developers who can create add-ons to the main platform and make use of the data collected.

EGNSS4CAP - Enabling the digitalisation of agri-government controls through Galileo and EGNOS
www.egnss4cap.eu

EGNSS4CAP is a mobile phone application for farmers in the European Union to digitalise procedures surrounding their reporting requirements under the current and post-2020 Common Agricultural Policy (CAP) reform. New rules adopted by the European Commission for the current and upcoming CAP allow a range of modern satellite-based technologies to be used when administering and controlling area-based payments. For example, automatic monitoring procedures employing data and signals from both the Copernicus and Galileo programmes can be used to reduce the number of On The Spot Checks (OTSC)**.** The use of these technologies is a part of the European Commission's ongoing commitment to modernise and simplify the Integrated Administration and Control System (IACS) processes within CAP. The EGNSS4CAP application will use Galileo differentiators to enable farmers to provide geo-tagged photos that both support and complement a Copernicus Sentinel-based monitoring approach for CAP. Mass market devices such as smartphones and tablets will be able to run the application and use GNSS to provide location and timing of the photo ensuring required accuracy and authentication for reporting to the paying agencies.

EO4Agri - Bringing together the Knowledge for Better Agriculture Monitoring
https://eo4agri.eu/

EO4AGRI main target is the preparation of the European capacity for improving operational agriculture monitoring from local to global levels based on information derived from Copernicus satellite observation data and through exploitation of associated geospatial and socio-economic information services. Thus, EO4AGRI enlarges and further systematizes the knowledge about Copernicus for agriculture and identifies gaps related to the utilisation of EO in AgriFood, related public services and needs of the financial sector, including international policy and coordination programmes.

SmartAgriHubs
https://www.smartagrihubs.eu/

Connecting the dots to unlease the innovation potential for digital transformation of the European agri-food sector (H2020-DT-RUR-12-2018). SmartAgriHubs is a €20 M EU project under the Horizon 2020 instrument and brings together a consortium of well over 164 partners in the European agri-food sector. The project aims to realize the digitization of European agriculture by fostering an agricultural innovation ecosystem dedicated to excellence, sustainability, and success. The SmartAgriHubs project

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involves digitisation efforts in 5 agri-food sectors: Arable farming, livestock, vegetable, fruits and aquaculture. These sectors all play a vital role in both the EU's economy and the diets of its citizens.

IoF2020 - Internet of Food and Farm 2020 (H2020- IoT-01-2016).
www.iof2020.eu
The IoF2020 project is dedicated to accelerate the adoption of IoT for securing sufficient, safe and healthy food and to strengthen the competitiveness of farming and food chains in Europe. It will consolidate Europe's leading position in the global IoT industry by fostering a symbiotic ecosystem of farmers, food industry, technology providers and research institutes. EV ILVO is WP co-leader and contributes through project management of the different trials and user cases in the proposal, whilst keeping a critical view on the agricultural and IoT challenges.
IoF2020 consortium has its roots in the EU FIWARE program with projects such as SmartAgriFood, Flspace, Flnish and Fractals, which were and are very successful in targeting the agri-food sector with Future Internet (FI) applications. Through this portfolio of R&D and accelerator projects, a strong and coherent ecosystem was developed over the years. For IoF2020, the leading partners of the FIWARE agri-food projects leveraged this installed ecosystem to bring the agri-food sector to the next level: a large-scale IoT pilot. To that end, the existing ecosystem was upgraded by bringing in new complementary partners, in particular end-users and their representative organizations such as CopaCogeca, CEMA, IFOAM EU in order to ensure user acceptability and large-scale take-up.
Also a substantial number of farmers are involved as end users and test beds through cooperatives such as Spanish Co-ops, ZLTO, DCOOP, Pegasus, NILEAS and Coexphal. The technologic base of the ecosystem was extended by large IoT suppliers such as NXP Semiconductors, ST Microelectronics, Philips and large Telecom and ICT providers such as Orange and KPN in order to cover the whole IoT value chain and maximise the project's impact and sustainability. The IoF2020 consortium represents 120+ partners from 22 EU countries.

EJP SOIL - European Joint Program SOIL
www.ejpsoil.eu
Towards climate-smart sustainable management of agricultural soils (Co-fund actions designed to support coordinated national research and innovation programs). EJP SOIL is a European Joint Programme Cofund on Agricultural Soil Management contributing to key societal challenges including climate change, water and future food security. The objectives are to develop knowledge, tools and an integrated research community to foster climate-smart sustainable agricultural soil management that:

- Allows sustainable food production
- Sustains soil biodiversity
- Sustains soil functions that preserves ecosystem services

EJP SOIL builds a sustainable European integrated research community on agricultural soils and will develop a roadmap on climate-smart sustainable agricultural soil management. EJP SOIL roadmap[44] is based on a knowledge framework with 4 interacting components. Knowledge development is set out

[44] http://dca.au.dk/fileadmin/user_upload/EJP_SOIL_roadmap_final-23-01.pdf)

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in projects with internal and external partners. Knowledge sharing & transfer is framed in capacity building for young scientists, enhancing general public awareness and fostering societal understanding and appreciation of agricultural soil management and its contribution to society. Knowledge harmonization, storage & organization support harmonized information and reporting practices. Knowledge application deals with ways to overcome barriers for the adoption of novel practices in policies.

EJP SOIL activities in interaction with stakeholders, MSs and DG AGRI will pursue the long-term goal of promoting farmers as stewards of land and soil resources and support the policy development and deployment, in particular, the future of CAP and Climate policies. EJP SOIL addresses 6 expected impacts in societal, scientific, policy and operational challenges. A first annual work plan based on the roadmap is provided as part of the proposal. The EJP SOIL consortium consists of 26 partners from 24 countries ensuring a large representation of European countries:

No.	Participating organisation name	Country
1	Institut National de la researche Agronomique	France
2	Wageningen Research	The Netherlands
3	BIOS Science Austria	Austria
4	Flanders Research Institute for Agriculture, Fisheries and Food	Belgium
5	Centre Wallon de Recherches Agronomiques	Belgium
6	Czech University of Life Sciences	Czech Republic
7	Aarhus University, Danish Centre for Food and Agriculture	Denmark
8	Estonian University of Life Sciences	Estonia
9	Natural Resources Institute Finland	Finland
10	Johann Heinrich von Thünen-Institut	Germany
11	Forschungszentrum Jülich	Germany
12	Centre for Agricultural Research of the Hungarian Academy of Sciences	Hungary
13	Teagasc	Ireland
14	Council for Agricultural Research and Economics	Italy
15	University of Latvia	Latvia
16	Lithuanian Research Centre for Agriculture and Forestry	Lithuania
17	Norwegian Institute of Bioeconomy Research	Norway

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18	Institute of Soil Science and Plant Cultivation – State Research Institute	Poland
19	National Institute for Agrarian and Veterinarian Research I. P.	Portugal
20	National Agricultural and Food Centre	Slovakia
21	University of Ljubljana, Biotechnical Faculty, Centre for Soil and Environmental Science	Slovenia
22	National Institute for Agriculture and Food Research and Technology	Spain
23	Swedish University of Agricultural Sciences	Sweden
24	Agroscope	Switzerland
25	Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies	Turkey
26	Agri-Food and Biosciences Institute	United Kingdom

Table 7 SOIL Project : Partners

The consortium has developed this proposal in close collaboration with its program owners and has secured over 40ME in co-funding and 10ME for external calls over 5 years. EV ILVO is the program manager for Flanders (Belgium) and will work closely together with the Department of Agriculture and Fisheries of the Government of Flanders (LV) (Programme Owner) and the Department of Environment of the Government of Flanders (Linked third Party).

CALLISTO

https://callisto-h2020.eu/codeless_portfolio/variety-of-opportunities-for-satellite-imagery/

In the scope of the project, the National Observatory of Athens (NOA), a research centre in Greece and partner in CALLISTO, focuses on the Common Agricultural Policy (CAP) with a use case targeting Paying Agencies and farmers. NOA identified that the Sentinel satellite data need to be supplemented and/or fused with data deriving from various other sources, such as Unmanned Aerial Vehicle (UAV) images and geotagged photos in order to achieve CAP monitoring. Two scenarios were developed dealing with crop classification as well as grassland outlier detection and reconversion.

Scenario 1 – Crop Classification

The provision of guidelines for the cultivation of specific crops in each EU Member State and the monitoring of this process by the relevant authorities are fundamental elements of EU's CAP. To this end, the CALLISTO project will refine the currently existing approaches for crop classification by utilising Deep Neural Networks and incorporating a variety of heterogeneous data sources for their training. The resulting services will not only improve crop classification, but also lead to better targeted On-The-Sport Checks (OTSCs), improved control of crop diversification and enhanced transparency of the subsidy allocations.

Scenario 2 – Grassland Outlier Detection and Reconversion

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Maintenance of permanent grassland is one of the key elements of the EU's sustainable land-use practices since it supports carbon sequestration and protects biodiversity. Each Member State determines the areas that are considered as environmentally sensitive permanent grasslands, which means that farmers should not plough or convert them. Through CALLISTO, grasslands will be identified using machine learning and/or deep learning algorithms and then each grassland area/parcel will be further labelled as permanent or not. This service will assist in cross-checking if grasslands declared as permanent are indeed permanent, as well as in verifying reconversion of such areas. The project will mainly focus on the Netherlands. This is not only because grassland is one of the prevalent crop types in the country, but there is also rich availability of crowdsourced street-level imagery on platforms like Mapillary and VHR satellite data shared by the Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland, RVO).

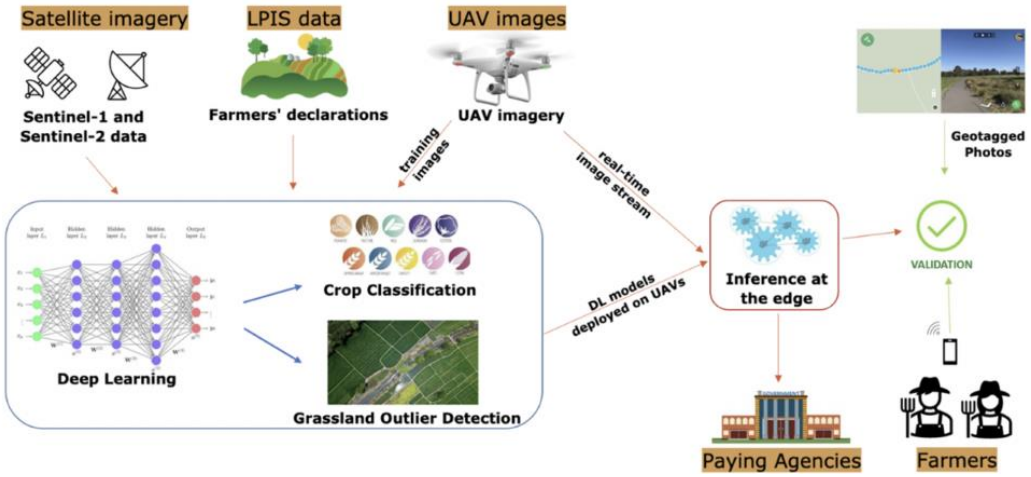

Figure 7 Project CALLISTO Scenarios

Pilot4CAP - Pilot4CAP is a platform for sharing Pilot projects for the new CAP2020+, hosted and coordinated in the G4CAP Web application. This platform calls for sharing and reporting of publicly known new or ongoing pilot projects performed in preparation for the new CAP 2020+. Projects on the following subjects can be entered: IACS, OTSC, LPIS, Land Use, Land Cover, (IT or other) services making use of imagery such as Sentinel optical, Sentinel radar, VHR/HR satellite, aerial photo, RPAS or High Altitude drones.

