GAP ANALYSIS REPORT (FINAL)

EO-FIN

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Reference Documents

The following documents, although not part of this document, amplify or clarify its contents. Reference documents are those not applicable and referenced within this document.

Ref.	Document ID.	Title	Rev.
[RD1]	Proposal	Proposal "EO-FIN Best Practice for Financial Management Support"	
[RD2]	PMP	The project management plan	
[RD3]	D1.1	Workshop-1 report	1
[RD4]	D1.2	EO-FIN-Geoinformation requirements report (draft)	0.1
[RD5]	D1.2	EO-FIN-Geoinformation requirements report (final)	1
[RD6]	D2.1	EO-FIN Current EO Capabilities Report (draft)	0.1
[RD7]	D2.1	EO-FIN Current EO Capabilities Report (final)	1.0
[RD8]	D2.2	Workshop 2 summary report (final)	1.0

Acronyms

Acronym	Definition
EO	Earth observation
FM	Financial Management
ESA	European Space Agency
GHG	Green House Gases
DEM	Digital Elevation Model
EARSC	the European Association of Remote Sensing Companies
STD	Stabdard Deviation
VHR	Very High Resolution
LIDAR	Light Detection and Ranging
GEDI	Global Ecosystem Dynamics Investigation
SWIR	Short Wave Infrared
NBR	Normalized Burn Ratio
GWIS	Global Wildfire Information System
FWI	Fire Weather Index Rating System
LST	Land Surface Temperature
AIS	Automatic Identification System
UK	United Kingdom
Flex	Fluorescence Explorer
LSTM	Copernicus Land Surface Temperature Monitoring
CHIME	Copernicus Hyperspectral Imaging Mission for the Environment
ROSE-L	Radar Observing System in L-band
CO2M	Carbon Dioxide Monitoring
MAIA	NASA Multi-Angle Imager for Aerosols
NASA	National Aeronautics and Space Administration
ISRO	Indian Space Research Organisation

Acronym	Definition
EO	Earth observation
NISAR	NASA-Indian Space Research Organisation Synthetic Aperture Radar
AGB	Above Ground Biomass
NIR	Near Infrared

1. EXECUTIVE SUMMARY

This report presents a comprehensive gap analysis resulting from comparing the consolidated 32 Financial Management (FM) geo-information needs (documented in the D1.2 Geo-Information Requirements report) with the consolidated of 38 Earth Observation (EO) products to address these needs (documented in D2.1 Current EO Capabilities report). The analysis combines both quantitative and qualitative assessments to provide a holistic understanding of the existing gaps.

To identify these gaps, a multi-faceted approach was undertaken. It included desk-based research conducted by the GMV team, interviews conducted by London Economics team with experts in the financial sector, two workshops, and two separate online questionnaires. The first questionnaire was about the level of the utilisation of the EO products with the FM sector, and it was designed for experts in the FM sector. The second questionnaire focused on the capabilities of the EO products and was designed for experts in the EO industry.

Three distinct types of gaps were identified during this analysis: Guideline gaps, Utilisation gaps, and Research and Development (R&D) gaps. Additionally, we have pinpointed certain critical gaps that deserve particular attention.

For clarity and detail, the gaps for each consolidated EO product have been documented in individual tables. This allows for a clear and organized view of the specific shortcomings and opportunities associated with each product.

In addition to outlining the existing gaps, this report also offers insights into the potential of forthcoming EO satellite missions in the next five years. These missions are analysed in terms of how they can contribute to addressing the geo-information needs of the financial management sector.

2. INTRODUCTION

This report presents a comprehensive gap analysis resulting from comparing the consolidated 32 Financial Management (FM) geo-information needs (documented in the D1.2 Geo-Information Requirements report) with the consolidated 38 Earth Observation (EO) products to address these needs (documented in D2.1 Current EO Capabilities report). The analysis combines both quantitative and qualitative assessments to provide a holistic understanding of the existing gaps.

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2.1. PROJECT OVERVIEW

The activity "Best EO practices to support financial management (EO-FIN)" is an ESA-fully funded project aiming to understand the current, and short-term future, EO capabilities that can support the FM sector. This project studies EO best practices meeting the best responses to the FM sector's needs and requirements. The best EO practices are expected to lead to better products, greater trust from the customers, and a more competitive position in the market.

2.2. PURPOSE

The goal of this activity can be broken down into the following objectives:

1. Identify and consolidate the geoinformation needs and priorities within the domains of concern: Investment Management, Green Finance, Risk Analysis, and Insurance Management.
2. Identify and characterize EO-based products and services meeting the needs of the domains of concern by assessing the gaps between these and what EO can offer, now and in the near future.
3. Implement and test on a Virtual Platform at least one prototype of an identified EO-based service.
4. Define a roadmap for building EO industry guidelines for the commonly accepted best-practice use of EO-based information by companies within the FM sector.
5. Disseminate the analysis results via key international associations and bodies representing the sector, like EARSC (on the EO side).

2.3. PROJECT BREAKDOWN STRUCTURE

Figure 1 shows the EO-FIN project breakdown structure by describing the entire scope of the EO-FIN project, and the distribution of the work among the three teams that form part of the consortium: GMV-NSL, London Economics, and GMV AD. Overall, there are five WPs defined, namely:

- WP1. Collection of geoinformation requirements and associated constraints (corresponding to Task 1 in the SoW)
- WP2. Definition of current EO capabilities and use (corresponding to Task 2 in the SoW)

- WP3. Development of a service prototype (corresponding to Task 3 in the SoW)
- WP4. Development of a best practice roadmap (corresponding to Task 4 in the SoW)
- WP5. Overall management

