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AGRI CULTURE

Analysing the pattern dynamics in Earth Observation Research & Innovation

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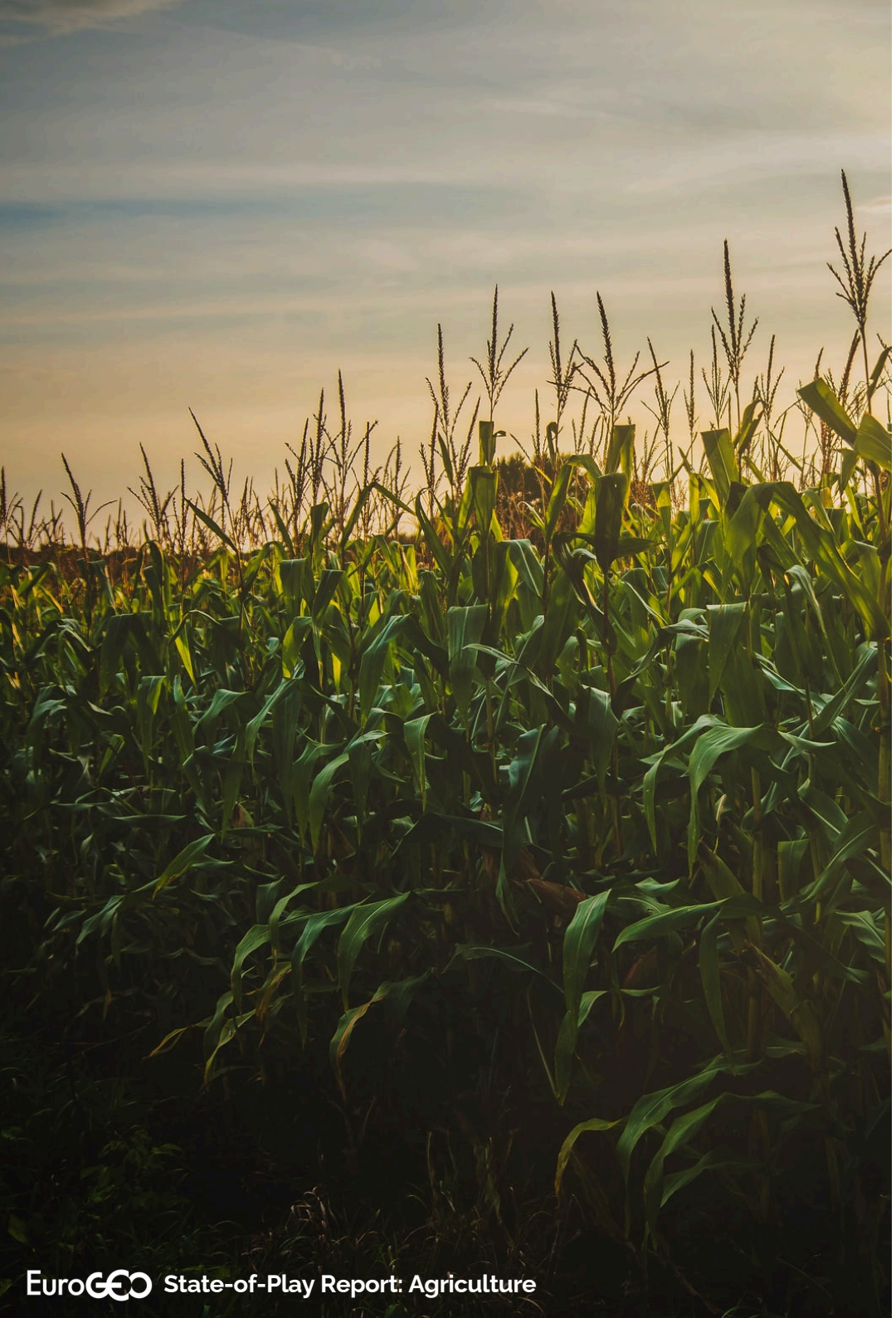

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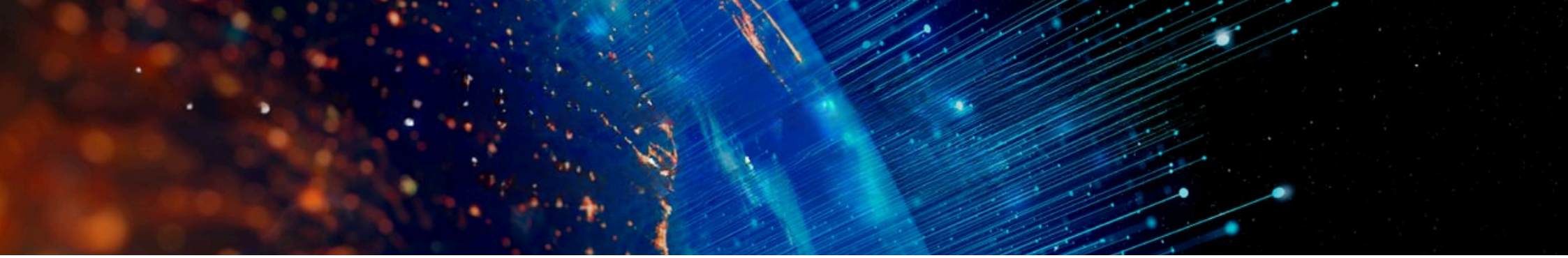