SINCOHMAP

Sentinel-1 **In**terferometric **Coh**erence for Vegetation and **Map**ping

www.sincohmap.org

SINCOHMAP is an ESA SEOM project with the objective of developing, analysing and validating novel methodologies for land cover & vegetation mapping using Sentinel-1 Interferometric Coherence Evolution. One of the main objectives of the project is to quantify the impact in using S-1 InSAR (Interferometric Synthetic Aperture Radar) data relative to traditional land cover and vegetation mapping using optical data (especially Sentinel-2, hereafter named S-2) or SAR-based (Synthetic Aperture Radar) approaches. In consequence, the project is designed to clearly state this point.

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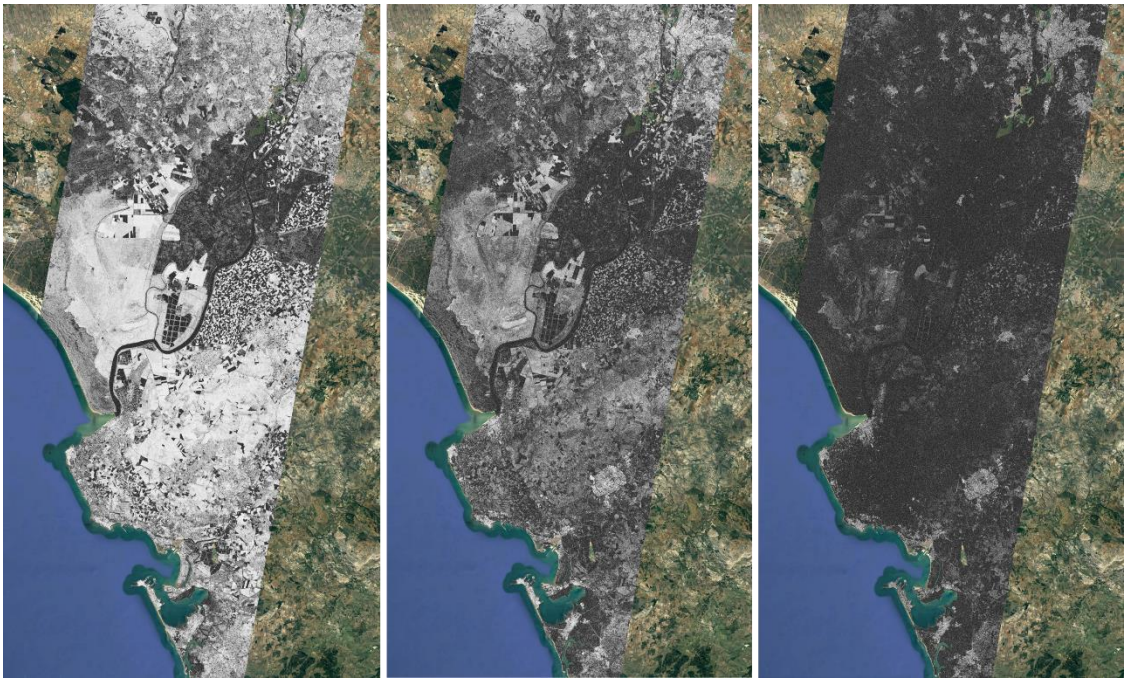

Figure 8 SINCOHMAP Project: Interferometric coherence evolution considering consecutive interferometric pairs of 6, 12 and 18 days. Sentinel-1 A/B data over Doñana (Spain)

Expected outcomes of the project are:

- InSAR coherence fingerprint**:** novel methodology tailored to the exploitation of the coherence evolution
- Machine learning approach at *pixel level* using Sentinel-1 and Sentinel-2
- Machine learning approach at *object level* using Sentinel-1 and Sentinel-2
- Alternative strategies proposed and extracted from a Round Robin consultation

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9 ANNEX C: Competition

Name	NEO, Geomatics & Earth Observation B.V (Netherlands)
Brief Description	
NEO provides unique information services starting from the changes in our habitat and keeps on innovating these services. In 2021 NEO monitors all buildings, roads, water courses, trees, fields, etc. in The Netherlands many times per year with an unmatched accuracy and completeness. From the changes detected, it built value-added services on offer in API. Examples are in crop management and control, tax register updates, pipeline monitoring, tree maintenance, solar panel location and size, etc. NEO works with customers and partners to customize the information one uses or provide to users and customers. NEO is the first company on Earth with the capabilities to monitor an entire country.	
Market Orientation	Agriculture policy makers
Relevance to ENVISION	**Crop Parcel Identification -** The working unit for the farmer is the crop parcel. So it is for the insurer to value, for the contractor to provide services and for the government to verify subsidies: It is essential to locate the crop parcel accurately. NEO provides the service to assess and map crop parcels in all climate zones and land use types. From subsistence farming and shifting cultivation to central pivots and modern large and small-scale farming in open air and glass houses. **Crop Parcel Monitoring -** Parcels change in use, cover and geometry from one season to another. So, once the parcel has been identified, stakeholders as insurers, subsidy providers, and contractors require updated information on every change. NEO runs a fully automated AI-based service to signal changes in use, geometry and cover. With every new satellite image change signals are produced for all parcels in e.g. a country. The signals indicate the nature of the change, the date and more. The change signal specifies the follow-up action of a stakeholder, e.g. to comply with LPIS-requirements as in the European Common Agricultural Policy (CAP). **Crop management -** NEO can assist the farmer in managing his crop by providing information to his/her business partners. On their turn partners can prepare themselves and be ready to support the farmer with the right timing. NEO also provides expert modern farmers with images of the current and previous years of their farms as well as of neighbouring farms on any device. The imagery, the statistics, the indices of choice and graphs in Crop Monitor illustrate how a crop performs in relation to other fields ansd years: Performs my crop better or worse, NEO's Crop Monitor has the answer.
References	www.neo.nl

Name	Assimila (UK)
Brief Description	
Using EO data and environmental modelling in understanding, monitoring and predicting the environment. Agriculture, land and climate risks are particular focus areas. Established in 2006, it: • develops innovative techniques to transform data into useful information for sustainable environmental management • builds tools and applications for operational systems • provides consultancy services for Earth observation programmes	

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It is staffed by a small, flexible and talented team, with expertise in Earth observation, data assimilation, space research and geo-computing. At Assimila they apply the latest research to practical problems in agriculture and the environment. They use Earth observation data with physical and biological models to monitor, understand and predict changes in the land surface. They work mostly in pest and disease management, land surface remote sensing and crop modelling.	
Market Orientation	Payment agencies Certification bodies for organic farming Farmers
Relevance to ENVISION	The following services and activities are relevant to ENVISION developments: **Crop modelling -** Food security is one of the biggest challenges in the face of climate change and a fast-growing population. Within these challenges, the resilience of food crops to remain productive throughout changes to local weather regimes is a key focus. All essential aspects to a crop's growth; water, radiation and soil, are all likely to be affected which could jeopardize the food security for regional and global communities. Assimila is working with partners in the UK and China, using EO data and crop models to improve understanding of crop performance. As the climate changes, past history of a crop can be an unreliable basis for future predictions. Numerical crop models can be used to simulate crop growth based on meteorological data with crop specific parameters that describe how the target crop reacts to meteorological and hydrological pressures. At Assimila they are using the WOFOST (WOrld FOod STudies) crop model which predicts certain crop characteristics on a day-by-day basis after a planting date. This is done by calculating the net energy available to the crop and partitioning it into different parts of the plant, based on the stage of the crop on that day and crop phenotype. One of the critical issues facing crop modellers is to determine the right local calibration parameters to use. Assimila implemenst an innovative approach, generating an ensemble of multiple model runs and comparing them to measurements of biophysical parameters derived from satellites. The satellite measurements inform of site-specific field conditions as well as import phenological timing events, which helps to make the yield predictions for WOFOST allot more accurate on local scales and in individual fields. **Extracting biophysical information from EO data -** Biophysical parameters can provide information on the state, health and growth of surface vegetation such as Forests, croplands and grasslands. Monitoring crop health and production is necessary for food security planning on regional, national and global scales but can also be used to support farmers on a local scale as well as for the agro-inputs industry. Monitoring of forests and grassland is necessary for management of these biomes as well as for locating land use change and ecosystem change risk factors. Satellite measurements are key for making these observations over large scales. The European Space Agency (ESA) Sentinel satellites provide observations of the land surface at high spatial resolutions. The optical, microwave and synthetic aperture radar sensors allow us to monitor land surface vegetation at up to 10 m resolution. These observations complement high temporal resolution satellites, like MODIS (which also has a long historical record); and commercial high-density satellites like planet labs, which produce very frequent, low accuracy, observations; among others. Assimila works closely with University College London to use the latest Data Assimilation techniques to combine satellite observations of the land surface with radiative transfer and other physical models to provide best estimates of biophysical parameters. Data assimilation

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	allows us to optimally combine multiple types of satellite observations together, with prior knowledge of the vegetation system and physically based models to monitor the land surface. Importantly Data assimilation also provides uncertainties on optimized parameters. Assimila has worked on several projects with partners across Europe to develop these tools including for ESA and on European Union Horizon 2020 projects as well as applications projects working with partners in the UK and China. Applications crop modelling and yield prediction services, as well as a yield gap dashboard for individual farm planning and management. Assimila is also working to incorporate biophysical parameter monitoring with crop modelling and weather forecasting for a comprehensive crop monitoring and modelling system. **Applying Earth Observation to assess UK land use change -** The UK has to make annual submissions on its Greenhouse Gas (GHG) Inventory. GHG inventories estimate emissions and removals from each sector of the economy . In the Land use, land-use change, and forestry (LULUCF) sector, activity data are often areas or changes in area of land use categories over time (i.e. expressed as hectares per year). Assimila developed for the UK Department for Business, Energy & Industrial Strategy (BEIS) a method to estimate activity data for the LULUCF sector using coarse resolution (>250m) Earth Observation data for a long time series going back to 1990 and capable of being extended in future years. A test area covering almost the whole UK (only excluding the far Eastern part), MODIS 500m and AVHRR 5km spatial resolution data were used to derive annual Land Cover / Land Use (LC/LU) products for 2011 and 2012. Using completely independent reference data to validate the 500m LC/LU product derived using MODIS data an overall classification accuracy of 96.57% and 96.58% for 2011 and 2012 respectively was achieved with all individual accuracies better than 94%. Change detection overall accuracy was 95.66%. Hence the methodology using MODIS 500m data is considered feasible to track LC/LU change over time at this coarse resolution.
References	http://www.assimila.eu/

Name	**AGRICOLUS (Italy)**
Brief Description	
Agricolus is an innovative startup working in Smart Farming sector. It was founded in February 2017 in Perugia, Umbria and it aims to support farmers and professionals in simplifying and enhancing the work in the field. The idea was born from the passion of the co-founders for the Umbrian territory, but especially for the "land" and for those who cultivate it, the farmers. Hence the intuition to use in Italy the innovative technologies for agriculture, already widespread in America, to help farmers struggling with sudden climate change to better manage and monitor their crops.	
Market Orientation	Farms - Farms with specific crops High qualified professional farms National (Italy) organisation
Relevance to ENVISION	Three different solutions are offered over the same platform, similar to ENVISION services: - *Crop monitoring for small farms: NDVI vigor index from Sentinel 2 and data collection from mobile App*. It is a solution for small farms that want to monitor crops remotely. It allows you to consult the NDVI