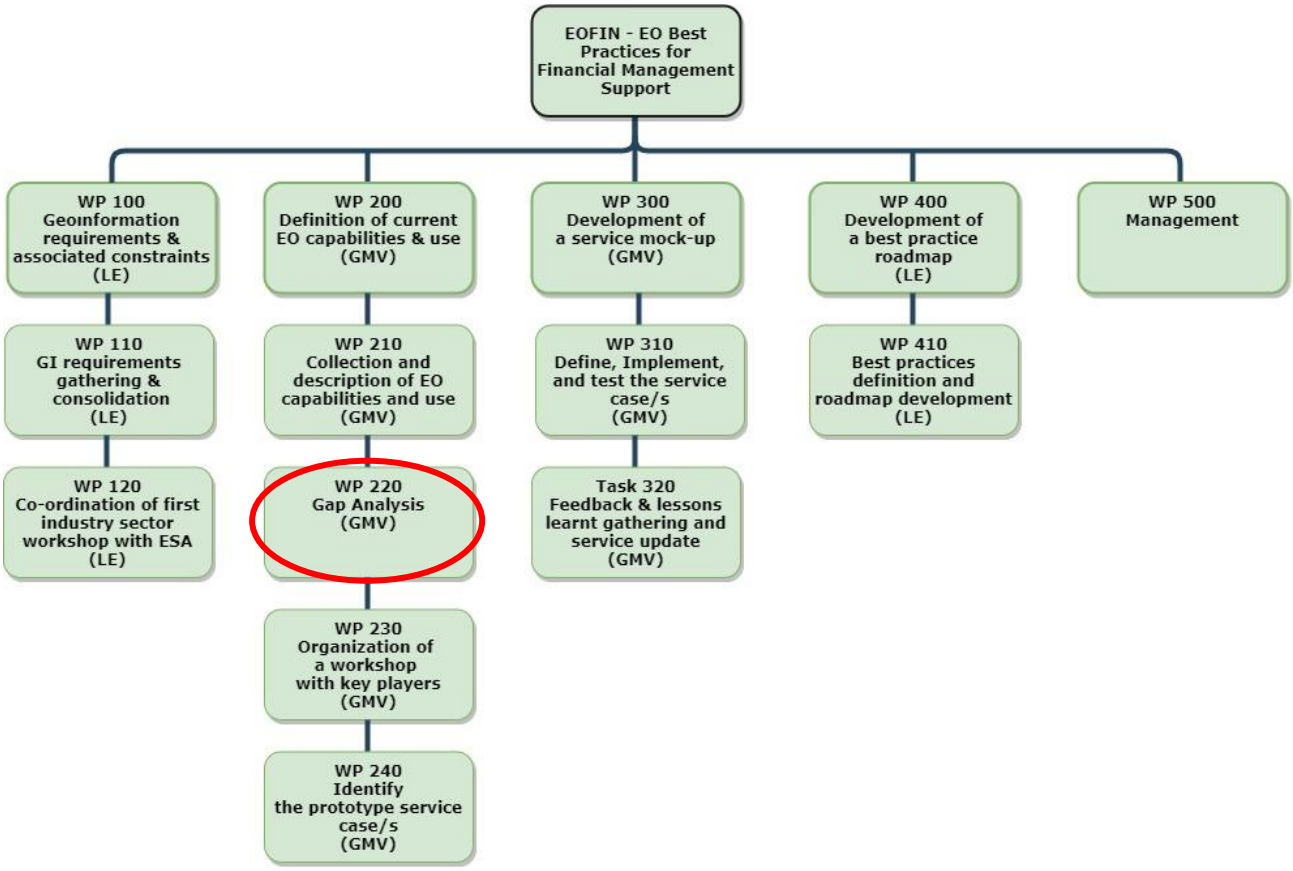

Figure 1. EO-FIN work breakdown structure

2.4. SCOPE OF THE PRESENT REPORT AND TARGET AUDIENCE

This report presents a gap analysis based on comparing the consolidated FM geo-information requirements documented in the D1.2 report with the current EO capabilities which was reported in the D2.1 report. It also considers the EO capabilities that may evolve over the next five years. This report discusses different types of gaps including guideline, utilisation, and R&D gaps which are described briefly in the body of the report. These gaps were identified via various activities including desk-based research, workshop discussions, and questionnaires targeted at experts from EO and FM industries. The target audience of this report is the EO service providers and FM stakeholders.

3. OVERVIEW OF THE URS AND CORRESPONDING EO PRODUCTS

In the previous report (D2.1 Current EO Capability), 38 EO products were consolidated to potentially contribute to fulfilling the FM geo-information requirements. These requirements were consolidated in the first phase of the project and documented in the D1.2 Geo-Information Requirements report. The 38 consolidated EO products are listed in Table 1 and categorized based on their EO application field. Furthermore, the EO products are linked to the relevant FM geo-information needs in Table 2.

Table 1. List of 38 Consolidated EO products.

Product ID	Product name	EO application field
P01	Land Use Map	Land use
P02	Crop Type and Acreage Mapping	
P03	Crop Phenology, Rotation, and Number of Seasons	
P04	Tillage, and Crop Residue Cover Practices	
P05	Green Biomass and Yield estimation	
P06	Milk and Cattle (in weight) Productivity Estimation	
P07	Monitoring Reforestation and Deforestation Activities	
P08	Trees Counting	
P09	Building Inventory	
P10	Mapping Travel Times to Assets	
P11	WorldPop – Population Counts	
P12	Monitoring Solar Panel Installations	
P13	Monitoring Changes in Port Activity Patterns	
P14	Stock Changes in Oil Tanks	
P15	Lithology and Surficial Geology Mapping	
P16	Predicting Terrorism Hotspots	
P17	Land Cover Maps	Land cover
P18	Crop Health (Diseases and Pests detection)	
P19	Vegetation Height Estimation	
P20	Nighttime Light Monitoring	
P21	Drought Monitoring at the Assets Level	Natural disaster
P22	Post Wildfires Monitoring (Area and Severity)	
P23	Wildfires Danger Forecasting	
P24	Identification of Flood Hazard Areas	
P25	Identification of Trends Related to Shifts in Rainfall Patterns	
P26	Green House Gases (GHG) Emissions Monitoring	Climate change
P27	Estimation of Above-Ground Carbon Stocks in Forests	
P28	Impact Of Increased Temperatures On Soil Moisture And Vegetation Condition	
P29	Heat Hazard Map	
P30	Satellite-Derived Bathymetry for Port and Coastal Monitoring	Coast management
P31	Coastal Erosion	
P32	Fish Stock Assessment	Marine
P33	Oil Spill Detection	

P34	Ship Detection and Categorization	
P35	Monitoring Highway and Railway Networks	Earth's surface motion
P36	Dams' Safety	
P37	Surveillance of Oil and Gas Pipelines for Geohazard and Ground Subsidence Vulnerabilities	
P38	Monitor Slow-Moving Subsidence	

Table 2. Consolidated user needs with the associated consolidated EO products.

User need ID	User's Expression	Relevant product(s) ID
UN9	Understanding stock levels and monitoring supply chains	P32, P05, P15, P06, P13, P14
UN10	Need to understand population density when making investment decisions	P01, P11
UN11	Realistic assessment of accessibility to assets	P17, P01, P10
UN12	Analysis of potential risks in specific regions	P31, P21, P29, P24, P25, P16, P30, P23
UN13	Need to geo-map clients	P21, P24, P25, P01, P23
UN14	Need to screen the feasibility of projects against different hazards criteria	P31, P21, P29, P24, P25, P23
UN15	Need to monitor carbon intensity of portfolio assets	P26
UN16	Nighttime light monitoring	P20
UN17	Need near real-time tracking of marine vessels to understand their routes and estimate fuel usage	P34
UN18	Need to monitor crop productivity	P03, P02, P05, P04
UN19	Identifying types of crops being grown is essential	P02
UN26	Need to monitor GHG emissions of projects funded	P26
UN27	Need to assess historical trend and baseline of natural assets	P17, P01, P07
UN28	Need to classify the types of crops being grown in order to assess the sustainability and environmental impact of agricultural investments	P02, P07

UN29	Need to accurately measure the planted area for crops	P02, P05
UN30	Need for monitoring with accurate measurements the growth and health of trees	P18, P27, P07
UN31	Need to link tree planting parcels to estimate the number of trees planted	P08
UN32	Need to periodically estimate the growth of above-ground carbon stocks (in forests).	P27
UN37	Projection of risk to portfolio assets into the future.	P35, P31, P18, P36, P21, P24, P38, P12, P16, P37, P19
UN38	Need for trustworthy time series of reliable data on assets	P05, P17
UN39	Need to assess the potential impact of business activities or investments on ecosystems and biodiversity	P17, P07, P33
UN40	Need to monitor the risk of sea level rise threatening coastal property, infrastructure, and supply chains	P31, P17
UN41	Need to monitor the impact of increased temperatures on assets	P29, P28
UN42	Need to monitor the impact of droughts on assets	P21
UN43	Need to monitor changing precipitation patterns and flood risk in vicinity of vulnerable assets	P24, P25, P17, P01
UN44	Need to measure the area vulnerable to wildfires before events	P23
UN45	Need to measure the area affected by wildfires after the fact	P22
UN46	Need to measure the intensity of wildfires (level of damage to assets)	P22
UN47	Need up-to-date geospatial data on residential and industrial infrastructures' locations	P09, P01
UN55	Detecting crop damage at the level of individual farms/fields	P18

UN56	Need to detect changes in land use (at the level of individual buildings)	P01
UN57	Automatically update changes in population density estimates based on observable land use changes	P11

4. GAP ANALYSIS APPROACH

In D2.1 the Current EO Capability report, we reported and described 38 consolidated EO products that can potentially contribute to the geo-information requirements of the FM sector. An evaluation process was employed to examine these 38 products, aiming to identify the obstacles preventing the FM sector from fully leveraging EO technologies. The evaluation process contained both quantitative and qualitative analysis as described in the following sections.

The objective was to focus on identifying three types of gaps which are Guideline gaps, utilisation gaps, and R&D gaps.

Guideline gap: means that there is an EO product/service that can address a financial management demand, however, the financial sector is not aware of this EO product/service.

Utilisation gap: means that the financial sector is aware of the EO product/service that can address the demand, however, there is a limitation in the utilisation of that EO product/service due to some reasons like the cost, regulations, reliability of the product, etc.

R&D gap: means that there is a demand in the FM sector for an EO product/service, but the existing EO capabilities are unable to deliver a product or service of the desired or necessary quality to meet this demand.

By focusing on all these types of gaps, FM institutions, and the EO industry can create a well-rounded strategy for improvement of the use of EO technologies to meet the geo-information needs of the FM sector. Guideline and utilisation gaps help ensure that currently existing EO capabilities are effectively utilized, while R&D gaps drive innovation and keep the EO industry evolving to meet the demands of the FM sector.

In addition to identifying those gaps, we also discussed generic regulatory gaps that are not specifically linked to the EO industry. However, these generic gaps put barriers for the FM sector to maximize the advantages offered by the EO technologies.