Introduction

In recent years, there has been an **increasing uptake of Earth Observation** (EO) as a tool in support of the implementation of various policies and the execution of a wide range of operational tasks. Users across the value chains of different sectors can utilise EO-based solutions in support of their work, **realising significant benefits** (economic, environmental, societal, etc.). Market demand for such solutions is driven by policies and sector-specific needs. Technological advances have the potential to enable solutions that match the specific needs.

EuroGEO, Europe's part of the Group on Earth Observation, stands at the intersection of research, policy, and markets. This **strategic position** allows it to identify and monitor relevant developments and trends, to engage stakeholders, and to assess the evolving EO landscape in Europe and beyond. Capturing insights relevant for the different stakeholders allows EuroGEO to document the current state of play of EO, its trajectory, and the required steps for broader adoption and increased benefits.

With the support of the 🔗**EuroGEOSec project**, and with the aim of **maximising the impact of Research and Innovation** (R&I), a dedicated effort has been made to establish the **R&I Observatory for Earth Observation** (RIO). This includes a team of analysts and an online tool to monitor and analyse past and ongoing R&I in EO in order to identify trends and support strategic decisions on future R&I activities. Relying on the RIO, the so-called **R&I State-of-Play Reports** are created presenting a concise overview of the policy context, technological perspectives, and market trends within the thematic areas covered by the 🔗**EuroGEO Action Groups** (AG). This present report focuses on analysing patterns in the **agriculture segment**. Research has been complemented by multiple other reports and studies, including studies performed by and for EuroGEO's Agriculture AG.

The aim of this report is to **support EuroGEO and its stakeholders in decision-making** regarding future work programmes and strategic innovation agendas (such as those of the Knowledge Centre on Earth Observation—KCEO), inform the review of the **EuroGEO Implementation Plan**, and contribute to the production of institutional outputs.

The following EuroGEO **Action Groups** develop application pilots/conduct other actions foreseen in the EuroGEO roadmap: Agriculture, Land Cover and Land Intelligence (LC&LI), Urban, Disaster Resilience and Health, Energy, Biodiversity, ecosystems and geodiversity (BEG), Marine, Climate, and Green Deal Data Spaces.

Methodology

The browser-based tool of the **R&I Observatory for Earth Observation** (RIO) allows retrieving relevant information from a variety of sources, including project information (e.g., descriptions, partners, budgets, results, timelines) for the majority of relevant European R&I programmes. Sources include information related to e.g., Horizon Europe (HE) and its predecessors, the LIFE programme, the Connecting Europe Facility, Eurostars, COSME, the European Defence Fund, and the European Defence Industrial Development Programme. Additional sources are being incorporated as part of the continuous development of the RIO.

The RIO structures the information into a standardised format for the uniform documentation of R&I activities. Functions of search, bookmarking, filtering, visualisation, and export allow the processing and analysis of the pre-curated information.

The focus of the analysis is on **mapping R&I efforts across segments** by analysing project information. **Core applications** of the agriculture segment have been defined and mapped in line with EuroGEO's priorities as well as accepted taxonomies, here largely based on the applications addressed by the European Agency for the Space Programme (EUSPA):

- Carbon capture & content assessment
- Environmental impact monitoring
- Biomass monitoring
- Crop yield forecasting
- Soil condition monitoring
- Vegetation monitoring
- Common Agricultural Policy (CAP) monitoring
- Farm management systems
- Field definition
- Pastureland management
- Precision irrigation
- Variable rate application
- Climate services for agriculture
- Weather forecasting for agriculture
- Drought monitoring
- Monitoring of locust swarms
- Biomass monitoring

To address the research questions—i.e., to identify trends in EO-related R&I for agricultural applications and the drivers behind them—the following **limitations or simplifications** were applied:

Data Processing

- Project information sourced from the RIO (including acronym, title, coordinators, topic, programme, pillar, objectives, work programme, status, start and end dates, budget, grant, and links) has been filtered using segment-specific keywords to ensure that only relevant projects are included and no projects are overlooked. This relies on full-text search in existing descriptions and meta data, along with the use of consistent terminology. Where data might be missing or unexpected terminology is used, certain projects may have been missed.
- The filtered list of projects considered relevant has been extracted (i.e., exported into a spreadsheet) for processing.
- Data has been manually checked for relevance and further cleaned accordingly, then augmented by segment-specific categorisation for more detailed analysis. This categorisation aligns with EUSPA's definition of segment-specific EO applications.