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	vigor index from Sentinel 2 every 5 days (in the absence of cloud cover) at a spatial resolution of 10 meters. You will be able to monitor crops remotely and assess their development and health and efficiently plan the activities to be carried out in the field. Thanks to mobile app it is possible to collect data directly in the field, geolocate information and insert photos and notes on damages, insects or plant diseases. - *Complete crop monitoring: vigor, chlorophyll, water stress indices from Sentinel 2.* Mobile app and asset management. It is the solution for farms that look for an efficient support for managing and monitoring crops. Focus is on satellite images and crop scouting. The platform manages 130 different crops and provides results for vegetables, cereals, and arable and horticultural crops. - *Complete agronomic management with satellite images from Sentinel 2, forecast models, DSS and weather stations.* It is a professional solution for farms willing a cutting-edge support for a complete agronomic management. The platform can be customised according to the specific needs of farms, in particular for those having multicrop fields and looking for weather stations to be implemented and forecast models to be consulted.
References	https://www.agricolus.com/en/solutions/ https://agritrack.eu/

Name	**Ariespace (Italy)**
Brief Description	
Satellite solutions for agriculture, developing operational solutions for the management of irrigation, agro-forestry resources and plants. They use remote sensing for Irrigation; Fertilisation monitoring; Vegetation indices	
Market Orientation	Its services target Assessors of Agriculture, Reclamation Consortiums, institutions and bodies involved in planning and territorial management, farms, farmers, land control bodies, research organisations
Relevance to ENVISION	*Vegetation monitoring* - Satellite imagery analysis enables a systematic and efficient process of controlling natural, environmental and land resources over time. Combining data from Earth Observation (satellite imagery) and Geographical Information Systems (GIS) ArieSpace can make maps and vegetation studies for different purposes. With the new satellites users can monitor vegetation in a cheaper and accessible way and on an almost weekly basis. The use of satellite data for the preparation of vegetation maps is a cheap and fast method to obtain quantitative information about the state and type of vegetation. The company uses satellite images captured by different satellites (Sentinel, Landsat, Geoeye, Rapideye, DMC, etc.) processed with the most advanced procedures that take into account the spectral response of vegetation in different wavelengths (from blue infrared). The procedures are validated with a series of measures in full field on specific targets for their validation. The ground measurements are complementary to remote observations, both because the functionality of the latter is linked to the accuracy of the calibration/validation procedure, and because they allow to complete the

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	observational basis necessary for a correct understanding and/or modelling processes. *Fertilisation monitoring - Nutrisat* is a service, conceived and developed, within the European project Fatima (FArming Tools for external nutrient Inputs and water MAnagement) in order to be able to warn-rare, through the use of satellite images, crops (Tomato and Wheat) in deficit Nutritional. The service is easily searchable through an interactive web-app, thanks to which it is possible, using the most common digital means, to easily identify crops that are in deficit of nitrogen and therefore growth. The system is based on the calculation of a Vegetation Index, the Nitrogen Nutrition Index (NNI), used to warn the concentration of nitrogen in the vegetative phase of crops. The calibration of the satellite data on which the system is based was carried out together with the Council for Agricultural Research and Economic Analysis CREA (www.crea.gov.it) during the three years of the European Fatima project with data collected in the field on wheat and pom-dore.
References	https://www.ariespace.com/en/home-2/

Name	**Brockman Consult (Germany)**
Brief Description	
Tailor-made software solutions, information products and expert advice in Earth Observation. EO data processing Brockmann Consult takes pride in supporting top-tier institutions like ESA, EUMETSAT, and the European Commission as well as numerous smaller customers to reach their ambitious objectives since 1999. Main activities include: **Environmental informatics –** Brockman Consult offers tailor-made software that effectively meets the requirements of its customers – regardless if it is just some lines of source code solving a very specific use case or a full-fledged software like the expert application SNAP, the Sentinel Application Platform, for the exploitation of Earth Observation products from many different sensors. Our solutions enable experts as well as end users to make the most of the available Earth Observation data. SNAP stands for Sentinels Application Platform and is a common software architecture on which a collection of free open source toolboxes for the scientific exploitation of Earth Observation missions is available. SNAP is an ESA development, technically lead by Brockmann Consult, and available through the ESA Website. SNAP supports the scientific exploitation for the ERS-ENVISAT missions, the Sentinels 1/2/3 missions, Proba-V, and a range of National and Third Party missions. SNAP contains the functionalities of historical toolboxes such as ENVISAT BEAM, NEST and Orfeo Toolbox that were developed over the last years. SNAP is addressing environment scientists, value adding companies, students and teachers. SNAP comprises an app for interactive work with the Earth Observation data (SNAP Desktop), the Graph Processing Framework to create and execute recurring workflows, a command line interface, as well as programming interfaces for python and Java.	

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Thus, SNAP can be used for interactive image visualisation and analysis, automation of processing chains, use of SNAP operators in own software and extension of SNAP with new functionality. All SNAP functions are implemented as plug-ins and are available from all above interfaces, so that interactive exploration can be further standardised and automated through the GPF and command line interface. SNAP has a large user community of more than 10.000 people globally. SNAP is continuously developed. A lively active forum allows users to interact, solve problems and exchange findings. Training courses are offered by ESA and Brockmann Consult. **Geoinformation services** Brockman Consult turns- the vast amount of Earth Observation data that is continuously produced by a growing fleet of satellites into valuable information on our environment and make it usable for public authorities, businesses, and the public. Our broad expertise allows us to offer the full range of services, marine and land applications with local, regional, and global scopes.

Market Orientation	Earth Observation use cases
Relevance to ENVISION	No direct relevance. Services of Brockmann Consult could be useful to implement add-ons and functional enhancements of ENVISION services.
References	https://www.brockmann-consult.de/

Name	**Cloudeo**
Brief Description	
Services focussing around geospatial and EO data for a range of industries, including agricultural Cloudeo's Application Services offer ready-made solutions for analytics and access information in either a web app or mobile app platform. These applications can then be set up to automatically access multiple data sources – like continuously running NDVI (Normalized Difference Vegetation Index) on Sentinel or Landsat data to determine the health of crops or vegetated areas, or automatically monitoring for disruptions in line-of-sight or Fresnel zones, which is important for telecom operations. Cloudeo Application Services cover four general areas: Digital Applications Development Services; Core Applications Development Services; Testing and Digital Assurance; Applications Management Services. cloudeo has built a reputation as a service provider in application management. It has designed a comprehensive catalog of services, which provide full-stack support for all technologies and environments. They leverage truly global delivery capabilities that the industry's leading technology partners support. Cloudeo´s Application Service Automation offers customers the ability to automate key process areas of application service management to improve productivity, quality, and service consistency. Our customers can either use these savings to improve their financial reserves or reinvest them to accelerate their organization's digital journey. cloudeo provides a comprehensive Applications Performance Management service. This service manages application experiences through your customers' lens, mitigating the business risk of failure through acceleration in fault detection, root cause analysis, and problem resolution times.	

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Market Orientation	Data and software services in relation EO data. Consultancy service - To agencies and certification bodies - To farmers
Relevance to ENVISION	Cloudeo supports the Agriculture Industry throughout the farming lifecycle: *Crop Selection* • Assess the feasibility of the crop considering climate and quality of land. • Compare crop productivity with other alternatives. • Forecast production yield. *Land Preparation* • Assess the effects of any disease from the previous cultivation and determine steps needed to minimize this impact. • Determine soil amendments which are required to bring the land to its normal fertility, depending upon the earlier crops and fertilizer used. • Create layout and design for efficient irrigation. • Incorporate latest techniques for field clearance and associated costs. *Seed Sowing* • Set the appropriate time to sow. • Determine optimal weather conditions at sowing time. • Establish best practices for sowing. • Control seed sowing depth. *Irrigation* • Find critical time for irrigation. • Calculate the volume of water needed. • Set frequency of irrigation. *Crop Growth* • Optimize the number of plants per unit of area. At times, plants may be too densely planted. Farmers must reduce density for the healthy growth of plants. • Monitor the average growth rate of the crop in normal conditions. • Compare crop growth rate, leaf size, crop color, etc. with expected growth for given situations and input. • Find interventions needed to maintain likely growth. • Determine frequency, quantity, and method for fertilization. • Set the proper time, frequency, and method for plowing. • Set the appropriate time, frequency, and method for weeding. • Prepare for pest and weed attacks, detect such attacks' symptoms, prepare precautionary measures that can be taken in advance to avoid these attacks, take immediate actions to combat them, determine the quantity of pesticide to be used per acre, find best practices for pesticide applications.

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	Harvesting • Set proper time and method for crop harvesting.
References	http://www.cloudeo.group

Name	**CROPIX (Switzerland)**
Brief Description	
CROPIX team are GIS experts with strong expertise in agriculture and remote sensing especially with SAR (synthetic aperture radar). In the past years CROPIX developed a crop vegetation index (ESVI) from Sentinel-1 SAR data in collaboration with sarmap. The ESVI (enhanced SAR vegetation index) is so far calibrated for corn, sunflower, sugar beet, wheat, barley, rye, rice, rapeseed and soybean. The calibration was done in countries like Germany, Italy, Denmark, Austria, Hungary, UK, USA, Argentina, Colombia, Brazil and India. CROPIX is based near Zurich/Switzerland and collaborate with partner in Santa Fé Argentina.	
Market Orientation	- Farmers - Payment agencies and Certification bodies mainly to certify and pay for disasters - Farm insurance providers - Agriculture policy makings
Relevance to ENVISION	CROPIX provides data products such as the following: • **ESVI** which shows the spatial variability of cropland over the season within one scale. The values (ranging from 0 to 100) correlate quite well with optical NDVI and other biomass indices. SAR measures structure and humidity of cropland. The signal can be transformed in an index that represents fresh biomass. In front season, it detects soil preparation measures like ploughing or harrowing before crop starts growing. The product can be used for decision making *in precision farming or crop monitoring for crop insurance or disaster management*. The map product can be delivered for single crop-types on field level or over all crop-types on regional level. • **COLOR** composite is purely derived from single date Sentinel-1 SAR data. It gives a high contrast and shows different zones within single plots. It is easy to perceive due to its natural color coding. It is ideal map product for *farm managers, crop insurance underwriters and investors to understand what is going on the farms*. • **Crop type maps -** it allows to aggregate the total cultivated area per crop-type and region. The information is useful for market survey as well as for disaster management to prevent from food shortfall. Crop-type differentiation for crop-type groups indicates parcels of cropland. **SWI** (SAR water index) shows the moisture content in the vegetation and topsoil. The product is suitable for large-scale drought monitoring. It reliably indicates a deficit in precipitation. It is suitable for use in irrigation management.
References	• https://cropix.ch/ • https://cropix.ch/map-products

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Name	CYBELETECH
Brief Description	
CYBELETECH combines several technologies from data acquisition, machine learning, model, numerical simulation, in order to bring a complete and relevant view of cropping system. The historical approach of the company is the mechanistic modelling of plants growth. Multiphysical and agronomical equations model complex interactions between climate, soil and genotype to simulate phenotypic traits : • Phenological stages, • Harvested organs weight, • Qualities, • Abiotic stresses, • … CYBELETECH data science team work towards the valorization of agronomical databases. They apply specific algorithms and methodologies to : complete, structure, make more reliable and safe farmer's data. To support the adoption of digital performance, CybeleTech software suite exposes its services through powerful dedicated infrastructures : web and SaaS solutions, safeness of sensitive data (protecting Intelligence Property as well as Client data), mobile applications… To optimize data circulation and computing it provides fast resource efficient solutions. The company works on the Cloud, HPC and Fog Computing strategies of our solutions through partnerships in the area of Cloud and high performance computing.	
Market Orientation	Farmers
Relevance to ENVISION	Remote sensing and signal processing is also in its portfolio. From drones to satellites, ways to observe agroforestry landscapes are numerous. To provide autonomous services, CYBELETECH uses the richness of spectrum to automatically access at large scale precise agronomic indicators. Its approach rely on data valorization to learn to understand plants. From statistical regression to deep learning techniques, the key is to choose the technique suited to farming objectives and data. It is the fusion of both approaches that enable CYBELETECH to provide services to valorize agronomical and climate data as well as imaging signals.
References	https://www.cybeletech.com/en/expertises/