4.1. QUANTITATIVE ANALYSIS

A Multi-Criteria Assessment (MCA) was implemented for the consolidated 32 geo-information FM sector's needs (which were documented in the Geo-Information Requirements report (D1.2)) and the consolidated EO products (which were documented in the Current EO Capability report (D2.1)). The assessment of the FM sector's needs is based on the **demand** level criteria, while it was based on two criteria for EO products which are **capability** and **utilisation**. Each criterion's scoring was categorized into 4 levels as described in Table 3, Table 4, and Table 5.

1- **Demand:** it is **related to the user needs** and can be defined as the varying degrees of interest, enthusiasm, and recognition expressed by stakeholders or potential users regarding a specific geospatial user need. It ranges from a complete absence of interest and awareness to a strong desire for the development and implementation of a solution, with different levels of enthusiasm and recognition in between as follows:

Table 3. Criteria scoring for demand level of the FM user needs.

Score	Level	Description
1	No demand	The product is not being used by the financial management sector, neither in its free nor in its commercial version
2	Low demand	Stakeholders express little to no excitement or interest, often demonstrating indifference or lack of awareness about the geospatial user need
3	Medium demand	Stakeholder responses vary, with some showing enthusiasm and recognition of potential benefits, while others remain uncertain or reserved about the geospatial user need

4	High utilisation	Stakeholders consistently demonstrate high levels of enthusiasm and interest. They recognize the value of addressing the geospatial user need and express a strong desire for the development and implementation of a solution

2- Capability: it is **related to the EO product** and refers to the EO product's ability to meet the relevant FM user needs. The scores are described as follows:

Table 4. Criteria scoring for the capability of the EO product to respond to the relevant user needs.

Score	Level	Description
1	Not at all respond	The EO product cannot respond to the FM user requirements
2	Partially respond	The EO product can only address the user requirements in a limited way (e.g., new sensors required).
3	Moderately respond	The EO product can often fulfil the demand, but there are some thematic content, accuracy, or delivery limitations to address the challenges and needs. In other cases, new sensors that are being developed should improve the product to highly meet the User Requirements.
4	Highly respond	The EO product can meet the current and anticipated user requirements of the FM sector. Initiatives such as standards, training, and integration tools can still benefit the EO solution.

3- Utilisation: it is also **related to the EO product** and refers to the current utilisation of the EO product by the FM sector. The scores are described as follows:

Table 5. Criteria scoring for utilisation of the EO product by the FM sector.

Score	Level	Description
1	No utilisation	The product is not being used by the FM sector, neither in its free nor in its commercial version
2	Low utilisation	Using freely available products without consulting EO service providers. E.g., using the SRTM product from NASA as a free source for Digital Elevation Model (DEM) with 30 m resolution.
3	Medium utilisation	The FM sector is using this commercial product; however, there are other products offered by the EO industry with better technical and usability specifications. E.g., using commercial DEM product with a 10 m resolution
4	High utilisation	Using the best commercial services/products available.

4.1.1. HOW THE SCORES WERE CALCULATED

The demand and utilisation scores have been built up by experts in the FM sector, whereas the capability scores have been built up by experts in the EO industry.

Demand scores for each geo-information need were identified by London Economics based on a discussion with FM experts during the first workshop and a series of semi-structured one-to-one interviews that were carried out with FM stakeholders from the private, public, and third sectors.

Utilisation scores for each EO product were identified through an online questionnaire disseminated to FM experts. In the online questionnaire, we provided information about each identified product with its relevant FM needs and kindly asked the participants to provide their opinions about the level of

utilisation of each product as described in Table 5 (utilisation levels definitions). We also asked the participants about the reason for the selected level of utilisation, this information was of great benefit for the qualitative analysis. There was also an option as 'I am not sure' in case respondents were not confident in their answers. This can potentially increase the reliability of findings.

For giving utilisation scores for each EO product, we relied on the mean scores selected by all participants discarding 'I am not sure' answers.

Capability scores for each EO product were also identified via an online questionnaire shared with EO experts through the channels of GMV, the European Association of Remote Sensing Companies (EARSC), and Space for Climate. In the online questionnaire, we provided information about each identified product with its relevant FM needs and kindly asked the participants to provide their opinions about the maturity level of the product as well as the level at which the product responds to the relevant FM needs as described in Table 4 (capability levels definitions). For the question on the response level, if respondents chose any of these three choices (i.e., not all respond, partially respond, or moderately respond), they were asked two further questions. The questions are regarding the gaps preventing the EO product from fully responding to the needs and the improvements required. There was also an option as 'I am not sure' in case respondents were not confident in their answers. This can potentially increase the reliability of findings.

For giving the Capability score for each EO product, we relied on the mean scores selected by all participants discarding 'I am not sure' answers.

4.1.2. TYPES OF GAPS

Based on the demand, utilisation, and capability scores, we identified three types of gaps based on the correlation between the EO products and associated user needs:

- **Guideline gap (Capability > Demand):**

if the capability score of an EO product was higher than the demand score of the associated user needs by more than or equal to 0.5. (For example, the capability score is 3.9 and the demand score is 3)

- **Utilisation gap (Capability ≈ Demand & Capability > Utilisation):**

if the capability score of an EO product is almost equal to the demand score of the associated user needs. At the same time, the utilisation score is less than capability by more than or equal to 0.5.

- **R&D gap (Capability < Demand):**

if the capability score of an EO product is less than the demand score of the associated user need by more than or equal to 0.5.

In addition, we found that is important to identify **critical gaps**. Knowing the critical gaps will be greatly beneficial to the FM sector and EO industry to take urgent actions and decisions. We recognized a gap as critical when the difference between scores is more than or equal to one. (For example, if the capability score of an EO product is 3.9 and the demand score of the relevant user need is 2.8, this would be a critical guideline gap)

One important issue that we should highlight, the gaps are identified based on the relation between the EO products and the related user needs. As we mentioned previously in the D2.1 report, an EO product might contribute to more than one user need. Therefore, we conducted a gap identification process (comparing scores) for each EO product against each user need separately. Let us give an example to make it more obvious. Land cover maps are an EO product that can potentially contribute to many consolidated user needs; UN11: Realistic assessment of accessibility to assets, UN27: Need to assess historical trends and baseline of natural assets, UN38: Need for trustworthy time series of reliable data on assets, UN39: Need to assess the potential impact of business activities or investments on ecosystems and biodiversity, UN40: Need to monitor the risk of sea level rise threatening coastal property, infrastructure, and supply chains, and UN43: Need to monitor changing precipitation patterns and flood risk in the vicinity of vulnerable assets. After the quantitative analysis, we found that it has a critical guideline gap for UN11 and UN27, whereas it has a critical utilisation gap for UN38.

In the Gaps related to the consolidated EO products 6.2.1.1 sub-section, we add the critical gaps for each EO product.

5. QUALITATIVE ANALYSIS

Quantitative analysis (which is described in the previous section), while valuable for providing numerical data and measurable insights, is not sufficient on its own for a complete understanding of the gaps. Quantitative data alone may oversimplify or miss important details. Therefore, qualitative analysis is crucial to complement quantitative data by providing insights about the reasons and factors that lead to certain quantitative results.

The qualitative analysis was carried out to give deep insights into the different types of gaps described previously, guideline, utilisation, and R&D gaps.

For guideline and utilisation gaps, the qualitative analysis was conducted via the online utilisation questionnaire which was described earlier. As we mentioned, based on the utilisation score selected by a participant, there was a question about the reason for the selected level of utilisation. The questions were as follows:

In your opinion, what is the reason for **no utilisation** of this EO product?

1. No utilisation:

- Unavailability of freely available sources of the EO product.
- Unacceptable reliability and accuracy of the EO product.
- Current regulations prevent the utilisation of the EO product.
- Users' lack of EO knowledge and skills to utilize the EO product.
- Unawareness of the existence of this EO product.
- Others, specify:

In your opinion, what is the reason for the **low utilisation** of this EO product?

Low utilisation:

- Higher cost of using the commercial EO product.
- The product is already satisfying the technical and usability requirements.
- Unawareness of the existence of commercial EO products with better specifications.
- Others, specify:

In your opinion, what is the reason for the **medium utilisation** of this EO product?

Medium utilisation:

- Higher cost of using the best available commercial EO product.
- The product is already satisfying the technical and usability requirements.
- Unawareness of the existence of the best available commercial EO product with better specifications.
- Others, specify:

In your opinion, what is the reason for the **high utilisation** of this EO product?