Methodology

Timeframe

In order to restrict the analysis to relevant activities while drawing from a significant enough sample size, a (roughly) **10-year timeframe** is used, covering the period **from 2014 to 2024** (i.e., only projects that have started before 2025 and have not ended before 2014 have been analysed). This timeframe is used to capture long-term trends, technological developments, and measurable outcomes of concluded projects. It also ensures that typical project lifecycles, such as those in Horizon Europe, are included. It coincides with the launch of the first Sentinel-1 satellite in 2014, the free and open data of Copernicus being considered as one driver of EO-related R&I, which has been attempted to confirm through the analysis.

Sample Size

The sample data is limited to the sources **currently included in the RIO**, expected to cover relevant European R&I projects to a large extent, but with further potentially relevant projects not included in the analysis where the data source has not been included yet. It is further limited to the keywords and queries applied (see data processing above) and timeframe selected (see timeframe above).

Budget allocations per application

Breaking down budgets of projects that address more than one segment-specific application and dividing them across these applications has been done following a simplified approach assuming an (unlikely) even distribution. Therefore, budget sizes per application can only **reflect trends** and may not be fully accurate.

To interpret and complement the findings from the RIO tool, **desk research** has been conducted across reports and studies, including:

- European Space Agency (ESA) application or industry articles
- European Commission (EC) documents, e.g., Climate factsheets, Reports on uptake barriers of EU space services
- EUSPA EO and Global Navigation Satellite System (GNSS) 2024 Market Report
- Stocktaking Reports from related Group on Earth Observations (GEO) initiatives
- Horizon Europe's Strategic Research and Innovation Agendas
- Segment-specific as well as EO-related strategic research and innovation agendas including outcomes of the Horizon 2020 (H2020) project FIRE
- EuroGEO Workshop Reports
- 🔗**EuroGEO Agriculture AG Expert Study**

These **sources** were carefully reviewed to extract relevant content that addressed the questions raised during the analysis. They were particularly useful in identifying gaps and barriers in each segment, as well as R&I trends and technologies that are (or can be) applied to address these issues.

The EuroGEO **Agriculture Action Group (AAG)** has been involved in the review process and has contributed to complementing the findings with their expertise in the segment.

Agriculture Overview

The world's population has been growing at an unprecedented rate for several decades, increasing by more than 200% since the mid-20th century and by 12% in the last 10 years🔗. This is putting **intense pressure on the agricultural sector**, which has to constantly increase food production to keep up with this growth🔗. Conversely, current production growth, which is slightly below 2%, has been decreasing since 2011 and is now at an all-time low since the start of food production data collection in the 1960s🔗. Some other challenges are **shrinking arable land** and **climate change consequences**. Agriculture plays a two-sided role in **greenhouse gas** (GHG) **emissions**, as it contributes 11% of the European Union (EU)'s overall amount while also bringing solutions through innovative practices like carbon sequestration and climate-smart farming🔗. These approaches are further explored in the following sections.

As a result of this challenging situation, innovation in this segment is extremely valuable and present: to address the need for **environmental sustainability**, innovative approaches that **enhance productivity** like **precision farming** have been gaining traction for several years🔗. In response to the decline in productive land and the need to **adapt to climate change**, sound farming practices based on geospatial data are also becoming more common. By measuring e.g., soil moisture, precipitation, and humidity, this approach supports efficient land condition monitoring and planning.

Moreover, geospatial solutions are increasingly used in areas such as **supply chain** tracking, **compliance** monitoring, and **policy implementation** (e.g., in relation to the CAP). Furthermore, EO-based services support **food security** planning through weather (e.g., floods and droughts) and crop damage prediction and assist public authorities (PAs) in disaster response.

EuroGEO aims to address these challenges through its dedicated Agriculture Action Group (AAG) and ongoing analysis of segment developments, market trends, technologies, relevant policies, and R&I efforts, as outlined in this document. The AGG's work under this scope ranges from taking part and promoting projects with a focus on developing innovative tools and methodologies, through organising training programmes and opportunities for knowledge sharing such as conferences and seminars, to advocating for appropriate policies to policymakers.

These efforts support GEO's strategic priorities of sustainable development, climate resilience, disaster risk reduction, and biodiversity and ecosystem sustainability.

Policy Context

EO can address agricultural challenges e.g., monitoring crop health, optimising water and nutrient use, detecting pests, managing soil resources and tracking climate impacts by **providing precise data** which can be leveraged to generate **key insights**. In view of that, relevant policies have been increasingly **encouraging the use of EO** data and information products and services in support of different agricultural practices and reporting responsibilities. The progressive uptake of EO in agriculture is reflected decisively in the size of investment in relevant R&I activities and its evolution over time. This is clearly illustrated in the graph below, generated with the help of the **R&I Observatory for EO** (RIO).