Name	DRAXIS (Greece)
Brief Description	
DRAXIS focuses on developing real life environmental ICT solutions and providing specialized environmental consultation services. It build environmental software and databases; it provides consultancy services . Indicatively, DRAXIS is specialized in developing: • Environmental decision support systems and web applications combining information from many sources and workflows and providing information and emergency alerting • Environmental simulation models (dispersion of air pollutants, noise radiation, risk etc) • Data hub systems that collect earth observation data offering them to other applications or the web via secure data bridges • Mobile applications that push the appropriate information • Crowdsourcing platforms that exploit the power of the crowd and combine the crowdsourced data with additional datasets to accomplish unique goals and provide personalized alerts	

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These tools can be expanded and applied to different fields of the environmental sector and create a whole new universe of opportunities for technological applications, in the following areas: **Digital government** – DRAXIS provides information system that enable e-government and public services at local, regional and EU level. It develops operational permitting tools that make the environmental permitting process more transparent, accessible and efficient. **Air quality** – DRAXIS provides advanced air quality modeling and semi-empirical forecasting algorithms, Impact assessment of air pollution on human health and the environment and operational plans. **Energy -** DRAXIS provides technical and professional services to the energy sector and works with organisations helping them to improve their energy efficiency and reduce their environmental impacts. In the frame of ongoing climate change they provide innovative solutions and build competitive advantage for our clients, as we assist them to identify their key business risks (Life Cycle Analysis, Feasibility Studies) and opportunities associated with carbon and energy use and develop ICT solutions to manage these. Its services include consultation for adaptation to Climate Change, RES planning and licensing as well as safety studies for industrial installations and industrial accidents. **Weather forecasting-** Laying on the availability of a huge amount of free and open observational data from both ground and satellite sensors and combining them with advanced high-resolution numerical weather prediction models and land-atmosphere data assimilation systems, DRAXIS offers operational weather intelligence services of increased precision and accuracy, both in the spatial and temporal domain. Furthermore, its fully qualified atmospheric scientists provide consulting services to private and public organizations enabling them to adapt their operational processes in order to mitigate extreme weather events and to become climate-smart. **Sustainable agriculture -** DRAXIS is offering a suite of operational farm advisory services for tillage, irrigation, crop monitoring, yield estimation and pest management through easy-to-use and fully customizable ICT web-applications and APIs. **Waste management -** DRAXIS consulting department develops integrated plans for the management of municipal solid waste including biowaste and food waste, as well as of special waste streams such as recyclables, spent batteries, waste electrical and electronic equipment to national and European level. Moreover, it undertakes the implementation of technical studies, environmental impact assessment studies and technical offers related to waste management. Having an experienced IT department, DRAXIS is able to deliver effective solutions to facilitate environmental monitoring, policy design, waste registration and submission of companies' annual waste report. **Circular economy -** DRAXIS focused on the application of new technologies to promote water efficiency, support industrial symbiosis, improve the management of municipal waste, and contribute to measurable and replicable resource-efficiency solutions that can be verified through indicators and appropriate data collection.	
Market Orientation	Environmental & Climate data users (tourism, risk management agiriculture)
Relevance to ENVISION	Crop management is a quite difficult and continuing challenge for small and large farm holdings and agri-food companies. Using its expertise both in the agricultural and the ICT sectors, DRAXIS combines datasets from various sources (satellites, weather stations, farmer-generated data) with advanced crop growth simulation models and machine learning algorithms in order to develop software solutions and services that make farm management simpler and more efficient. DRAXIS is offering a suite of operational farm advisory services for tillage, irrigation, crop monitoring, yield estimation and pest management through easy-to-use and fully customizable ICT web-applications and APIs.
References	www.draxis.gr

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Name	ENERGISE
Brief Description	
A geographical information system is an essential part of an Integrated Administration and Control System (IACS) implementation. Supporting a Land Parcel Identification System (LPIS), system of ENERGISE can be used from within the institution and made publicly available if desired. THe GIS infrastructure is built so that it can run on both high-end (blades) and low-end (PC clusters) servers. Furthermore, a number of integrated applications for administration and control, such as: Farm Registry, LPIS, On-the-spot controls are available. Components of the applications can handle, for example, land consolidation, meliorations, disease outbreak, forestry and others.	
Market Orientation	- Farmers - Certification Bodies and Payment Agencies
Relevance to ENVISION	The agricultural GIS solutions of ENERGISE are listed below: **Farm Registry** is a web-based application, which includes the basic data about farms and farm holders. It is an umbrella application for all systems related to IACS - LPIS evidence (Land Parcel Information System), the data of Registry of common pastures, evidences of hop, olives, fruits, grapes and wine producers, etc. **LPIS -** Sinergise has developed an innovative and powerful set of Java-based tools that cover all aspects of Land Parcel Identification System (LPIS). They can be deployed in client-server architecture, in an Internet-based system or even on a CD. It combines these tools into an Internet-based system for editing the graphical and descriptive information on usage of agricultural land. The application is being used on a daily basis by hundreds of users in Slovenia, Croatia and Macedonia for EU farming subsidy applications monitored under IACS regulation. **Giselle Farm Management** is a web-based farm management system to assist farmers and land managers in achieving "best practice" agricultural outcomes. It is used all over the agricultural industry to manage resources, increase yields, reduce input costs, predict outcomes, and more. The powerful analytical capabilities allow for the examination of farm conditions and monitor the effects of farm management practices, including crop yield estimates and soil amendment analyses. Giselle Farm Management can be also used to reduce farm input costs such as fertilizer, fuel, seed, labor, and transportation. In addition, farm managers can use the platform to automatically generate reports required by law. **Controls** is an on-the-spot control system that has been developed to provide an effective support for inspectors when reviewing, determining, evaluating, and resolving irregularities on the field. Equipped with GPS receivers, latest aerial photography and satellite images the inspectors perform measurements for claimed parcels and compare the overlays with imported declared data. After this procedure a report is issued to the land owner and the data are notified and synchronized with central data base. The application assures flexibility, accuracy and proper course of the process, which greatly reduces the effort, time and number of errors. The application supports all steps of the on-the-spot controls process such as risk analysis (selection of farms to be inspected according to the legislation), logistics, preparation of supportive layers (aerial photography, LPIS data, land use, previous check results, …), downloading of data to laptop. Map printings, export/import to/from GPS, post-processing (overlays of data layers, findings report, photos

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	attachments, calculations, …), report printing, control results, uploading to other registers, etc. **Animal Controls** are also developed for animals apart for checking parcels. Each parcel can have its own animals on it and controller can perform on-the-spot check for this animals. Visual Controls Application for visual control has been developed for quick and efficient change control of LPIS parcels. Changes are related either to remarks from a farm holder (LPIS Update) or to change of reference spatial layers - orthophoto or similar. System is designed to support most efficient work of the operators. One can use two synchronized map screens, each displaying different spatial layers. In that way the changes are as clear as possible. Process is based on task lists - the operator moves from one task to another, focusing on one parcel at a time and deciding whether to approve the parcel or not. **Disease Outbreak Control** is a web based GIS application that provides an efficient IT support for governmental services with the intention to prevent spreading of contagious diseases from potential outbreak areas to other farms, agricultural regions or into the environment. The Disease Outbreak application is equipped with tools for prediction of possible course and speed of spreading of the disease considering different characteristics of diseases and some geographical factors such as relief, water network, climatic conditions, etc. By using this application, the coordination of actions in animal disease outbreak control centre becomes very manageable and effective. **Land consolidation** application purpose is to support the management of agricultural land with regard to the process of land consolidation. Due to the inheritance laws in the past agriculture land is divided into many patches, which are not suitable to organize and construct efficient irrigating systems, thus the parcels would be merged into bigger entities. Our application offers all solutions and operations needed for organizing and managing such agricultural land. **Meliorations** application is developed for the management of agricultural regions that are irrigated and to control irrigation infrastructure. It is composed of several tools enabling different processes for controlling, planning, development of irrigation systems, and also for taxing, subvention assigning and refunding in case of droughts, heavy storms and other natural disasters. The application has four modules - graphical module for management and surveying of the irrigated parcels, cadastre maps, ortho-photos, and other topographic maps; graphical module to manage the irrigating systems; attribute database of irrigating systems; and the administrative - managing module. **Geo Spatial Aid Application** is a Web application that includes the basic GIS tools and managing data through intuitive GUI. **Vineyard registry** application provides an effective support for the management of the registry of wine producers and their products, such as grapes, must, and wine. The application also supports the over-viewing and realization of chemical analyses, mixing of different sorts of vine and quality controls. Finally, it provides the certificate of origin, quality and sort, and prepares sale permission. Also, on the bases of all inputted data, the management decrees the permission for renovation of the vineyards to the owners.

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References	• https://www.sinergise.com/solutions/agriculture • https://youtu.be/gmWo57S8uM4

Name	**Geosys**
Brief Description	
Geosys provides satellite-based analytics supporting unbiased decision making and risk mitigation in agriculture. From regional to field level, its expertise in geographic information systems provides scalability of a global platform while its presence in major agricultural countries offers localized solutions. Through the use of advanced analytics and machine learning, Geosys continues to drive Ag technology forward.	
Market Orientation	Farmers Agronomics
Relevance to ENVISION	Geosys products include: ○ Agriquest© Global Monitoring Tool - Crop production monitoring tool using satellite data to understand yield, mitigate origination risk & easily evaluate impact of weather events on crops. ○ Croptical© Monitoring Application - Daily satellite crop scouting supporting prioritization and agronomic decisions with quick, easy customizable website and apps. ○ Farmsat© Precision Ag Tool - Precision agriculture solution using satellite for large scale deployment to help better manage variable rate inputs application throughout the season. Examples of tailor-made agro-analytics solutions include: ○ NDVI, EVI, LAI and others - Geosys provides both NDVI measured by satellite and LAI modeled from reflectance to evaluate crop health, yield potential, or nitrogen status of a crop. It applies what makes sense where and when it makes sense. An accurate field variability maps will help to sample fields, gain time and statistical representativeness but also informs farmers on the quality of the production at an early stage. ○ Change Detection – This is to address needs of owners who are overwhelmed by too many maps and has trouble analyzing all the maps on the fields he manages. High-quality analytics-ready data allows to compute an accurate change detection index and alert of what one needs to look at when it matters. ○ Yield Trend Benchmarking - Benchmark crops in every field vs past years, average performance and vs. all the comparable fields in farmer portfolio to know where the yield potential is, and where it needs to be protected: decide whterh micro-nutrients are needed or Fungicide. Useful also, t0 prioritize field operations according to maturity for optimal quality.
References	www.geosys.com

Name	**e-GEOS (Italy)**
Brief Description	
e-GEOS, an ASI (20%) / Telespazio (80%) company, is a leading international player in the Earth Observation and Geo-Spatial Information business. e-GEOS is the global distributor for the COSMO-SkyMed data, the largest and most advanced Radar Satellite constellation available today.	

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e-GEOS offers a unique portfolio of application services, specially thanks to the superior monitoring capabilities of COSMO-SkyMed constellation. It has acquired a leading position within European Copernicus Program. Covering the whole value chain, from data acquisition to the generation of analytics reports, e-GEOS, thanks to proprietary assets and algorithms, integrates data from all satellites with the IoT information gathered over different sources, creating a BigData lake where all the e-GEOS platforms are able to extract significant indicators dedicated to different markets. This approach is one of the key assets of the new services and products offered by the company and it can be run both on premises and on cloud.