High utilisation:

- Only this product satisfies the technical and usability requirements.
- Others, specify:

For R&D gaps, the qualitative analysis was carried out via three different activities: desk-based research conducted by the GMV team, workshop group discussions, and an online capability questionnaire. In the online questionnaire as mentioned earlier, if respondents chose any of these three choices (i.e., not all respond, partially respond, or moderately respond), they were asked two further questions including:

- What are the main factors preventing this EO product from fully responding to the above-mentioned User Requirement(s)?
- What are the main factors preventing this EO product from fully responding to the above-mentioned User Requirement(s)?

The detailed information for the guideline, utilisation, and R&D gaps for each EO product can be found in the Gaps related to the consolidated EO products6.2.1.1 6.2.1.1 sub-section.

about some products with demand in the FM sector, however, they are low maturity and less capable of meeting the needs.

Apart from those three types of gaps, some generic regulatory gaps were discussed during the workshop. These generic gaps are not specifically linked to the EO industry, however, they put barriers for the FM sector to maximize the advantages offered by the EO technologies. These gaps are provided separately in sub-section 7.2.1.

6. GAP ANALYSIS RESULTS

6.1. QUANTITATIVE ANALYSIS RESULTS

The quantitative analysis of 38 consolidated EO products was completed based on their capability to address the FM needs and the current utilisation level. The gaps were identified based on the demand level of the correlated FM needs.

For each FM domain, Table 6, Table 7, Table 8, and Table 9 provide detailed information about the demand score of each user need and the associated EO products with their capability and utilisation scores. To identify the gaps, we go through each user need and check the following conditions for each corresponding EO product:

Guideline Gap (If Capability > Demand):

Gap exist: If 0.5 ≤ Capability - Demand < 1.

Critical Gap: If Capability - Demand ≥ 1.

Utilisation Gap (If Capability = Demand & Capability > Utilisation):

Gap exist: If 0.5 ≤ Capability - Utilisation < 1.

Critical Gap: If Capability - Utilisation ≥ 1.

R&D Gap (If Capability < Demand):

The gap exists: If 0.5 ≤ Demand - Capability < 1.

Critical Gap: If Demand - Capability ≥ 1.

Besides the visualization with red colour for the critical gaps in the tables, we have added them in the Gaps related to the consolidated EO products 6.2.1.1 sub-section for each EO product.

Note: we added the STD of the scores based on the responses we received to give the reader an insight into the uncertainty of the capability level of an EO product among EO experts, as well as the utilisation level of the product among FM experts.

Note: we did not assign a critical utilisation gap for the 'Fish stock assessment' product for UN9 as the maturity level of the product is too low. The maturity level of each product can be found in the Gaps related to the consolidated EO products sub-section.

Table 6. Invest Management user needs demand scores with the capability and utilisation scores for the associated EO products.

The user needs' ID and expression	The demand level of the need	Corresponding EO product(s)	Capability score		Utilisation score		Critical gaps
			Mean	STD	Mean	STD	
UN9: Understanding stock levels and monitoring supply chains	3	Fish Stock Assessment	2.80	1.17	1.40	0.49	
		Green Biomass and Yield estimation	3.15	0.77	2.40	0.80	
		Lithology and Surficial Geology Mapping	3.67	0.47	2.00	0.00	Utilisation
		Milk and Cattle (in weight) Productivity Estimation	2.83	1.07	2.00	0.71	
		Monitoring Changes in Port Activity Patterns	3.30	0.90	2.33	0.94	
		Stock Changes in Oil Tanks with Floating Roof	3.60	0.66	2.83	1.07	
UN10: Need to understand population density when making investment decisions	3	Land Use Maps	3.67	0.47	2.71	0.70	
		WorldPop – Population Counts	3.60	0.49	3.00	0.89	
UN11: Realistic assessment of accessibility to assets	2	Land Cover Maps	4.00	0.00	2.86	0.64	Guideline
		Land Use Maps	3.67	0.47	2.71	0.70	Guideline
		Mapping Travel Times to Assets	4.00	0.00	2.50	1.32	Guideline
UN12: Analysis of potential risks in specific regions	3	Coastal Erosion	3.70	0.46	2.17	1.07	Utilisation
		Drought Monitoring at the Assets Level	3.43	0.62	2.71	0.70	
		Heat Hazard Map	3.33	1.11	2.80	0.98	
		Identification of Flood Hazard Areas	3.54	0.84	3.13	0.60	
		Identification of Trends Related to Shifts in Rainfall Patterns	3.11	0.99	2.60	1.02	
		Predicting Terrorism Hotspots	3.00	0.82	2.50	1.12	
		Satellite-Derived Bathymetry for Port and Coastal Monitoring	3.50	0.50	2.50	0.87	Utilisation
		Wildfires Danger Forecasting	3.50	0.87	2.71	0.70	

UN13: Need to geo-map clients	4	Drought Monitoring at the Assets Level	3.43	0.62	2.71	0.70	
		Identification of Flood Hazard Areas	3.54	0.84	3.13	0.60	
		Identification of Trends Related to Shifts in Rainfall Patterns	3.11	0.99	2.60	1.02	
		Land Use Maps	3.67	0.47	2.71	0.70	
		Wildfires Danger Forecasting	3.50	0.87	2.71	0.70	
UN14: Need to screen the feasibility of projects against different hazards criteria	3	Coastal Erosion	3.70	0.46	2.17	1.07	Utilisation
		Drought Monitoring at the Assets Level	3.43	0.62	2.71	0.70	
		Heat Hazard Map	3.33	1.11	2.80	0.98	
		Identification of Flood Hazard Areas	3.54	0.84	3.13	0.60	
		Identification of Trends Related to Shifts in Rainfall Patterns	3.11	0.99	2.60	1.02	
		Wildfires Danger Forecasting	3.50	0.87	2.71	0.70	
UN15: Need to monitor carbon intensity of portfolio assets	4	GHG Emissions Monitoring	2.90	1.04	2.33	0.94	R&D
UN16: Nighttime light monitoring	3	Nighttime Light Monitoring	3.50	1.02	2.86	1.12	
UN17: Need near real-time tracking of marine vessels to understand their routes and estimate fuel usage	3	Ship Detection and Categorization	3.50	0.76	2.00	1.26	Utilisation
UN18: Need to monitor crop productivity	2	Crop Phenology, Rotation, and Number of Seasons	3.70	0.64	2.00	0.58	Guideline
		Crop Type and Acreage Mapping	3.50	0.50	2.60	1.02	Guideline
		Green Biomass and Yield estimation	3.15	0.77	2.40	0.80	Guideline
		Tillage, and Crop Residue Cover Practices	3.00	0.76	1.80	0.40	Guideline
UN19: Identifying types of crops being grown is essential	3	Crop Type and Acreage Mapping	3.50	0.50	2.60	1.02	

Table 7. Green Finance user needs demand scores with the capability and utilisation scores for the associated EO products.

The user needs' ID and expression	The demand level of the need	Corresponding EO product(s)	Capability score		Utilisation score		Critical gaps
			Mean	STD	Mean	STD	
UN26: Need to monitor GHG emissions of projects funded	3	Green House Gases (GHG) Emissions Monitoring	2.90	1.04	2.33	0.94	R&D
UN27: Need to assess historical trend and baseline of natural assets	3	Land Cover Maps	4.00	0.00	2.86	0.64	Guideline
		Land Use Maps	3.67	0.47	2.71	0.70	
		Monitoring Reforestation and Deforestation Activities	3.93	0.26	3.00	0.82	
UN28: Need to classify the types of crops being grown in order to assess the sustainability and environmental impact of agricultural investments	3	Crop Type and Acreage Mapping	3.50	0.50	2.60	1.02	
		Monitoring Reforestation and Deforestation Activities	3.93	0.26	3.00	0.82	
UN29: Need to accurately measure the planted area for crops	3	Crop Type and Acreage Mapping	3.50	0.50	2.60	1.02	
		Green Biomass and Yield estimation	3.15	0.77	2.40	0.80	
UN30: Need for monitoring with accurate measurements the growth and health of trees	3	Crop Health (Diseases and Pests detection)	3.20	0.65	2.20	0.75	Guideline
		Estimation of Above-ground Carbon Stocks in Forests	3.27	0.96	2.29	0.88	Utilisation
		Monitoring Reforestation and Deforestation Activities	3.93	0.26	3.00	0.82	
UN31: Need to link tree planting parcels to estimate the number of trees planted	3	Trees Counting	3.63	0.48	2.14	0.64	Utilisation

UN32: Need to periodically estimate the growth of above-ground carbon stocks (in forests).	3	Estimation of Above-ground Carbon Stocks in Forests	3.27	0.96	2.29	0.88	Utilisation

Table 8. Risk Analysis user needs demand scores with the capability and utilisation scores for the associated EO products.