Fig. 1: Evolution of EO R&I Agriculture Budget (€M) and Key Policy Shifts

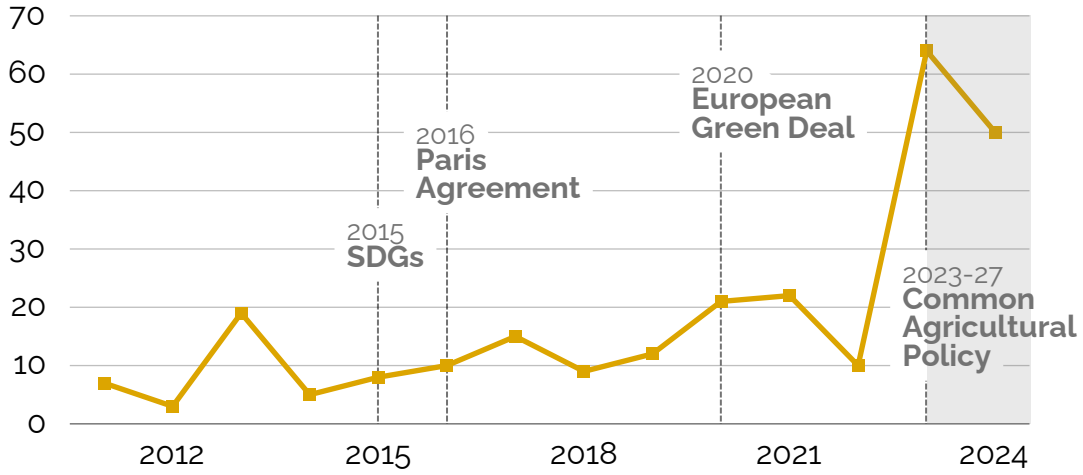

Figure 1 depicts the fluctuations in European budgets for EO-related R&I efforts in the agricultural segment, generated with the sampled data of 89 European-funded projects extracted from the RIO. This data has been mapped against specific EO applications and complemented with annotations of relevant policy implementations or changes to analyse the potential correlation between the two. Thus, one can clearly see (i) **the significant increase of investment over time**, (ii) the **correlation of the investment with key policy drivers** discussed below.

The **Common Agricultural Policy** (CAP) constitutes the overarching policy framework related to Agriculture in Europe. The CAP delivers financial support through direct payments, rural development funding, and market stabilisation tools, ensuring sustainability across the sector. The CAP has been progressively encouraging the use of EO across its segments, with a major boost in recent years thanks to sustained investment in fit-for-purpose solutions on one hand and strengthening capacity among the key stakeholders in the sector on the other. Paying Agencies, the bodies of the EU countries responsible for executing the payments to beneficiaries, have been increasingly adopting EO. Working in tandem with the European Green Deal (EGD), the revamped CAP has introduced additional areas where EO can provide significant support. Thus, the eco-schemes are a CAP mechanism that incentivises farmers to adopt sustainable practices by preserving natural resources. Since the launch of the 2023–2027 CAP in 2023, at least **11 new EO-related R&I projects addressing CAP monitoring** were launched with a combined budget of more than €43M. Complementing the efforts of the CAP, the EU has invested heavily in building communities of practice. For instance, the **European Innovation Partnership 'Agricultural Productivity and Sustainability'** (EIP-AGRI) fostered competitive and sustainable farming, aiming to produce "more and better from less". By safeguarding essential natural resources, EIP-AGRI ensured the steady supply of food, feed, and biomaterials; in 2023 it became part of the **EU CAP Network**. Another major effort is represented in the **European Partnership on Agriculture of Data** under Horizon Europe which aims to improve the climate, environmental, and socio-economic sustainability of agriculture, while enhancing policy monitoring and evaluation through the use of Earth Observation and data technologies.

The CAP works in tandem with the **EGD**, the European Union's strategic plan to achieve **climate neutrality** by 2050. It establishes ambitious targets to enhance environmental sustainability and economic viability in agriculture, focusing on reducing pesticide use, boosting organic farming, and protecting soils. Key to these objectives are, among others, the **Farm to Fork Strategy** and the **revamped CAP**. Further, the **European Climate Law** writes the EGD's goal into the law, setting binding targets for reducing GHG emissions, including from agriculture, aligning with the **Paris Agreement**. Since the approval of the EGD in 2020, at least **12 new EO-related R&I projects** addressing environmental impact monitoring have started with combined budgets of close to €60M (see Figures 2 and 3). Including projects that address carbon capture & content assessment brings numbers up to 13 projects and combined budgets of about €63M.