Through the AWARE platform is possible to access the e-GEOS interferometric measurements (thousands of measures over single sqKm) for, ground subsidence and landslides analysis, thematic mapping for city management, agronomy/ precision farming, cultural heritage, Inherent Defect Insurance (IDI) and forestry. e-GEOS, provides Geo-information services such as monitoring for environmental protection, rush mapping in support to natural and man-made disaster specialized platforms for defense and intelligenceNear Real time oil spill and vessel detection services for maritime surveillance platforms.

e-GEOS runs a multi-purpose 24h Emergency mapping Centre that is able to work in rush mode, supporting the customers with challenging ServiceLevel Agreement. Today this services is well used by both institutional and civilian customers: from the emergency mapping center, in which European Copernicus Program (EMS) represents one of the main success cases, to the IMINT reports for defence and intelligence in which Copernicus SEA (The Copernicus services in Support to EU External Action) is the latest example.

In support to its operational applications and activities, the Matera Space Centre represents a unique and advanced premise for acquisition, archiving and processing multi-mission satellite data, including COSMO-SkyMed, ESA Sentinels, Radarsat-2 and the new micro-satellite missions ICEYE and BLACKSKY missions. The e-GEOS Space Center hosts the Matera User Ground Station (MUGS) for the European Data Relay System (EDRS). This innovative Ground Station is designed to receive process and distribute streams of data for the EDRS space segments, which will serve the EU's Earth Observation Programme Copernicus, supporting agriculture, urban area management, civil and nature protection. The Space Centre is dedicated to Earth observation activities and also provides operational services for the Space Geodesy Centre. The Matera Space Centre acquires, processes, stores and distributes remotely-sensed data from the main Earth observation satellites, and also produces images, products and services in near real time for maritime surveillance.

In particular, the Centre contributes to the design, integration and testing of the civil ground segment data of the Italian radar satellite constellation COSMO-SkyMed. It has provided operation and maintenance services since the launch of the first satellite in 2007. Since 2012, the Matera Space Centre has been one of the four stations of the Core Ground Segment of the European Space Agency (ESA) to receive and process in real-time radar and optical data acquired by Copernicus (the European Earth observation programme) Sentinel satellites. e-GEOS through the Geoinformation Information Centre (GIC) program is able to set up a complete and operational centre in house of the customer with all the training required for a complete knowledge transfer.

Market Orientation	PAs CBs Farmers Agriculture Policy Makers//
Relevance to ENVISION	STUDY CASE To guarantee a correct supply of CAP funds, the Italian Agency AGEA uses a complex geographic information system that collects data on the national agricultural territory and from the agricultural producers. The Copernicus satellite constellation (Sentinel) is opening new approaches for a systematic monitoring of the agronomic parcels, allowing semi-automatic check of the overall crop declaration correctness and of the environmental protection applied.

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	An operational pilot has been successfully performed over Foggia province (south of Italy), automatically processing more than 450,000 agricultural parcels, using more than 200 Sentinel images collected in 2017 and 2018. The processing workflow is based on information extraction in terms of "activity markers" obtained by the processing of satellite time series. In order to support the workflow, satellite data are preprocessed through the elimination of all atmospheric disturbances and clouds, the radiometric normalization and stored as DataCube, allowing their efficient usage as input to information extraction procedures COMMON AGRICULTURE POLICY (CAP) SUPPORT SERVICES Multitemporal optical satellite capability to follow the agronomic seasons of each single agro-field by identifying, in a fully automatic way, the field activities aiming at: - «Mark» every farming actions (ploughing, seeding, harvesting, ..) - Match the «markers» versus the expected phenologic time windows and local agronomic scenarios - Support the semi-automatic monitoring of the European CAP farmer declarations for subsidies PRODUCTION ESTIMATION SUPPORT AND RISK MANAGEMENT SERVICES Comparing the temporal trend of spectral indices computed by satellite over different year on each single crop parcels along the whole crop life cycle, and integrating with meteorological models, for: - Monitoring the crops health condition - Support herbaceous crop production estimation - Historical analysis of crop behaviour for supporting risk assessment INSURANCE SERVICES – CLAIMS MANAGEMENT SAR satellite data allow the extraction of flooded areas over agricultural fields on optical data even immediately after an event, for: - Mapping the real flooded crop area - Monitor, thanks to the guaranteed SAR collection even under clouds, flood evolution and the water stagnation area along time - Evaluate the possible damage in support to the insurance, depending on crop type and phenological phase during the submerging phase PRECISION FARMING FOR INDIVIDUAL NEEDS Satellite allows the identification of crop growth and health at "intra-parcel" level for: - Identify crops local vigour or disease conditions within each parcel - Provide, along the season and in real time, precise local indications for the better agronomic works (fertilization, irrigation, harvesting starting time and point, etc) FOREST MONITORING SERVICES SAR data, by analysing both amplitude and coherence information, allows the identification of deforested area (clear cut of high forest or rotational coppice) in tropical areas, as in figure. In boreal environments, optical satellite land change analyses provide relevant support for:

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	- legal and authorized deforestation monitoring, both for administration and timber companies - illegal cuts detection and mapping in real time, also for necessary repressive actions - forest fires burn scar mapping after the event and relative damage evaluation - trees crashed delineation areas after wind storms
References	www.e-geos.it

Name	**EOX IT Gmbh (Austria)**
Brief Description	
EOX IT Services GmbH offers solutions and services in the geodata domain in general and in the Earth Observation domain in particular. EOX is strongly committed towards utilizing and contributing to Open Source Software for example via the EOX GitHub organization. EOX is committed to comply to and improve Open Standards particularly those of the Open Geospatial Consortium (OGC). It is a technology partner of choice in major European environment monitoring and space programs like the European Copernicus initiative.	
Market Orientation	Farmers ICT developers
Relevance to ENVISION	**Sentinel-2 cloudless & EOxMaps** the global and cloudless Sentinel-2 map, crafted by us and included in EOX global maps offering Users can play around with the interactive map below and compare different years. Farmers can get prerendered Sentinel-2 cloudless as map cache and create their own layer using mapping optimized source mosaics for web maps or desktop GIS tools. **Products and Services for development ecosystem** EOX offers various development services such as: • Euro data cube: the Earth Observation Information Factory, combines the strength of several services to offer a one-stop-shop for Earth Observation. • EOxHub offers Workspaces, managed JupyterLab instances with curated base images ready to kick off your EO workloads, as well as marketplace functionality. • Data Products - off-the-shelf multispectral mosaic data from Sentinel-2 or customizable bespoke mosaic tailored for further analysis and processing.
References	www.eox.at

Name	**GAF AG (Germany)**
Brief Description	
GAF AG is an e-GEOS (Telespazio/ASI) company seated in Munich, Germany. GAF, founded in 1985, was the first German company to work specifically with applied remote sensing. It is now one of the largest European geographic information service providers and has a particular focus on earth observation. The company is the most important distributor of commercial earth observation data in the German-speaking countries. GAF has many years of specialist and technical expertise in the application and evaluation of remote sensing data as well as extensive national and international experience of providing services involving geodata and spatial software. The company has an excellent reputation among numerous German authorities and ministries, as	

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well as in the private sector and with the EU, ESA and World Bank. This has resulted from the conducting of international activities in over 144 countries in Europe, Africa, Asia and South America. GAF is one of the leading companies in the geo-spatial service market. • a one-stop shop for geo-information. • products and services in a large number of consulting domains. • focused on quality, technical excellence and customer satisfaction. **Geo-data, technology, solutions, products -** GAF offers a comprehensive end-to-end service portfolio: earth observation data, geo-products, integrating space technologies (satellite communication, earth observation and positioning) into real world applications. Software and -systems, technology consulting and institutional strengthening. It is keeping pace with the accelerating technological developments - for customer benefit. **Development, sustainability, compliance -** GAF works in the fields of natural resources and raw materials, environment and water, forestry and agriculture, infrastructure and emergency management. We provide sustainable end-to-end solutions in resources management, inventories, monitoring and planning - with a strong focus on capacity building. **Presence -** Besides its home markets in Germany and Europe, GAF is internationally active - having an impressing track record of more than 1000 projects in 100 countries worldwide. GAF works for industry and private sector, for international institutions and development banks, national authorities and clients. They are headquartered in Munich, Germany with a branch in Neustrelitz (North of Berlin) and project offices worldwide. The company brings more than 200 highly qualified staff and 30 years of experience	
Market Orientation	Agriculture policy making Farmers
Relevance to ENVISION	AgroView® - for both administrations and farmers Clients are mostly state ministries of agriculture, forestry and the environment, are using an increasing number of applications that are being filed electronically, which is primarily the result of using AgroView®: "With AgroView®, the acknowledged high standards of GAF in the field of GIS cater optimally for the additional requirements regarding the filing of applications, such as form design and complex plausibility checks. As a result, this application tool is a real all-rounder and acceptance by farmers is very high. The 'silver disk' or web-client application from Munich is therefore eagerly anticipated by farmers in March each year." An efficient e-government solution Just as positive are the vibes coming from the various state agricultural offices. Since the introduction of the payment entitlements system, with annual activation being related to eligible area and cross-compliance obligations, and most recently to greening practices, the complexity of administrative procedures has increased enormously. Even highly dedicated agricultural office staff sometimes therefore cannot possibly know every last detail of the European guidelines. In this context, the Application CD, with its straightforward user guide and comprehensive plausibility checks for all forms, has emerged as an essential digital work of reference for farmers. The complexity of the administrative procedures affects not only the farmers but also the agricultural office. Without digital data transfer, the deadline for application processing could not be met. GAF - a competent, cooperative and reliable business partner Administrations and farmers thus benefit in equal measure from the advantages provided by using AgroView®. In various agricultural administrations, the LaFIS® product suite is also deployed alongside AgroView®, along with GAF remote sensing services in the field of subsidy control that have developed over the course of many years. This is no pure coincidence but is a result of the enthusiasm, professional competence and customer-

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	friendly service of GAF. As a satisfied customer describes it: "The technical skills and not least the excellent spirit of cooperation during project development mean that GAF AG will also in the future be an indispensable partner for the realisation of further e-government projects". **GAF Recent News - GAF AG has won the first European call for tenders for the operational implementation of the agricultural area monitoring system in Germany in 2021** stipulated by the European Common Agricultural Policy (CAP). The Paying Agency makes use of GAF's sophisticated cloud-based solutions for the automatic monitoring of agricultural parcels. The contract runs for the next three (+1) years (starting Feb 2021) and covers the rapid, accurate and fully automated continuous monitoring and precise verification of numerous crop types covering the entire area of Sachsen-Anhalt, and the evaluation of compliance with agri-environmental and climate measures, using both optical and radar data from the European Copernicus Sentinel Missions. GAF's sophisticated system and wide range of innovative digital geo-solutions provides highly accurate, systematic and regular information retrieval from earth observation data in accordance with the newest CAP requirements. Based on the machine and deep learning algorithms developed by GAF and time series analyses, verified decisions for more than 100 agricultural land-use classes are enabled. This system heralds a new era in the use of remote sensing data analysis for operational use.
References	• www.gaf.de • https://earsc.org/2021/02/25/members-news-gaf-has-been-awarded-a-multi-year-contract-by-the-german-federal-state-of-saxony-anhalt-to-perform-crop-monitoring-in-the-context-of-the-european-cap/

Name	**GISAT (CZ)**
Brief Description	
The company mission is to provide its clients with wide range of value added, complete, high quality, affordable and 'state-of-the-art' geoinformation services based on the Earth Observation technology. GISAT brings to its domestic and international clients complete portfolio of services starting from satellite data and geomatics software distribution, through specialized image and GIS data processing and analysis, up to advanced geoinformation products and services. Based on the long-term presence on the geospatial market and extensive experiences from the past projects GISAT has established sustainable and reliable partnerships with its clients and partners. Products and services include wide spectrum of application domains. However, the key satellite usage application areas for Gisat services remain agriculture and environment. Besides the geoinformation services Gisat menu also includes portfolio of geoinformation products. Mostly, these are the results of standardized satellite data processing and derived map or GIS based products. GISAT brings to its domestic and international clients complete portfolio of services related to the acquisition, interpretation and exploitation of spatial information, namely with the use of advanced technology of remote sensing and GIS. Detailed description of GISAT services are divided into several thematic packages : • Distribution of satellite data and other geo-spatial databases • Distribution of geomatics software • Processing and analysing of airborne and satellite data • Database creation, GIS analysis and modeling • Consultancy services • Research, education and training activities	

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- Project management services

Based on their nature and usage, its data products may be divided into several categories:

- data products
  - vector data
  - raster data
  - digital elevation models
- maps a marketing products
  - satellite maps
  - thematic maps
  - posters and other presentation products

</td></tr>
<tr><td>Market Orientation</td><td>Remote sensing data and services to support CAP
PAs</td></tr>
<tr><td>Relevance to ENVISION</td><td>Gisat was responsible in Sen4CAP project for the implementation of Agricultural Practices Monitoring use cases. They were mostly focused to improve the efficiency and traceability of the control of the greening measures of the CAP, in particular dedicating 5% of arable land to ‘ecological focus areas’. Three practices were proposed as separate use cases: check of compliance with declared land lying fallow; catch crops and nitrogen fixing crops. Additional use cases developed methods to identify crop harvest on arable land parcels and ploughed grassland parcels.
DROMAS service – An ESA-enabled service
Objectives of the service - According to the principal national strategic document in respect of climate change “one of the most important adaptation measures is developing a system of integrated agro-meteorological monitoring and alerts. Its output must be directed to the operational advisory in agriculture.