The user needs' ID and expression	The demand level of the need	Corresponding EO product(s)	Capability score		Utilisation score		Critical gaps
			Mean	STD	Mean	STD	
UN37: Projection of risk to portfolio assets into the future	2	Monitoring Highway and Railway Networks	3.38	0.99	1.80	0.75	Guideline
		Coastal Erosion	3.70	0.46	2.17	1.07	Guideline
		Crop Health (Diseases and Pests detection)	3.20	0.65	2.20	0.75	Guideline
		Dams' Safety	3.25	0.83	2.50	0.50	Guideline
		Drought Monitoring at the Assets Level	3.43	0.62	2.71	0.70	Guideline
		Identification of Flood Hazard Areas	3.54	0.84	3.13	0.60	Guideline
		Monitor Slow-Moving Subsidence	3.44	1.07	2.00	0.82	Guideline
		Monitoring Solar Panel Installations	2.78	1.13	2.25	0.83	
		Predicting Terrorism Hotspots	3.00	0.82	2.50	1.12	
		Surveillance of Oil and Gas Pipelines for Geohazard and Ground Subsidence Vulnerabilities	3.50	0.71	2.25	1.09	Guideline
		Vegetation Height Estimation	3.17	0.99	2.40	0.49	Guideline
UN38: Need for trustworthy time series of reliable data on assets	4	Green Biomass and Yield estimation	3.15	0.77	2.40	0.80	
		Land Cover Maps	4.00	0.00	2.86	0.64	Utilisation
UN39: Need to assess the potential impact of business	2	Land Cover Maps	4.00	0.00	2.86	0.64	
		Monitoring Reforestation and Deforestation Activities	3.93	0.26	3.00	0.82	Guideline

activities or investments on ecosystems and biodiversity		Oil Spill Detection	3.40	0.80	2.25	0.83	Guideline
UN40: Need to monitor the risk of sea level rise threatening coastal property, infrastructure, and supply chains	3	Coastal Erosion	3.70	0.46	2.17	1.07	Utilisation
		Land Cover Maps	4.00	0.00	2.86	0.64	
UN41: Need to monitor the impact of increased temperatures on assets	2	Heat Hazard Map	3.33	1.11	2.80	0.98	Guideline
		Impact of increased temperatures on soil moisture and vegetation condition	3.17	1.21	2.20	0.75	Guideline
UN42: Need to monitor the impact of droughts on assets	2	Drought Monitoring at the Assets Level	3.43	0.62	2.71	0.70	Guideline
UN43: Need to monitor changing precipitation patterns and flood risk in the vicinity of vulnerable assets	3	Identification of Flood Hazard Areas	3.54	0.84	3.13	0.60	
		Identification of Trends Related to Shifts in Rainfall Patterns	3.11	0.99	2.60	1.02	
		Land Cover Maps	4.00	0.00	2.86	0.64	
		Land Use Maps	3.67	0.47	2.71	0.70	
UN44: Need to measure the area vulnerable to wildfires before events	3	Wildfires Danger Forecasting	3.50	0.87	2.71	0.70	
UN45: Need to measure the area affected by wildfires after the fact	2	Post Wildfires Monitoring (Area and Severity)	3.83	0.55	3.00	0.82	Guideline
UN46: Need to measure the intensity of wildfires (level of damage to assets)	2	Post Wildfires Monitoring (Area and Severity)	3.83	0.55	3.00	0.82	Guideline
UN47: Need up-to-date geospatial data on residential and industrial infrastructures' locations	4	Building Inventory	3.64	0.77	2.25	0.83	Utilisation
		Land Use Maps	3.67	0.47	2.71	0.70	

Table 9. Insurance Management user needs demand scores with the capability and utilisation scores for the associated EO products.

The user needs' ID and expression	The demand level of the need	Corresponding EO product(s)	Capability score		Utilisation score		Critical gaps
			Mean	STD	Mean	STD	
UN55: Detecting crop damage at the level of individual farms/fields	3	Crop Health (Diseases and Pests detection)	3.20	0.65	2.20	0.75	Utilisation
UN56: Need to detect changes in land use (at the level of individual buildings)	2	Land Use Maps	3.67	0.47	2.71	0.70	Guideline
UN57: Automatically update changes in population density estimates based on observable land use changes	2	WorldPop – Population Counts	3.60	0.49	3.00	0.89	Guideline

6.2. QUALITATIVE ANALYSIS RESULTS

6.2.1. GUIDELINE, UTILISATION AND R&D GAPS

In the process of consolidating EO products for the FM sector, we found that almost all of the user needs can be potentially addressed by currently available EO products and services. However, there are some limitations and challenges that should be considered to increase the capability of the EO products to fully respond to user needs. Only one of UNs that we did not find a mature EO product in the industry, despite the need for it by the FM institutions. This user need was **UN17: 'Need near real-time tracking of marine vessels to understand their routes and estimate fuel usage'.** In the context of this user need, the FM stakeholders outlined that this information is a crucial input to estimate the marine vessel's GHG emissions, which are identified by professionals as increasingly important data. However, we did not find a product in the EO market that responds to this user need due to the limitation of the current EO capabilities. The main constraint arises from the limitations of the frequency of revisit time by current and near-future GHG monitoring missions, which hinders the ability to track ships effectively. Additionally, another limitation is associated with the spatial resolution of these missions, further impacting their ability to capture and monitor ship-related GHG emissions.

6.2.1.1. GAPS RELATED TO THE CONSOLIDATED EO PRODUCTS

We conducted a comprehensive analysis of each of the 38 consolidated EO products to identify the gaps that prevent the FM sector from fully leveraging EO technology. These gaps (as mentioned) are not only related to the maturity and quality of the EO products/services but also the gaps may be related to the utilisation of the available mature products by the FM sector. We tried in this section to provide detailed information about the guideline, utilisation, and R&D gaps related to each consolidated EO product considering the corresponding FM needs. We have created 38 tables, each accompanying an EO product, which detail the respective gaps in that specific product. The main information in the table is organized and presented in the following manner:

Maturity score: It is related to the maturity of the EO product, independently of any specific user needs or requirements. The scores of each product were identified through an online questionnaire shared with EO experts as described in the D2.1 report (Current EO Capability). We added the mean and standard deviation of all scores selected by the questionnaire participants to provide a more complete understanding of the responses. distribution

Constraints and limitations: the limitations that should be considered in the usage and development of the EO product.

Relevant user needs: those are the consolidated FM needs during the first phase of the project, which the EO product can contribute to adder them.

R&D gaps: the gaps related to the capability of the EO product, which prevent it from fully responding to the user needs.

Potential improvements drivers: Potential improvements drivers.

Utilisation score: the score that describes the level of utilisation of the EO product by the FM sector (it was described briefly earlier in the report). We added the mean and standard deviation of all scores selected by the questionnaire participants to provide a more complete understanding of the responses. Distribution.

Reasons for the utilisation level: as we mentioned earlier, we defined four levels of utilisation ('No utilisation', 'Low utilisation', 'Medium utilisation', and 'high utilisation'). We asked FM experts via an online questionnaire about the level of each product with a provided explanation of that level of utilisation. We received different levels of utilisation per EO product, so we found that it is important to not ignore any of the responses we received. Therefore, for each EO product, we added relevant reasons for each utilisation level selected by the FM experts for each specific EO product.

Critical gaps: it is the critical gaps for the EO product per user need as briefly described earlier in the report.

P01: Land use maps	
Maturity score	
Mean: 2.9	**STD:** 0.34

Constraints and limitations

- Cloud presence
- Creating high-quality and diverse labelled data for land use mapping can be challenging for specific land cover classes.

Relevant user needs

UN10: Need to understand population density when making investment decisions.

UN11: Realistic assessment of accessibility to assets.

UN13: Need to geo-map clients.

UN27: Need to assess historical trends and baseline of natural assets.

UN43: Need to monitor changing precipitation patterns and flood risk in the vicinity of vulnerable assets.

UN47: Need up-to-date geospatial data on residential and industrial infrastructures' locations.

UN56: Need to detect changes in land use (at the level of individual buildings).

R&D gaps

- Available land use maps cover a partial set of interesting indicators.
- The variation of resolution and products around the world. There are coarse global products, various higher-resolution regional products, and specific urban-focused products.