Further legal frameworks supporting the EGD in agriculture include e.g., the **Nitrates Directive** (regulating nitrate pollution from agricultural sources to protect water quality), the **Water Framework Directive** (encouraging sustainable water management practices in agriculture to prevent overuse and contamination), or the **Sustainable Use of Pesticides Directive** all of which have also been reflected in relevant R&I activities.

Policy Context

The intersection of the EGD and the **European Digital Strategy** highlights agriculture as a sector where **digital transformation and sustainability converge**. EO data underpins policy frameworks aimed at achieving these goals by providing accurate, actionable insights. Programmes such as the EU's CAP benefit from EO's ability to monitor compliance, assess the environmental impact of subsidies, and support decision-making processes.

Under the EGD, the **Farm to Fork Strategy**, aims to establish a **sustainable food value chain**. It promotes sustainable agriculture (and fisheries) for producing safe, nutritious, and high-quality products. In the same context, the **EU Biodiversity Strategy for 2030** addresses the role of **sustainable farming practices** in halting biodiversity loss and restoring ecosystems through targeted commitments and actions. One key deliverable of the biodiversity strategy is the **Soil strategy for 2030** aiming at the protection and sustainable use of soils including in the context of agriculture. Since its inception in 2020, at least **14 relevant EO-related R&I projects** addressing soil condition monitoring have started with a combined budget of close to €70M.

At the international level, the EU's agricultural policies align with several global frameworks that underscore sustainability and climate action. Most prominently, the Paris Agreement stresses the **role of agriculture in mitigating climate change and building resilience to its impacts**, while the **Sustainable Development Goals** (SDGs) guide global efforts to integrate sustainable agricultural practices. Goal 2 is to **end hunger**, achieve **food security** and improved nutrition and promote **sustainable agriculture**. Goal 13, which calls for urgent action to **combat climate change and its impacts**, includes the transformation of agriculture practices. The **United Nations Framework Convention on Climate Change** (UNFCCC), through initiatives like the Koronivia Joint Work on Agriculture, addresses agriculture's role in reducing GHG emissions and fostering climate adaptation.

The **Convention on Biological Diversity** (CBD) highlights the need for **biodiversity** integration into farming practices, which is crucial for maintaining ecosystem health. Similarly, the **UN Convention to Combat Desertification** (UNCCD) addresses **land degradation** and promotes sustainable land use in agricultural contexts. Global trade frameworks like the **World Trade Organisation** (WTO) **Agreement on Agriculture** ensure fair agricultural trade while reducing harmful subsidies and fostering sustainability. Additionally, the **Food and Agriculture Organisation of the United Nations** (FAO) **Global Soil Partnership** focuses on enhancing **soil management** practices essential for long-term agricultural productivity.

These international commitments complement EU policies, reinforcing a unified global effort to promote sustainable, resilient, and inclusive agricultural systems while addressing critical environmental challenges. This **creates demand for precise, real-time data provided by EO** solutions in support of **policy compliance** and **agricultural resilience**. And this demand has been supported by GEO-related projects that target agriculture over the years. In view of all this, there is a strong expectation that R&I supporting the implementation of agriculture-related policies will retain significant focus over the coming years.

Technological Perspectives

The agriculture sector is amongst the most advanced in terms of leveraging digital technologies, including EO, whether satellite-based, aerial, or in situ. Its ability to monitor the state and evolution of agricultural fields has made EO indeed an invaluable tool for agricultural practitioners.

Looking into the space segment of Copernicus, Sentinel-1 and -2 provide open, high-resolution, real-time data that enhance farm resource management by **monitoring environmental conditions, crop health, soil moisture**, and **land use**. Sentinel-2 plays a significant role in agriculture, particularly for monitoring land cover changes, crops, vegetation, and inland water, as well as supporting food security and environmental monitoring. This is complemented by Sentinel-1, which helps analyse water content in agricultural fields and build richer time series thanks to its ability to monitor through the clouds. This EO data serves as a vital input for farmers' production decisions through **Farm Management Information Systems** (FMIS). Moreover, satellite data resolution and update frequency are constantly evolving, allowing for existing applications to continuously grow, such as precision agriculture to be available at a larger scale. As a result, the agriculture sector has moved towards a more **data-driven approach**. Therefore, current research and innovation efforts towards smart agriculture rely heavily on integrating EO data with Big Data and Internet of Things (IoT) technologies. Combining **IoT** and EO data—by integrating EO data with LoRaWAN and NB-IoT networks—can enhance continuous monitoring of soil health and crop conditions, leading to more precise farming interventions. In this context, **edge computing** is becoming an increasingly important driver, allowing real-time processing of EO data closer to the source. By reducing latency and bandwidth constraints, it improves the accessibility and responsiveness of precision agriculture solutions.