DROMAS Agricultural Crop Monitoring service delivers an innovative tool to provide periodically updated information on crop types and crop cover to national administration. The service products are represented by crop maps with associated metadata layer of anomaly detection allowing monitoring of agro-environmental degradation and agricultural crop damages on the agricultural parcel level. The service is provided on-line via web mapping services.

DROMAS Farming Management Service provides monitoring of agricultural crops at parcel level to support farm decision making. The service delivers field-level historical time-series analysis of crop spatial variability to assess farming management practice and provides current crop growth monitoring to enhance the practice. The field crop historical analysis is interpreted together with auxiliary data (e.g. soil map, topographic map, temperature and precipitation data). Current year monitoring can be supplemented by the soil moisture measurements to interpret drought events. The service products are provided in the form of printed crop maps.
Users and their needs

The Czech Ministry of Agriculture (MoA), State Agricultural Intervention Fund (SAIF) and agricultural producers (Farmers) represent three main end users of the proposed monitoring services. They stand on opposite sides of the financial flows resulting from damage caused by natural disasters and agro-environmental</td></tr>
</table>

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	degradation but they have a common interest in minimizing the threat to agricultural production in the country. User needs: ○ Timely information on which farms and which parcels are affected by the natural disaster ○ Up-to-date information on know which crops are grown on individual parcels and if there are any anomalies in the crop growth. ○ Information on which agricultural parcels are characterized by high spatial and temporal crop variability within the parcel repeated over a multi-year period. Target users are from the Czech Republic. Service/ system concept - The proposed system consists of separated components that represent technical solution to fulfill individual service requirements identified in the feasibility study: ○ Earth Observation component - selection and provision of suitable satellite imagery ○ In-situ component – acquisition and provision of field survey crop information and soil moisture data ○ Data storage component – data storage and data management ○ Data processing component – data processing and analysis ○ Map server component – service products provision to the user DROMAS Feasibility study concluded in May 2015. The Feasibility study assessed and proved the concept of two agricultural services focusing at operational monitoring of agricultural vegetation to serve decision makers on national level and to provide historical and current year crop analysis to support farm management at agricultural parcel level. Due to the positive feedback received by the users and the confirmed viability of the service, the team is in the process of preparing an ARTES 20 demonstration project.
References	• http://www.gisat.cz/content/enn • https://business.esa.int/projects/dromas-fs

Name	**Earthi (UK)**
Brief Description	
Geo-spatial Information provider fusing multi-operator / multiresolution / multi-sensor Earth Observation (EO) data including satellite video coupled with advanced analytics and geo-spatial experts to provide near-real time actionable insights. Applications and projects span into many different areas: military, agriculture, environment, commercial & insurance, urban planning, disaster management, energy and natural resources, etc Earth-i offers precision agriculture companies access to timely and detailed geospatial information that can assist agricultural guidance systems to manage crop production and maximise yields in large-scale farming enterprises or provide critical decision-support to small-holder farms in developing countries. Earth-i delivers geospatial intelligence to farmers, governments and agri-companies with a level of detail and actionable insight, over wide areas and with high frequency revisits. This enables effective decision-support and farm-based technologies that increase crop yields, crop health and farm productivity. When integrated with other data sources, such as predictive models for weather and pests, geospatial analytics	

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and intelligence are combatting the impact of climate change and working towards more sustainable global food supply.	
Market Orientation	Mapping agricultural land and crop classification Vegetation and crop health monitoring
Relevance to ENVISION	Sample Applications: • Mapping agricultural land and crop classification Vegetation and crop health monitoring • Terrain feature identification and change monitoring • Site-specific crop yield management programmes • Climate change mitigation
References	https://earthi.space/industries/agriculture/

Name	**KAPPAZETA (Estonia)**
Brief Description	
A science-driven radar remote sensing company offering ready-to-use high quality Sentinel-1 timeseries and change detection services. Sentinel-1 data is the only freely available radar data source which enables global monitoring at parcel scale with a revisit rate of between 3 to 12 days. KAPPAZETTA has the expertise to meaningfully utilize this data using a unique processing chain for radar interferometry. In comparison, optical satellites do not provide as regular and as timely data feed globally as radar satellites due to cloud interference and variable illumination conditions. Its cutting-edge technology converts raw data from the Sentinel-1 radar satellite into time series of features valuable for machine learning, used in both scientific and industrial applications. The key focus area is agriculture. The analysis ready radar satellite services with high accuracy enable to observe changes as they happen and make better decisions. Some key projects and achievements are mentioned below: • Incentive Scheme (IIS) project “Grassland mowing detection for agricultural subsidy checks with Sentinel-1 and Sentinel-2" with demo applications in Denmark, Sweden and Poland. • 2018 – Nation-wide fully automated mowing detection system operational in Estonia and started incubation programme in ESA BIC Estonia • 2019 – As a consortium member in “National Programme for Addressing Socio-Economic Challenges through R&D” started to develop a crop classification methodology for Estonian conditions. 5 employees. • 2020 – KappaZeta received funding from European Space Agency (ESA) for three projects: o Harvesting Time Recommendation for maximum crop Yield (HaTRY) o Grazing Detection from Copernicus Data for Agricultural Subsidy Checks o AI-based Cloud Mask Processor for Sentinel-2 **KAPPAZETTA mission -** It is often impossible to develop operational, high accuracy Earth observation application based only on the data from optical satellites. If clouds or smoke block the view, optical satellites are unable to capture the situation on ground. One can overcome this obstacle by adopting data from synthetic aperture radar (SAR) satellites. SAR data has another significant advantage – it contains information about the structure and water content of land cover. ESA Copernicus Sentinel-1 is a great SAR mission and provides huge potential for the EO community. Unfortunately, its data is largely under-exploited because it is too complex to use for a large majority of potential beneficiaries. The entrance barrier for correct adoption of Sentinel-1 data is too high in sense of lacking know-how about right pre-processing. Our experience shows that most of ICT, GIS, EO, consultancy companies, and governmental users overlook SAR data because it is not economically reasonable to build the processing competence in their organization. This is the exact place where KappaZeta makes things easier. They take the SAR data of Sentinel-1 and refine it with science-grade processing chain. Then, they turn images distorted by thermal noise into highly accurate analysis-ready time series of statistics and raster	

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layers. The output KAPPAZETTA provides enables its clients to have reliable analysis and make better informed decisions in various domains.	
Market Orientation	Payment agencies Certification Bodies National Authorities Consultancy companies
Relevance to ENVISION	The main deliverables of KAPPAZETTA customers and partners are listed below: • *InSAR coherence raster time series* - A sequence of high-resolution InSAR coherence raster images of your AOI for a specified period. • Especially suited for event and change detection such as farming events. Data sources are ESA Copernicus Sentinel-1 radar satellites. KappaZeta value added includes high accuracy provided by science-grade calibration process and noise removal. It supports imaging frequency: 2-4 images per 6 days, depending on the geographic location. Examples of application domains include agriculture, forestry and environmental protection. • *SAR backscatter raster time series* - A sequence of high-resolution SAR backscatter raster images of your AOI for a specified period. Especially good as an input for various plant type detection tasks, e.g., crop type identification by its temporal signature via phenology. Data sources are ESA Copernicus Sentinel-1 radar satellites. KappaZeta value added includes high accuracy provided by science-grade calibration process and advanced speckle suppression. It supports imaging frequency: 2-4 images per 6 days, depending on the geographic location. Examples of application domains include agriculture, forestry and environmental protection. • *SAR raster time series for visual use* – A sequence of high-resolution SAR coherence and backscatter raster images of your AOI for a specified period of time with dedicated color scheme to facilitate visual inspection. Designed to make distinguishing patterns as easy as possible for human eye. Data sources are ESA Copernicus Sentinel-1 radar satellites. KappaZeta value added includes high accuracy provided by science-grade calibration process and advanced speckle suppression. It supports imaging frequency: 2-4 images per 6 days, depending on the geographic location. Examples of application domains include agriculture, forestry and environmental protection. • *Synthesized biomass estimate raster timer series* - A sequence of high-resolution biomass estimate images synthesized from radar combined with cloud-free optical data of AOI for a specified period. Especially useful when one needs continuous time-series of biomass estimates. Sources include ESA Copernicus Sentinel-1 radar and Sentinel-2 optical satellites. The added value are the refined SAR data and Deep Learning modelling. It supports imaging frequency: 2-4 images per 6 days, depending on the geographic location. Examples of application domains include agriculture, forestry and environmental protection.

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	• SAR parcel level statistics time series – A parcel level time series of InSAR coherence and SAR backscatter statistics for a list of polygons depicting a specified period. The service provides reliable observations for 30-50% more parcels with complex shape and as small as 0.5 hectares. Especially useful when one needs to investigate polygons with low spatial variability (e.g., crop fields, forest parcels), which have distinct signatures in time. Source includes ESA Copernicus Sentinel-1 radar satellites. KappaZeta value added includes high accuracy provided by science-grade calibration and noise removal. It supports imaging frequency: 2-4 images per 6 days, depending on the geographic location. Examples of application domains include agriculture, forestry and environmental protection. • *Agri subsidy compliance monitoring* - Automated monitoring of fields to detect completion of agricultural works necessary to qualify for subsidy. Kappazetta provides reliable monitoring for 30-50% more parcels with complex shape and as small as 0.5 hectares. Main sources are ESA Copernicus Sentinel-1 radar satellites and Sentinel-2 optical satellites. KappaZeta value added includes Refined SAR data and Deep Learning modelling. • *Crop type identification* - It supports automated identification of 28 crop types, reliable monitoring for 30-50% more parcels with complex shape and as small as 0.5 hectares, and mid-season reporting. Sources are ESA Copernicus Sentinel-1 radar satellites and Sentinel-2 optical satellites. KappaZeta value added includes Refined SAR data and Deep Learning modelling.
References	• www.kappazeta.ee • https://kappazeta.ee/services • https://kappazeta.ee/cases