Potential improvements drivers

- Add automatic urban settlement mapping that automatically delineates urban footprints.
- A data framework defining a structure of the available datasets outlining what sources should be used when and in which locations to give you an accurate picture of your area of interest.

Utilisation level review	
Utilisation score	
Mean: 2.71	**STD:** 0.7

No utilisation:

Low utilisation

- Existing mapping is considered good enough for many use cases.
- Higher cost of using the commercial EO product.
- The free product already satisfies the technical and usability requirements.

Medium utilisation

- Higher cost of using the best available commercial EO product.
- The product already satisfies the technical and usability requirements.

• High usability in the developed, but not likely emerging and developing economies. Certainly not the "global south." **High utilisation** Only this product satisfies the technical and usability requirements
Critical gaps related to relevant user needs
Guideline gap UN11: Realistic assessment of accessibility to assets UN56: Need to detect changes in land use (at the level of individual buildings)

P02: Crop type and acreage mapping	
Maturity score	
Mean: 2.5	**STD:** 0.5
Constraints and limitations • Cloud presence • The lack of local in-situ data to train the machine learning models. • Machine learning model uncertainty	
Relevant user needs UN18: Need to monitor crop productivity. UN19: Identifying types of crops being grown is essential. UN28: Need to classify the types of crops being grown to assess the sustainability and environmental impact of agricultural investments. UN29: Need to accurately measure the planted area for crops.	
R&D gaps • Limitations in discrimination of crop types with similar spectral signatures. As the crop type maps are often group classifications where crops with similar spectral signatures are grouped together. • Smallholder farming remains an issue because of the small size of farms where intercropping happens very often. (This comment may not apply in the case of large commercial farms).	
Potential improvements drivers The main limitations are due to the input data rather than the methodology, so the improvements include: • More field data worldwide. • Increased spatial and temporal resolution of the input EO data. • Increasing spectral resolution by using hyperspectral data to better discriminate between crop types. • Crop-type predictions using multiple datasets may allow you to differentiate between those crops that are similar spectrally.	

Utilisation level review	
Utilisation score	
Mean: 2.6	**STD:** 1.02
No utilisation: **Low utilisation** **Medium utilisation** Unawareness of the existence of the best available commercial EO product with better specifications. **High utilisation** Only this product satisfies the technical and usability requirements.	
Critical gaps related to relevant user needs	
Guideline gap UN18: Need to monitor crop productivity	

P03: Crop phenology, rotation, and number of seasons	
Maturity score	
Mean: 2.9	**STD:** 0.3
Constraints and limitations • Cloud presence • The lack of local in-situ data to train the machine models	
Relevant user needs UN18: Need to monitor crop productivity.	
R&D gaps • The limited temporal resolution can make it challenging to capture specific phenological changes or detect short-duration crops accurately. • May not directly capture the underlying physiological processes driving phenological stages, limiting the understanding of crop responses to environmental stressors.	
Potential improvements drivers • Higher temporal resolution EO data with adequate spectral bands.	
Utilisation level review	
Utilisation score	
Mean: 2	**STD:** 0.58

No utilisation: Users' lack of EO knowledge and skills to utilize the EO product. **Low utilisation** • Unawareness of the existence of commercial EO products with better specifications. • Higher cost of using the commercial EO product. **Medium utilisation** **High utilisation**
Critical gaps related to relevant user needs
Guideline gap UN18: Need to monitor crop productivity

P04: Tillage and crop residue cover practices	
Maturity score	
Mean: 2.1	**STD:** 0.83
Constraints and limitations • Cloud presence • The lack of local in-situ data to train the models. • Machine learning model uncertainty • The effectiveness of the product can be affected by environmental conditions such as heavy rain, snow cover, or flooding, which can obscure the view of the land surface or modify tillage and residue patterns. • Different crops and crop varieties may have varying residue cover practices, making it challenging to establish a one-size-fits-all monitoring system.	
Relevant user needs UN18: Need to monitor crop productivity.	
R&D gaps • Limited training data. • Smallholder farming remains an issue because of the small size of farms where intercropping happens very often. (This comment may not apply in the case of large commercial farms).	
Potential improvements drivers • Methodology for the retrieval of ground data for model training and validation. • Increasing spectral resolution by using hyperspectral data.	

Utilisation level review	
Utilisation score	
Mean: 1.8	**STD:** 0.40
No utilisation: Users' lack of EO knowledge and skills to utilize the EO product. **Low utilisation** • Unawareness of the existence of commercial EO products with better specifications • Higher cost of using the commercial EO product • Higher cost in terms of internal training and resources to use the data that comes from this process/data source. **Medium utilisation** **High utilisation**	
Critical gaps related to relevant user needs	
Guideline gap UN18: Need to monitor crop productivity	

P05: Green biomass and yield estimation	
Maturity score	
Mean: 2.2	**STD:** 0.58
Constraints and limitations • Cloud presence • The lack of local in-situ data to train the models. • Machine learning model uncertainty.	
Relevant user needs UN9: Understanding stock levels and monitoring supply chains. UN18: Need to monitor crop productivity. UN29: Need to accurately measure the planted area for crops. UN38: Need for trustworthy time series of reliable data on assets.	
R&D gaps • Limited training data. • Models will often be very specific to particular species and cash crops. Also, region-specific. • The accurate and frequent estimation of stock levels will need further information.	

Potential improvements drivers • Work may be required to review what models are available and then to Identify which are transferable to different regions and potentially different crops and which need to be improved or built from scratch. • Effort in truthing of predicted values against actual accepted values is likely to need to be undertaken to confidently use the data operationally.
Utilisation level review
Utilisation score
Mean: 2.4 | **STD:** 0.80
No utilisation: Users' lack of EO knowledge and skills to utilize the EO product. **Low utilisation** • The product is already satisfying the technical and usability requirements. **Medium utilisation** The product is already satisfying the technical and usability requirements. **High utilisation**
Critical gaps related to relevant user needs
Guideline gap UN18: Need to monitor crop productivity

P06: Milk and cattle (in weight) productivity estimation
Maturity score
Mean: 1.9 | **STD:** 0.64
Constraints and limitations • Cloud presence • Lack of historical milk and cattle (in weight) productivity data to train the models
Relevant user needs UN9: Understanding stock levels and monitoring supply chains.
R&D gaps • Livestock can be stored in livestock barns and fodder can be imported. The proposed correlation is tricky. • The data exchange between the user and the EO provider. • Data and correlation vary a lot between countries and regions

Potential improvements drivers • More forums on this issue • Investigation of the product in different regions
Utilisation level review
Utilisation score
Mean: 2.4 | **STD:** 0.80
No utilisation: **Low utilisation** Unawareness of the existence of commercial EO products with better specifications **Medium utilisation** **High utilisation**
Critical gaps related to relevant user needs

P07: Monitoring reforestation and deforestation activities
Maturity score
Mean: 2.9 | **STD:** 0.26
Constraints and limitations • Cloud presence • By using medium-resolution imagery for large forests, distinguishing reforestation, or deforestation activities from other land uses, such as agriculture or natural disturbances, can be challenging due to similar visual characteristics. • The accuracy of land cover data used for classification can impact the precision of change detection results. • Changes in vegetation cover due to natural seasonal cycles can impact the accuracy of change detection, potentially leading to false positives or negatives.
Relevant user needs UN27: Need to assess historical trends and baseline of natural assets. UN28: Need to classify the types of crops being grown to assess the sustainability and environmental impact of agricultural investments. UN30: Need for monitoring with accurate measurements the of growth and health of trees. UN39: Need to assess the potential impact of business activities or investments on ecosystems and biodiversity.
R&D gaps

The product highly responds to the user's needs
Potential improvements drivers No crucial improvements were provided as it highly responds to the user's needs
Utilisation level review
Utilisation score
Mean: 3.00 | **STD:** 0.82
No utilisation: **Low utilisation** lack of company and portfolio-specific data to do very robust assessments. However, at a project level, it makes sense, as it is highly used. **Medium utilisation** Unawareness of the existence of the best available commercial EO product with better specifications **High utilisation** Only this product satisfies the technical and usability requirements
Critical gaps related to relevant user needs
Guideline gap UN39: Need to assess the potential impact of business activities or investments on ecosystems and biodiversity