Artificial Intelligence (AI) and **Machine Learning** (ML) are innovations that are increasingly being leveraged by and in conjunction with EO and other geospatial data. Together, they are being used to automate tasks such as **predicting crop yields**, **managing pests** and **optimising farm operations**. These innovations are also leading to **greater accuracy in data analysis**, resulting in better informed decisions. As an example, the GeoAI_LULC_Seg project uses AI and geospatial data to track land changes like deforestation in Bulgaria and Turkey. AI helps to predict future trends and supports informed decision-making. As another example, AIGreenBots trains researchers to use AI and ML with space data for precision agriculture, ensuring capacity building keeps up with technological advancements.

Further, farmers are becoming increasingly aware of **robots**' and **drones**' usefulness as they also leverage satellite navigation (GNSS) and EO data for atomised tasks such as planting, weeding, and harvesting, which can help mitigate labour shortages.

In addition, EO data is steadily being used in **blockchain-enabled supply chains** to improve transparency and accountability across them, especially for carbon farming verification and CAP compliance.

Lastly, the use of **nanosatellites** is expanding due to their reduced cost and launch time. These provide targeted observations at **higher frequency and resolution**, addressing to two of the most important data needs in the sector. The use of large constellations orbiting in low Earth orbit (LEO) is increasing, providing low-latency, high-bandwidth internet service to rural areas where internet access is lacking, crucial for the use of EO data services.

Although all of these technologies gaining traction and awareness, they are still far from becoming an integral part of agricultural procedures due to several **application challenges**:

- **Lack of awareness and knowledge** of how to use new technologies.
- **System overload and integration challenges** with data coming from multiple sources (e.g., satellites, field sensors, drones), as opposed to **user-friendly**, **all-encompassing** platforms.
- **Elevated initial investments** for equipment and **training** required.
- Lack of support systems in **rural areas** for applications that require remote monitoring and real-time transmission such as **stable high-speed internet connection**.
- Challenges among **public authorities** in **integrating and coordinating** data across different departments.

Technological Perspectives

Fig. 2: Agriculture Project Count Timelines by Application & Sentinel Missions

In Figure 2, we have plotted the number of identified EO-related agricultural R&I projects over time and against the Copernicus Sentinel missions relevant for agriculture, i.e., Sentinel-1 and -2. The rising number of such R&I projects and increasing budget allocation over time seem to suggest that the advent of free and open Copernicus data and services sparked a boom in EO-related agricultural R&I projects. A first notable peak in activity occurred in 2014 when Sentinel 1A went live (and in expectation of Sentinel 2A); this trend continued strongly over the coming years culminating in 2018 when Sentinel-1 and -2 were fully operational and when Horizon Europe kicked off. Another important peak takes place in 2023 and 2024, sparked by policy developments (EGD and revamped CAP) and aligning nicely with Sentinels 2C and 1C coming live.

The primary focus areas of identified projects **are vegetation monitoring and soil condition monitoring**, with developments and efforts in land use, soil condition and moisture level tracking, vegetation coverage, and plant health analysis, all aimed at optimising farm management. ROI indicates that agriculture and marine are the most mature segments (or AG thematic areas) based on the overall number of projects in these fields.

Looking to the near future and acknowledging our climate emergency, all stakeholders in agriculture will greatly benefit from the technological integration of EO and other geospatial data, IoT and edge computing for cost-effective, smart farming operations that improve productivity while reducing environmental impact.

Market Trends

Fig. 3: Budget Distribution for EO-Related R&I in Agriculture

In the context of **growing populations** and **climate change**, optimising food production is key in terms of desired output as well as minimising environmental footprint. EO plays a crucial role in addressing critical challenges related to **food security**, **environmental sustainability**, and **climate resilience**.

Global revenues from EO data and service sales across all agricultural applications are expected to increase from almost €450m in 2023 to around €670M in 2033🔗. This market is dominated by applications such as **vegetation monitoring**, **crop yield forecasting** and **variable rate application**. This is confirmed by the analysed EO-related R&I activities, where during the past 10 years active projects counted amounted to at least **39 for vegetation monitoring** with combined budgets of close to €117M, **26 addressing variable rate application or precision irrigation** with combined budgets of more than €75M, and **11 projects with a focus on crop yield forecasting** and a combined budget of more than €9M. On top of sales, accounting for contributions of EO to e.g., cost savings, environmental impact and prosperity of e.g., farmers, agricultural EO applications are estimated to provide close to a $400B economic opportunity in 2030🔗.

The increasing demand for agricultural outputs, coupled with soil degradation and resource scarcity, drives the market for **precision agriculture**. EO enables farmers to remotely monitor **crop health**, optimise **irrigation**, and apply inputs like **fertilisers** and **pesticides** more efficiently. This enhances productivity while minimising environmental impact. In line with this trend, EO service providers are increasingly adopting subscription-based models, offering **Data-as-a-Service** (DaaS) solutions that make high-quality EO analytics accessible even to smaller farms. Precision irrigation and variable rate application already account for substantial market shares. These applications optimise water use and input distribution, ensuring higher efficiency and cost savings.