Name	**NEUROPUBLIC**
Brief Description	
NEUROPUBLIC develops Information systems and Services with the ultimate purpose of providing services that modernise and digitise Public Administration. It occupies a leading position in the Agricultural sector in Greece, by providing a wide range of technological services for the private and public sector. With specialized information systems-services, NEUROPUBLIC aims to ensure the integration of Agencies and Enterprises to the European business Environment (e business). Since 2006, they have been developing and maintaining information systems for the OPEKEPE (Payment and Control Agency for Guidance and Guarantee Community Aid) and have developed complex and demanding information systems for the Ministry of Rural Development and Food. NEUROPUBLIC follows and actively participates in discussions among representative bodies at European level concerning the digitalization of the European agricultural sector . NEUROPUBLIC invest sizeable funds in Research & Development (more than € 2mil.), developing the gaiasense intelligent agriculture system, aiming at digitalizing and reforming agricultural production in Greece. It follow sand implements a quality management system for the development and support of our software during its whole life cycle. NEUROPUBLIC is a permanent member in organisations such as the European Association of Remote Sensing Companies (EARSC), the Alliance for the Internet of Things Innovation (AIOTI), the Big Data Value Association (BDVA), the Hellenic Emerging Technologies Industry Association (HETiA), and more. They participate in the shareholder scheme of "GAIA EPICHEIREIN S.A.", a leading company in modernizing the	

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country's primary sector, contributing to making the most of modern technological developments and scientific practice in order to benefit Greek producers and their (cooperative) organisations. The services developed by NEUROPUBLIC for the agrifood sector are "smart" tools and the essential digital work environment to provide quality and reliable consulting services – easy, fast and simple. NEUROPUBLIC develops Custom services that have the following unique characteristics: • They are available as Cloud Services • Online access and support (via the web) • The Cloud Technology ensures user data security and 99,99% availability and integrity of the data. • They utilize cutting-edge technologies at a low subscription cost Custom applications are accessible via the technology platform www.c-gaia.gr, which is managed by GAIA EPICHEIREIN S.A. and constitutes the technology channel, between the parties involved in the agrifood sector.	
Market Orientation	Paying Agencies National Authorities Farmers
Relevance to ENVISION	In the context of the operating model of the CAP, NEUROPUBLIC has designed and developed a series of systems and services that satisfy the proper application of the CAP requirements and support a number of interventions concerning Pillar I (Direct Payments to farmers) and Pillar II (Rural Development Policy). Since 2006, NEUROPUBLIC has been the main supplier of the Payment and Control Agency for Guidance and Guarantee Community Aid (OPEKEPE), undertaking the development of Information Systems to assist the work of the Agency in the above field. NEUROPUBLIC develops all technological aspects of the gaiasense system, namely its software, the telemetric stations, the sensors, the computing systems, the data processing analytical methods, and additionally has the operational responsibility for the development and operation of the stations in an extensive network across Greece. Gaiasense is an integrated system consisting of a technological infrastructure of thousands of IoT sensors installed on productive agricultural land across Greece and Europe. A digital platform collecting and processing satellite land data, a cloud ecosystem of applications for mobile devices and computers. It can be utilized by farmers, agriculturists, researchers, industries and analysis laboratories. The gaiasense system combines a multitude of informatics technologies (Big Data, Cloud Computing, Internet of Things, Machine Learning, Service-oriented Architectures, modern techniques and programming languages, and Semantic Web) with interdisciplinary fields like soil science, agricultural engineering, meteorology, agronomic and biological sciences and environmental sciences.
References	www.neuropublic.gr

Name	**QUANTIS (Switzerland)**
Brief Description	
QUANTIS has developed the geoFootprint product addressing the agriculture market. geoFootprint is accelerating sustainable agriculture by transforming how you measure and manage the footprint of your supply chains. By combining data from satellite imagery with environmental metrics,	

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geoFootprint visualizes the environmental footprints of key commodity crops on an interactive world map, giving you quick answers to complex sustainability questions.

An initiative launched by Quantis in 2018 with financial support from EIT Climate-KIC, geoFootprint was built collaboratively in partnership with more than 25 public, private and academic stakeholders, including arx iT, Cool Farm Alliance and leading agrifood companies.

Companies in crop-based industries that set ambitious environmental targets to reduce their footprint face massive supply chain management data challenges.

To set and track progress toward sustainability goals, businesses often rely on incomplete, inconsistent and generic, country-level environmental data on one hand, and highly precise farm-level data for selected locations on the other. The two are often incompatible due to the difference in assessment methodologies.

geoFootprint bridges this gap with granular visibility — down to 10×10 km — that allows companies to instantly understand the impacts of their sourcing decisions, identify the factors contributing to their environmental footprint and simulate interventions to reduce it. Users can plug in their own proprietary data for even sharper insights.

For policy makers and NGOs, geoFootprint creates a consistent baseline for all geographies, providing science-based metrics to target interventions and engage with local stakeholders.

geoFootprint Open, the open-access version of the tool, enhances public knowledge on sustainable agriculture by making solid environmental data of key commodity crops accessible to non-expert audiences, students or stakeholders who may not otherwise have access to this information.

Market Orientation	Policy makers Paying agencies Certificatio bodies Acedemia
Relevance to ENVISION	The application enables to: • Visualise crop production and environmental data. The user can select customized geographic areas from country level down to 10×10 km to view the footprint of a crop anywhere in the world. Crops include Barley, cotton, maize, oil palm, peanut, potato, rapeseed, rice, rye, sorghum, soybean, sugar beet, sugarcane, sunflower and wheat. The metrics include yield, production volume, fertilizer application rates, soil type and characteristics, precipitation and more. Environmental indicators at the farm include water availability, water quality, solit health and risk of biodiversity loss. • Identify and compare the main drivers of farmer's environmental footprint, including irrigation, land-use change (deforestation) and field emissions from fertilizer use. He can see how field management practices, local soil and climate conditions, and upstream activities translate into environmental impacts. • Model interventions to identify solutions. User can overwrite the input data to run his own customized simulations and gain unprecedented insights on the potential environmental risks and benefits of large-scale changes in cultivation and field management practices.

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	View data sources and methodologies. At the heart of geoFootprint is a repository of publicly available geospatial data, as well as metrics from the databases and tools (such as World Food LCA Database, Cool Farm Tool) and state-of-the-art agricultural emission models. As transparency is key to accelerating the transition to sustainable agriculture, all data sources and methodologies for all computations and indicators are detailed in a third-party reviewed technical document.
References	• https://www.foodnavigator.com/Article/2021/01/26/Quantis-leverages-satellite-tech-to-map-crop-footprint-It-fills-a-giant-knowledge-gap# • https://quantis-intl.com/strategy/collaborative-initiatives/geofootprint/ • https://geofootprint.com/

Name	**SatAgro (Poland)**
Brief Description	
Through SatAgro, one can make use of satellite imagery from NASA, the European Space Agency and private satellite operators. SatAgro processes data for each of farmer fields individually and sends it to in an easy-to-understand format that helps farmers to increase their farm's efficiency. With this app, one can monitor his crops' development in near real-time, observe the effects of weather events and agronomic treatments, and use historical data to improve decision-making. Custom-built variable-rate prescription maps allow to sow, fertilise and spray with unprecedented precision. Automated alarms warn about sudden changes in crop condition and weather. Farmers can optimise and even reduce use of agrochemicals, protect the environment, and use SatAgro to help maximise their land's potential.	
Market Orientation	Farmers
Relevance to ENVISION	**Crop Monitoring -** Electronic variable-rate prescription maps, compatible with machinery from a wide range of manufacturers, make it easy for users to carry out precision fertiliser application, drilling, and spraying. By adjusting inputs to specific local needs, users save money and optimise crop yields. **Historical Data** - SatAgro delivers vegetation maps from the previous season along with current season maps by default. Our charts show vegetation growth on each field as far back as 2002, as well as meteorological data and indices derived from them (Growing Degree Days, Cumulative Rainfall). **Prescription Maps -** Electronic variable-rate prescription maps, compatible with machinery from a wide range of manufacturers, make it easy for users to carry out precision fertiliser application, drilling, and spraying. By adjusting inputs to specific local needs, users save money and optimise crop yield **Event and treatment log -** A detailed log of crops, treatments and other events allows users to keep track of all relevant information and integrate it with SatAgro crop growth and weather data. **Water management -** The soil moisture deficit module assists users in optimizing water use and estimating drought-induced crop losses. **Alarms –** Alarm setting when a specific variable is exceeding a value (tep,merateure, crop growth, precipitation, o ther) **User data support** - Maps and table data can be easily exported to other applications, using popular file formats. **Soil sampling -** Our app helps our users plan soil survey locations. The resulting soil data can easily be integrated into users' SatAgro accounts.

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	Yield estimation - Crop-specific productivity and yield analysis models for institutional customers.
References	• https://satagro.net • https://satagro.net/#prices

Name	**SIRS (France)**
Brief Description	
Supports international and local groups / organisations in the management of territories through data from satellite, aircraft and drones and on-site visits Following up on CAP; Crop inventories; Hedgerow geo-referencing; Mapping soils.	
Market Orientation	Agriculture policy makers PAs CBs
Relevance to ENVISION	*Observational data for better management of territories.* SIRS (Spatial Reference Information Systems) supports international and local actors in the management of territories. For more than 30 years, the company has been producing geographic data from satellite, aerial (aircraft and drone) but also in situ observations. An experience recognized worldwide. Monitoring of the Common Agricultural Policy, inventory of crops, georeferencing of hedgerows, monitoring of the evolution of grassland areas... SIRS maps on a daily basis the soils exploited, cultivated or left to rest. Valuable information to accompany agricultural policies.
References	https://www.sirs-fr.com

Name	**Sustainable Environmental Consultants (brief SEC) (USA)**
Brief Description	
Sustainability verification and validation platform to provide solutions to help you meet your sustainability goals. Offerings include sustainability risk management, agricultural compliance and engineering, and erosion control solutions The Regulatory Landscape Is Ever Changing. SEC has helped livestock operations and row crop producers with environmental regulatory compliance concerns since 2009. SEC os knowledgeable in regulatory compliance, environmental design, groundwater protection, soil health, Natural Resources Conservation Service (NRCS) practice standards, and many other disciplines.	
Market Orientation	US focus Agricultural monitoring schemes Regulatory monitoring Certification bodies
Relevance to ENVISION	*Nutrient Management Plan Development* - Nutrient management plans help increase the efficiency of all the nutrient sources a crop uses while reducing environmental impact. The company develops customized nutrient

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	management plans using field-specific soil analysis and facility-specific waste analysis along with projected crop rotations and yields. Manure application rates are either nitrogen based for fields with low phosphorous levels or phosphorous based for fields with higher phosphorous levels. Once determined, field specific application rates for both solid and liquid waste are provided *Soil Sampling with GPS Mapping* - SEC has an in-cab, hydraulic soil sampler unit installed in a pick-up truck that collects samples, taking only seconds to pull a 24-inch sample. All samples are tagged and mapped with their GPS coordinates, so we can return to the same location in subsequent years to collect additional samples. *Satellite Imagery, Soil Type and Topographic Mapping* - Each nutrient management plan contains several maps of each of the land application fields – satellite aerial imagery, soil type, and topography maps. The maps show the locations of the land application fields in relation to the facility and include information such as field name, legal description, number of spreadable acres, and areas of restricted waste application due to the close proximity to surface water. *Assessing sustainability practices*- Sustainable Environmental Consultants offers solutions through its three divisions—all powered by its EcoPractices® platform. EcoPractices defines what sustainability means for producers and food companies using a science-based approach to measure your sustainability practices and goals that is third-party verified. *For producers* – it helps document and verify sustainability practices – everything from soil health to water quality to biodiversity. A Sustainable Continuous Improvement Plan™ is generated that helps continue the path of environmental responsibility and helps tell your sustainability story. *For food companies and manufacturers* – it is about shoring up risk for supply chain. It helps verify what they say in their corporate social responsibility plans and gives confidence that producers are implementing measurable actions. The result is greater collaboration between producers and food companies that share a common goal – ***environmental responsibility***. *Growers – Specialty Crops, Row Crop/Grain* - SEC works with row crop producers on soil quality and quantity. Collecting soil samples using either the benchmark or grid sampling method to monitor soil health, ultimately leading to decreased inputs and increased outputs. Soil analysis also addresses soil quantity through the implementation of best management practices, such as buffer strips, to prevent erosion and soil loss. *Erosion Control* - Sustainable Environmental Consultants Is a Trusted Partner in Erosion Control powered by Filtrexx® Whether erosion issues are influenced by the weather or human activities, erosion can be an environmental issue and a threat to project compliance. At Sustainable Environmental Consultants, they are committed to assisting the construction and agriculture industries, plus utilities and municipalities, in delivering high-performance erosion