P08: Trees counting	
Maturity score	
Mean: 2.4	**STD:** 0.70
Constraints and limitations • Cloud presence • Machine learning model uncertainty	
Relevant user needs UN31: Need to link tree planting parcels to estimate the number of trees planted.	
R&D gaps • Cost of Very High Resolution (VHR) satellite imagery which is essential for the product. • Global inconsistency due to the diversity of tree species. • Limitations in homogeneous forests where the trees are connected to each other. • The lack of local in-situ data to train and validate the models. • Lack of spectral resolution to differentiate between tree species	

Potential improvements drivers • Advances in AI models to detect and count individual trees. • Datasets for training and validating the models. • Price models for commercial EO data. • Fusion of hyperspectral and multispectral EO data.
Utilisation level review
Utilisation score
Mean: 2.14 | **STD:** 0.64
No utilisation: Unawareness of the existence of this EO product **Low utilisation** • Higher cost of using the commercial EO product. • The current method (manually counting for a sample area and multiplying up to estimate the whole area) is considered good enough in terms of accuracy, reliability, and price. • Ground truth data is not sufficient for counting individual trees. **Medium utilisation** • Unawareness of the existence of the best available commercial EO product with better specifications. • Higher cost of using the best available commercial EO product . **High utilisation**
Critical gaps related to relevant user needs
Utilisation gap UN31: Need to link tree planting parcels to estimate the number of trees planted

P09: Building inventory
Maturity score
Mean: 2.6 | **STD:** 0.64
Constraints and limitations • Cloud presence • Urban areas across the world can have different building styles, densities, and layouts, which can make creating universally applicable methods challenging. • Tall buildings or structures can cast shadows making it challenging to accurately identify their characteristics, and occlusion might hinder the detection of buildings behind vegetation or other structures.

Relevant user needs
UN47: Need up-to-date geospatial data on residential and industrial infrastructures locations
R&D gaps • Cost of VHR satellite imagery which is essential for the product. • Generality of the models used in one region to another. • Using satellite imagery for building inventory might raise legal and privacy concerns, especially when dealing with sensitive areas or personal property.
Potential improvements drivers • Provide more training data for different regions of the world with different building characteristics. • Price models for commercial EO data.
Utilisation level review
Utilisation score
Mean: 2.14 | **STD:** 0.64
No utilisation: • Unavailability of freely available sources of the EO product. • Not aware of any product from which this could be extracted directly. **Low utilisation** • Higher cost of using the commercial EO product. • The current method (manually counting for a sample area and multiplying up to estimate the whole area) is considered good enough in terms of accuracy, reliability, and price. • Ground truth data is not sufficient for counting individual trees. **Medium utilisation** The product already satisfies the technical and usability requirements. **High utilisation**
Critical gaps related to relevant user needs
Utilisation gap UN47: Need up-to-date geospatial data on residential and industrial infrastructures locations.

P10: Mapping travel times to assets
Maturity score
Mean: 3.00 | **STD:** 0.00
Constraints and limitations

• The product is static and may not account for dynamic factors like traffic congestion, seasonal changes, or road closures, which can impact travel times. • The product represents the travel time of using motorized means without considering the type of vehicle.
Relevant user needs UN47: Need up-to-date geospatial data on residential and industrial infrastructures' locations
R&D gaps • The relatively coarse spatial resolution (~ 1 km)
Potential improvements drivers Provide more global friction maps with higher spatial resolution. These maps are used to generate the travel time maps.
Utilisation level review
Utilisation score
Mean: 2.14 | **STD:** 0.64
No utilisation: • Unawareness of the existence of this EO product • Uncertainty of the need for this product **Low utilisation** • Unawareness of the existence of commercial EO products with better specifications There is a high utilisation of Global Friction Surface which is an open-access map produced through a collaboration between the Malaria Atlas Project (MAP) (University of Oxford), Telethon Kids Institute (Perth, Australia), Google, and the University of Twente, Netherlands. **Medium utilisation** **High utilisation**
Critical gaps related to relevant user needs
Guideline gap UN11: Realistic assessment of accessibility to assets

P11: WorldPop – Population Counts
Maturity score
Mean: 3.2 | **STD:** 0.90
Constraints and limitations

• WorldPop data is available at a relatively high spatial resolution (often 100 meters) and is dynamic from 2000 to 2020. However, for some applications, even higher resolution and more recent data may be required.
Relevant user needs UN10: Need to understand population density when making investment decisions. UN57: Automatically update changes in population density estimates based on observable land use changes
R&D gaps • The accuracy of population estimates relies on multiple factors, including the quality of input data, the assumptions made in modelling, and validation against ground truth data. Errors can occur, especially in areas with limited ground data for validation. • There can be a lag between the actual population changes and the availability of updated WorldPop data, as it is not real-time information. However, this can be overcome by calculating the maps by an EO provider with the same methodology as WorldPop.
Potential improvements drivers More validation is required to make the data more robust
Utilisation level review
Utilisation score

Mean: 3.00	**STD:** 0.89

No utilisation: **Low utilisation** • The product is already satisfying the technical and usability requirements. • Unawareness of the existence of commercial EO products with better specifications. This product is being used by the insurance sector to assess vulnerability to physical risks and potential costs. **Medium utilisation** **High utilisation**
Critical gaps related to relevant user needs
Guideline gap UN57: Automatically update changes in population density estimates based on observable land use changes.

P12: Monitoring Solar Panel Installations	
Maturity score	
Mean: 2.00	**STD:** 0.82

Constraints and limitations • Cloud presence. • Panels integrated into complex rooftop configurations can be harder to identify due to varying angles and orientations.
Relevant user needs UN37: Projection of risk to portfolio assets into the future.
R&D gaps • The availability and size of solar panels dataset to train the deep learning model. • Higher costs as balancing higher spatial resolution (to detect small panels) with broader coverage (to monitor larger installations) can be challenging due to cost constraints. • The resolution of thermal sensors is insufficient at the solar panel level. • Price models for commercial EO data.
Potential improvements drivers • Provide more training datasets. • Higher-resolution thermal sensors.
Utilisation level review
Utilisation score
Mean: 3.00 | **STD:** 0.89
No utilisation Unawareness of the existence of this EO product. **Low utilisation** **Medium utilisation** Unawareness of the existence of the best available commercial EO product with better specifications. **High utilisation**
Critical gaps related to relevant user needs

P13: Monitoring Changes in Port Activity Patterns
Maturity score
Mean: 2.4 | **STD:** 0.66
Constraints and limitations • Cloud presence near large water bodies

• No observation at night • Cost of VHR satellite imagery
Relevant user needs UN37: Projection of risk to portfolio assets into the future.
R&D gaps • Limited available labelled data of port activities. • Temporal resolution and cloud presence of the satellite data can limit the frequency of monitoring and timely detection of rapid changes in port activities. • Discerning fine-scale details of port activities. • Limited nighttime observations
Potential improvements drivers • More frequent VHR optical satellite imagery. • More investigation of the use of VHR Synthetic Aperture Radar (SAR) imagery. • Fusion, with in-situ sensors, long time series of data to model the specificities of the location, combination of optical sensors, hyperspectral, and SAR, but they need to be acquired at the same time. • Provide more labelled data on port activities. • VHR nighttime light observation.
Utilisation level review
Utilisation score
Mean: 2.33 | **STD:** 0.94
No utilisation **Low utilisation** Unawareness of the existence of commercial EO products with better specifications. **Medium utilisation** **High utilisation** High importance and relatively accurate versus comparable methods of gathering this type of information.
Critical gaps related to relevant user needs

P14: Stock changes in oil tanks with floating roof	
Maturity score	
Mean: 2.5	**STD:** 0.50

Constraints and limitations
• While VHR imagery provides detailed views, there might still be limitations in identifying very small details. • The product is only limited to oil tanks with floating roofs. • Cost of time series of VHR images.
Relevant user needs
UN9: Understanding stock levels and monitoring supply chains
R&D gaps
• Few commercial missions with VHR SAR satellite imagery as this product is preferable to be developed using SAR image to provide data day for all weather conditions.
Potential improvements drivers
• More VHR SAR constellations • Price models for commercial EO data
Utilisation level review
Utilisation score

Mean: 2.83	**STD:** 1.07

No utilisation
Unawareness of the existence of this EO product.
Low utilisation
Medium utilisation
Unawareness of the existence of the best available commercial EO product with better specifications.
High utilisation
Some financial organizations already purchase this EO product and use the data in their modelling of prices for trading
Critical gaps related to relevant user needs

P15: Lithology and surficial geology mapping	
Maturity score	
Mean: 3.00	**STD:** 0.00
Constraints and limitations	
• Cloud presence.	