Digital technologies, including **farm management systems**, are creating solutions for farmers that integrate EO data with other data and tools to streamline farm operations, improve decision-making, and enhance efficiency. During the past 10 years, at least **22 EO-related projects** have been active **addressing farm management systems**, with combined budgets of close to €50M. Developments such as digital twins in agriculture are enhancing **predictive modelling** for many applications, enabling farmers to visualise and plan more effectively for future scenarios. These digital platforms also contribute to more robust **ESG** (Environmental, Social, and Governance) reporting, as they provide verified EO data that is increasingly demanded by food retailers and investors to assess sustainability metrics.

Market Trends

EO technologies are also essential for monitoring and mitigating both agriculture's contribution to **climate change** and its impacts on the sector. By analysing land use changes, tracking deforestation, and assessing biodiversity, EO helps policymakers and stakeholders implement sustainable agricultural practices. EO-powered systems also enhance climate resilience by predicting climate impacts on crops and enabling better planning for extreme weather events. Here, R&I activities for applications such as environmental impact monitoring, soil condition monitoring, carbon capture & content assessment, or weather forecasting for agriculture are highly relevant. The transition to climate-smart agriculture (CSA) is underway, with technologies like decision-support systems (DSS) and platforms combining drone and satellite data. CSA aims to build agri-food systems in line with the SDGs and the Paris Agreement, as demonstrated by the 🔗VISCA project (2017-2020), which developed DSS integrated weather forecasting, climate prediction, crop planning, etc. to help the Southern European wine industry adapt to climate change.

Monitoring regenerative agriculture through EO provides actionable insights into **soil health**, **carbon sequestration**, and sustainable land management. This approach to farming is gaining momentum, leveraging EO to ensure environmental sustainability while maintaining productivity. Integrated pest management relies on EO to help farmers **reduce pesticide use**, balancing agricultural needs with ecological preservation. EO-related R&I for applications in the area of **soil condition monitoring** and c**arbon capture & content assessment** are emerging, while R&I efforts related to **variable rate application** have been constant during the last decade. The agricultural sector is focusing on carbon farming practices, such as no-till farming, agroforestry, and cover cropping, to enhance carbon sequestration. European-funded programmes and projects like 🔗EJP SOIL (2020-2025) and 🔗ORCaSa (2022-2025) support these efforts. EJP SOIL improves soil management through research synergies and a multi-stakeholder approach, while ORCaSa specifically addresses the imbalance in organic carbon absorption caused by rising carbon emissions.

Eco-schemes within CAP strategic plans are critical in ensuring agriculture remains green. EO data empowers public authorities to **measure compliance and effectiveness** of these initiatives, promoting transparency and accountability. By facilitating data-driven governance, EO strengthens agricultural policies and supports their alignment with broader sustainability goals. The significance of EO in this context is confirmed by the ever-increasing number of R&I projects addressing **CAP monitoring**, with a significant peak after the release of the 2023-2027 CAP.

By integrating EO data with other advanced technologies, agriculture can transition toward more sustainable and efficient practices. As global initiatives and policies **increasingly prioritise sustainable development and climate action**, EO will remain a key enabler of transformation in the agricultural sector.

Using the RIO as a source, we have identified key stakeholder groups driving innovation in the development of R&I EO solutions for agriculture in order to assess the uptake and awareness maturity of the sector. We have found that Small and Medium-sized Enterprises (SMEs) are the most prevalent in R&I, followed by academia. Larger private companies and public institutions are relatively less involved in such initiatives.

Projections

By combining **satellite data with AI and ML** technologies, **crop intelligence** systems and **renewable resource management** will be possible in the future. Currently, at the academic level, crop intelligence systems can help enhance **yield**, **sustainability**, and **resilience** to climate change. Renewable resource management is an emerging field that focuses on conserving ecosystems that provide essential services to humanity (e.g., food, clean water, and air).

Supported by the CAP reforms and the EGD objectives, there is still a lot of room for improvement in the use of EO when applying data-driven farming solutions such as **precision agriculture**, **DSS**, **IoT**, and **regenerative practices** like no-till farming, cover cropping, agroforestry to build climate resilience. Regulatory frameworks, including the EGD, Farm to Fork, revamped CAP, and the Paris Agreement, emphasise **reducing pesticide use**, implementing **soil-protective practices**, and **lowering GHG emissions**. Geospatial data can help farmers meet these regulatory requirements.

An example of this is the **increasing use of pilot demonstration farms**, which allow researchers to test and refine practices on a smaller scale. For instance, the 🔗HE Climate Farm Demo (2022-2029) aims to reduce GHG emissions by 30% across a network of 1,500 farms. Another significant development is the growing use of EO in **parametric insurance models** for climate risk adaptation.