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	control and stormwater compliance products and solutions. As a certified Filtrexx® manufacturer, SEC can manufacture and distribute the entire line of Filtrexx® products to achieve carbon footprint reduction, LEED certification, and more.
References	https://sustainableenviro.com/

Name	**TerraNIS (France)**
Brief Description	
TerraNIS is an innovative SME specializing in the design, development and sale of geoinformation services, derived from satellite/drone imagery, in the fields of agriculture, environment and land management. The company was founded in March 2014 by Marc Tondriaux and David Hello. Both have more than 25 years of experience in space applications, acquired in the Airbus group (first within Matra then Astrium / Infoterra / Spot Image). *Remote sensing* - Main raw material is the image, whether it comes from satellites or other sources as drones. More competence is the ability to choose the right image for the right use and to process it to extract accurate and relevant information. TerraNIC usse algorithms developed in-house or by partners. For example, it uses the Overland software developed by Airbus Defense and Space. *Proximity and partnerships* - TerraNIS is always looking to rely on local intermediaries to sell services. Thanks to them, they are able to adapt methods and products to the local context (farming practices, regulatory framework etc). In the same way, they are always looking for the right partners, either commercial or technical, to expand offers and improve performance. *Business Application* - TerraNIS always strive to be as close as possible to the needs of end users. Its teams features dual competence in remote sensing and agronomy or land use planning, capable of understanding customers' issues and of meeting their expectations as well as possible.	
Market Orientation	Agronomic, viticultural and oenological advice and decision support tools for land management EO data acquisition and processing for e.g. crop and biodiversity monitoring
Relevance to ENVISION	*Irrigation monitoring by Wago* (web application and mobile app) - It is an online service for irrigation monitoring. Easy to use, it is based on a water balance model developed within research projects. Wago calculates daily the state of the soil water reserve from plot data (useful reserve of the plot for example), weather data (rainfall) and satellite images. With Wago, several indicators are accessed to monitor irrigations and the development of crops. - Monitoring of the soil water reserve accessible to the crop. - Monitoring of the vegetation development thanks to the estimation of the biophysical parameters of your crops. Calculated based on satellite images, the fCover (fraction of green cover) is a stable and robust parameter allowing the monitoring of the vegetation evolution. - Access weather forecast for up to 7 days. All the indicators available via the Wago service can be visualized via an online graphic interface. This interface allows the soil water content monitoring and

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	the identification of water balance risks. An API is also provided that makes possible to access to several services: Reading of the data stored on the server Addition or modification of the data on the server Deleting of certain data *A simplified access to useful indicators for the monitoring and the characterization of crop development is provided by Cropeo product.* The product enables to detect more rapidly potential anomalies in the plots to better orientate field based actions. Cropeo follows the growth of crops from seeding to harvesting on the web platform. The vigor and heterogeneity of each plot are assessed with maps, charts and downloadable documents. This analysis helps decision making on the field and allows a moniroting complementary with technicians' actions. CropEO benefits from TerraNIS' experience in Earth Observation image processing to offer robust and reliable monitoring indicators. Several vegetation indices (e.g. NDVI) and biophysical parameters (e.g. fCover or LAI) are calculated. Treatments specific to crops can be defined to guarantee the quality of the deliverables. Formats are adapted to use, either through web application **or** via an online graphic interface application. The web interface allows you to analyse the crop development and easily and rapidly identify anomalies. functionalities are available: - Assess the vegetative development of crops - Analyse crop development thanks to historic records - Characterize the heterogeneities within the crops - Detect anomalies and target field observations An API is available to integrate the data directly in other applications Thanks to the CropEO API, it is possible to access several services: - Access the data stored on the server - Add or modify the data on the server - Delete certain data *Optimization of the nitrogen fertilization using the Fertisat product* -Produced with specific algorithms and multispectral satellite images, acquired before each nitrogen input, modulation maps are delivered under different formats (PDF or digital files). They allow the identification of zones of deficiency and then the optimization of the inputs by modulating the doses. The treatments performed allow the estimation of a nitrogen nutrition index. Homogeneous zones are grouped to make the field work easier. *Monitoring of crop development by Pixagri product.* Users can characterize and monitor crop development. Based on multispectral satellite imagery and specific algorithms, vegetation maps are generated at key stages and delivered with several formats (PDF or digital files). The treatments made facilitate the extraction of certain biophysical characteristics of the crops such as vigor, heterogeneity or other deficiencies. Then, these characteristics are analyzed in order to extract information allowing users to make decisions. Thanks to the Pixagri service, users can analyze each of their plots and optimize cultural practices, at all key stages. Vegetation mapping delivered

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	with the PIxAgri service guarantees a fast, global and objective vision of crop development. PixAgri helps identify heterogeneities within plots, locate specific zones and compare situations in order to better understand them and better adapt practices and facilitate field actions. Main gaols are: - Reduce production costs - Reduce environmental impact modulating practices - Improve quality and productivity *The Pixagri product was developed by Airbus Defence and Space Geo-Intelligence program line, and benefits from an original technology.*
References	• http://www.terranis.fr/en/precision-agriculture/ • http://www.terranis.fr

Name	**BASF Digital Farming**
Brief Description	
BASF xarvio™ offers digital products that deliver independent field-zone specific agronomic advice enabling farmers to produce their crops most efficiently. We started to develop our algorithms on real fields more than 25 years ago. Among the most important recent market facts, Bosch and BASF smart farming joint venture gets global green light. Stuttgart / Cologne, Germany – The 50/50 joint venture (JV) between Bosch and BASF Digital Farming to globally market and sell smart farming technologies from a single source has now received approval by all relevant merger control authorities. The JV has been registered as Bosch BASF Smart Farming (BBSF) GmbH. A major milestone, BABF has since set up its headquarters in Cologne, Germany, and appointed experienced managing directors BASF's Silvia Cifre Wibrow and Bosch's Florian Gwosdz to jointly lead the company. The company will distribute its Smart Spraying solution, which Bosch and BASF are developing and testing, to initial markets in North America, South America and Europe. Its Intelligent Planting Solution is already commercially available in Brazil and Argentina, and will use the advanced digital agronomic intelligence of BASF's xarvio™ crop optimization platform to enhance zone-based seeding recommendations in the near future in Brazil. Smart configuration aiding efficiency - The Smart Spraying solution offers real-time, automated pre-emergence ("green-on-brown") and post-emergence ("green-on-green") weed identification and management day and night. Combining Bosch's high-tech camera sensor technology and software with xarvio's agronomic intelligence enables Smart Spraying in milliseconds to precisely detect weeds in crop rows and to spot apply herbicide only where needed. Its unique configuration supports a more efficient use of herbicide, with trials showing herbicide volume savings of 70% are achievable. Higher savings are also possible, with variability dependent on the prevailing field conditions and weed pressure of individual fields. Bosch BASF Smart Farming remains on-track to launch the Smart Spraying solution in limited numbers by the end of 2021.	
Market Orientation	Farmers Agronomists Agroconsultancy

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	Certification bodies
Relevance to ENVISION	Xarvio™ provides several applications such as the Field Manager, Scouting and Healthy Fields. ***Field Manager*** **-** Receive, upload & analyze all field-zone specific information in one place. Increase transparency & take better informed decision for your fields, all year long. Set-up field management zones; for example, buffer & biodiversity zones, trial plots or field obstacles; according to your farm's needs. The product provides • current Biomass Maps so that to identify high & low performing field-zones based on current satellite data • Historic Biomass Maps , to identify high & low performing field-zones based on up to 15 years of historic satellite data The farmer can use these maps • Before Season: to plan seeding and field preparations • In-Season: Guaranteed availability of variable application maps based on historic field-zone performance, independently of in-season cloud coverage The farmer can set up field management zones according to farm's needs, permanently or season specific. He can identify the right place for management zones by seeing different information layers in the background, e.g. historic & current biomass, soil maps, yield maps He can categorize them and manage them according to buffer & biodiversity zones (e.g. bird windows), trial plots, field obstacles. He can upload or send the management zone maps to his terminal for automatic on-field implementation. The farmer can • Create one central hub to document, visualize & analyze field management activities and see the resulting in-season zone specific biomass development right next to it. • Monitor and measure the impact of agronomic decisions on crop performance throughout and across seasons. • Achieve higher yields by comparing the results of different field management strategies on your fields. *Weather Pro application* provides detailed in season weather analysis, hourly weather forecasts & access to the historic climatic database. This is to know exactly when the best conditions are for field management activities, considering temperature, rain, wind and sunshine forecasts. The user can compare rainfall & temperatures of the current season with the average of the last 10 years. The user can connect his own weather station so that to get even more precise weather & data field analysis. ***SCOUTING integration*** **-** xarvio™ SCOUTING is developed for agronomists as well as farmers to automatically identify problems in the fields. The users just takes a picture and instantly receives the result. SCOUTING supports more than 50 crops globally and helps to document in-field stress easily

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	xarvio SCOUTING supports six different use cases from seeding to harvest: weed identification, disease recognition, nitrogen status, yellow trap analysis, leaf damage, emergence analysis. xarvio SCOUTING app is connected to xarvio FIELD MANAGER. By connecting xarvio SCOUTING to FIELD MANAGER he can store all his own in-field pictures for documentation and analysis. He can also create scouting tasks and assign it to your employees or advisors. ***Healthy Fields*** - This application service offers security. It provides recommendation for an optimal fungicide and growth regulator strategy for wheat and barley fields. Farmers want to be sure that the optimal fungicide and growth regulator strategy is being applied and they need the certainty that their crops are being kept healthy. The disease models behind HEALTHY FIELDS have been tried and tested over decades and provide reliable recommendations for the right application timing. The recommendations are based on extensive data, complex plant disease models, field trials, as well as information on location, weather, previous crop and variety. This results in an optimal strategy for each individual field. In 2020, HEALTHY FIELDS delivered an average leaf health of more than 80 percent on all HEALTHY FIELDS farms. The HEALTHY FIELDS application recommendations are not only precise, but above all safe. They are based on numerous satellite images, proven agronomic models and a great deal of experience. In combination with factors such as location, regional weather, previous crop, cultivated variety etc., the result is an optimised field-specific fungicide and growth regulator strategy.
References	• https://agriculture.basf.com/global/en/business-areas/digital-farming.html • xarvio.com • https://www.xarvio.com/global/en/products/field-manager.html

Name	**Zebris (Germany)**
Brief Description	
An innovative technology company with more than 30 years of experience in biomechanics. In the four business areas of medicine, veterinary medicine, dentistry and sports, it develops and produces measuring and therapy systems at its site in Isny im Allgäu and in Seltmans. Sales and distribution is carried out worldwide through cooperation and trade partners. The systems are used in acute and rehabilitation clinics, medical practices and scientific institutions as well as in orthopedic and dental technology.	
Market Orientation	Data acquisition, processing, analysis and storage Solutions and services utilising geoinformatics and remote sensing as well as scientific consulting services on questions of forest science, water management, environmental monitoring, soil protection, agriculture and the management of georisks.
Relevance to ENVISION	Not relevant. Can only contribute to supplementary tools and functional components for measuring and sensing.
References	www.zebris.de

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End of Document

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