There is a clear opportunity for stakeholders to collaborate on better resource allocation and increased automation using drones, robots, AI, and ML for repetitive tasks such as planting, harvesting, and fertilising.

Future trends are predicted to emphasise sustainable practices, supported by the CAP eco-schemes mechanism. At a more general level, the sector has a clear need for the **integration of higher resolution EO data**. This projected demand for higher-resolution EO data will push the need for sub-field-level monitoring and hyperspectral imaging to enhance the precision and effectiveness of crop and resource management practices. There is also a need for integration of small-scale EO applications to address local needs of public authorities, such as **flood or drought management**. Overall, policymaker support is crucial for addressing agriculture's modern challenges effectively.

EuroGEO Contribution

EuroGEO's unique value proposition, which encompasses all stakeholder types within each Action Group, positions the initiative to have a significant impact in the sector. Some of the suggested elements below stem from the discussion at the EuroGEO Workshop 2024 in Kraków on the Expert Study developed for the Knowledge Centre for Earth Observation (KCEO) of the Joint Research Centre (JRC)🔗. EuroGEO has the potential to address key market gaps by tackling the underutilisation of EO technologies, due to limited awareness among end-users and decision-makers about the benefits satellite data and innovative technologies can bring to farming. Secondly, public authorities often lack the technical expertise and funding required to advance these capabilities.

To address these challenges, awareness campaigns should be developed to promote EO adoption at the local level sharing success stories that highlight the benefits of EO for agricultural monitoring and climate resilience. For instance, small-scale EO applications tailored to regional needs, such as flood management and urban farming, could be encouraged. Secondly, the development of targeted promotional materials is recommended, showcasing the specific benefits that stakeholders miss by not engaging with or investing in EO. For example, creating informative leaflets for farmers—distributed locally and nationally—could demonstrate how following the Common Agricultural Policy enables them access to eco-schemes. For policymakers, a dedicated leaflet showcasing how EO data can improve reporting and enforcement capabilities under CAP regulations would be very impactful. More broadly, EO-based solutions could play a greater role in helping policymakers and farmers to comply with CAP and Green Deal regulations by providing real-time and accurate data for compliance monitoring and decision making.

On a larger scale, other actions could include the design of tailored training sessions to complement the AAG's existing offerings, aimed at improving public authorities' technical understanding and ability to integrate EO data into their operations. Using techniques such as co-design and panel discussions, standardised workflows could emerge from these workshops to simplify the processing and use of EO datasets in compliance monitoring and decision making. Other training topics that have been identified as necessary are those that focus on the use of data in the field.

Additionally, EuroGEO can facilitate better data-sharing mechanisms across European EO platforms, enhancing interoperability and supporting the Research to Operations (R2O) Pipeline, which would support a more seamless integration of EO data into existing and emerging systems.

Through targeted funding, EuroGEO should support the GEO initiative on Global Agricultural Monitoring (GEOGLAM) by promoting projects aligned with similar monitoring priorities, ensuring activities funded by the EU contribute to global efforts. This includes supporting operational pilots, validation studies, and user engagement to facilitate the transition from research to market and advance the operationalisation of GEOGLAM's monitoring system.

In conclusion, for R&I in the agriculture sector, EuroGEO's priorities should align with the most in-demand applications, such as **vegetation and soil monitoring**, **CAP monitoring**, and **carbon capture & content assessment**. These application areas also align closely with the key objectives of the EU Soil Strategy and the Common Agricultural Policy. At the same time, they are clearly on the rise in terms of R&I funding.

Glossary

AAG	EuroGEO's Agriculture Action Group
AG	EuroGEO Action Group
AI	Artificial Intelligence
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CSA	Climate-smart Agriculture
DaaS	Data-as-a-Service
DSS	Decision-support Systems
EC	European Commission
EGD	European Green Deal
EIP-AGRI	European Innovation Partnership 'Agricultural Productivity and Sustainability'
EO	Earth Observation
ESA	European Space Agency
ESG	Environmental, Social, and Governance
EU	European Union
EuroGEO	Europe's part of the Group on Earth Observations
EUSPA	European Agency for the Space Programme
FAO	Food and Agriculture Organization of the United Nations
FMIS	Farm Management Information Systems
GEO	Group on Earth Observations
GEOGLAM	GEO initiative on Global Agricultural Monitoring
GHG	Greenhouse gases
GNSS	Global Navigation Satellite System
H2020	Horizon 2020
HE	Horizon Europe
IoT	Internet of Things
JRC	Joint Research Centre
KCEO	Knowledge Centre on Earth Observation
LEO	Low Earth orbit
ML	Machine Learning
PAS	Public Authorities
R&I	Research & Innovation
R20	Research to Operations Pipeline
RIO	R&I Observatory for Earth Observation
SDGs	Sustainable Development Goals
SMES	Small and Medium-sized Enterprises
UNCCD	UN Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
WTO	World Trade Organisation

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