• Mapping lithology is most effective in arid and semi-arid regions. It becomes more difficult and less accurate in temperate and tropical areas where weathering is extensive, and dense vegetation cover is prevalent. • The product relies on reference data. • Machine learning model uncertainty.
Relevant user needs UN9: Understanding stock levels and monitoring supply chains.
R&D gaps • Limited training data. • Limited spectral bands of currently available EO data.
Potential improvements drivers • Using Hyperspectral data (there are upcoming missions). • More training datasets
Utilisation level review
Utilisation score
Mean: 2.00 | **STD:** 0.00
No utilisation **Low utilisation** • Unawareness of the existence of commercial EO products with better specifications • The product is already satisfying the technical and usability requirements. **Medium utilisation** **High utilisation**
Critical gaps related to relevant user needs
Utilisation gap UN9: Understanding stock levels and monitoring supply chains

P16: Predicting terrorism hotspots
Maturity score
Mean: 1.70 | **STD:** 0.70
Constraints and limitations • The complexity of terrorism which related to plenty and complex factors. • Some of the factors are not directly correlated with terroristic activity which may lead to false predictions.

Relevant user needs
UN12: Analysis of potential risks in specific regions. UN37: Projection of risk to portfolio assets into the future.
R&D gaps • Cloud presence for nighttime light data. • Much of the data is paid for security information for supply-chain businesses.
Potential improvements drivers • The product needs to be validated for many use cases.
Utilisation level review
Utilisation score
Mean: 2.50 | **STD:** 1.12
No utilisation Unawareness of the existence of this EO product. **Low utilisation** Higher cost of using the commercial EO product. **Medium utilisation** • The product is already satisfying the technical and usability requirements. • Unawareness of the existence of commercial EO products with better specifications **High utilisation** Primary government, security, and growing large population or urban police usage.
Critical gaps related to relevant user needs

P17: Land Cover Maps
Maturity score
Mean: 3.00 | **STD:** 0.00
Constraints and limitations • Missing information on seasonal variability. • In some cases, pixels may represent a mix of multiple land cover classes.
Relevant user needs UN11: Realistic assessment of accessibility to assets. UN27: Need to assess historical trends and baseline of natural assets.

UN38: Need for trustworthy time series of reliable data on assets. UN39: Need to assess the potential impact of business activities or investments on ecosystems and biodiversity. UN40: Need to monitor the risk of sea level rise threatening coastal property, infrastructure, and supply chains. UN43: Need to monitor changing precipitation patterns and flood risk in the vicinity of vulnerable assets.
R&D gaps The product is highly responsive to UNS.
Potential improvements drivers No crucial improvements were provided as it highly responds to the user's needs
Utilisation level review
Utilisation score
Mean: 2.86 | **STD:** 0.64
No utilisation **Low utilisation** • The product is already satisfying the technical and usability requirements. • The product is already being used by sovereign bond investors. Also, sectors such as asset management may be interested in using these maps in combination with asset-level data, but as they are already limited on the asset-level data (incompleteness, inaccurate locations), trying to do a detailed analysis wouldn't add much value. **Medium utilisation** • Greater knowledge about the capability of the product. • Higher cost of using the best available commercial EO product. The existing stock of maps and mapping tools (including LiDAR and other aerial photography) is considered good enough in many cases. Organizations may lack the budget to motivate using this EO product to replace these existing resources and methods. **High utilisation**
Critical gaps related to relevant user needs
Guideline gap UN11: Realistic assessment of accessibility to assets UN27: Need to assess historical trends and baseline of natural assets. **Utilisation gap** UN38: Need for trustworthy time series of reliable data on assets.

P18: Crop health (diseases and pests detection)	
Maturity score	
Mean: 2.6	**STD:** 0.49

Constraints and limitations

- Cloud presence
- Challenges in fields with mixed land cover (multiple crops, bare soil, vegetation)
- Depending on the crop/plant/disease, the accuracy can be very low, but sufficient for some use cases

Relevant user needs

UN30: Need for monitoring with accurate measurements of the growth and health of trees.

UN37: Projection of risk to portfolio assets into the future.

UN55: Detecting crop damage at the level of individual farms/fields.

R&D gaps

- Lacking the ability to differentiate specific disease types due to limited spectral discrimination.
- Temporal coverage of the data from existing sensors at a high enough spatial resolution.
- Similar spectral characteristics between pest damage and other vegetation stress factors require additional in-situ data.
- Limitations in predictive analytics
- When it comes to vegetation diseases, the biggest limitation in setting up an EO service is the lack of field data to validate it.
- Lack of matureness of EO needs from stakeholders. Not clear to them what can be demanded or expected.
- Inertia in using traditionally established analysis products, which mostly require human supervision. Greater credibility to human reports than to automatic remote monitoring.

Potential improvements drivers

- Increased efforts in downscaling current sensor data to provide the necessary temporal coverage.
- Additional in-situ data to calculate/validate the product in each region where it is needed.
- Capacity building: workshops, meetings, more information about what EO can provide.
- Improvements in models for predictive analytics.
- Hyperspectral sensors to differentiate between different types of diseases.

Utilisation level review	
Utilisation score	
Mean: 2.20	**STD:** 0.75

No utilisation

Low utilisation

- Unawareness of the existence of commercial EO products with better specifications

• Lack of knowledge of executives and low-risk tolerance. **Medium utilisation** • Unawareness of the existence of the best available commercial EO product with better specifications **High utilisation**
Critical gaps related to relevant user needs
Guideline gap UN30: Need for monitoring with accurate measurement of the growth and health of trees. UN37: Projection of risk to portfolio assets into the future. **Utilisation gap** UN55: Detecting crop damage at the level of individual farms/fields

P19: Vegetation height estimation	
Maturity score	
Mean: 2.5	**STD:** 0.65
Constraints and limitations • Cloud presence • High cost of VHR satellite imagery • The machine learning models are limited to regions with similar vegetation characteristics where it was trained. • Uncertainty related to machine learning models	
Relevant user needs UN37: Projection of risk to portfolio assets into the future.	
R&D gaps • Lack of time series ground truth data (Light Detection and Ranging (LIDAR))	
Potential improvements drivers • Provide training datasets for different vegetation types over different regions in the world	
Utilisation level review	
Utilisation score	
Mean: 2.40	**STD:** 0.49
No utilisation **Low utilisation** • The use of the Global Ecosystem Dynamics Investigation (GEDI) sensor to assess carbon capture in standing/planted forests which are part of an offset mechanism.	

• Unawareness of the existence of commercial EO products with better specifications **Medium utilisation** Higher cost of using the best available commercial EO product **High utilisation**
Critical gaps related to relevant user needs
Guideline gap UN37: Projection of risk to portfolio assets into the future

P20: Nighttime light monitoring	
Maturity score	
Mean: 2.5	**STD:** 0.66
Constraints and limitations • Cloud presence • Natural light sources like moonlight can interfere with the detection of artificial nighttime light. • May not be sensitive enough to detect low-intensity light sources accurately, which can lead to underestimation of nighttime light in less densely populated areas.	
Relevant user needs UN37: Projection of risk to portfolio assets into the future.	
R&D gaps • The lower spatial resolution of the products	
Potential improvements drivers • New missions with higher spatial resolution	
Utilisation level review	
Utilisation score	
Mean: 2.68	**STD:** 1.12
No utilisation Unawareness of the existence of this EO product **Low utilisation** • The product is already satisfying the technical and usability requirements. • Unawareness of the existence of commercial EO products with better specifications, Awareness of its use as a proxy for economic activity. Would be good for the FM community to check if it has other use cases within the industry.	

Medium utilisation **High utilisation**
Critical gaps related to relevant user needs

P21: Drought monitoring at the assets level	
Maturity score	
Mean: 2.6	**STD:** 0.62
Constraints and limitations • Cloud presence to calculate vegetation indices. • The impact on assets for drought is complex as the spatial and temporal scales of the events are different.	
Relevant user needs UN12: Analysis of potential risks in specific regions. UN13: Need to geo-map clients. UN14: Need to screen the feasibility of projects against different hazard criteria. UN37: Projection of risk to portfolio assets into the future. UN42: Need to monitor the impact of droughts on assets.	
R&D gaps • Low spatial resolution of climate data • In some specific cases, the data comes later than needed (limitations in latency) • Limitations in the availability of adequate stream flow and groundwater data which are the inputs to calculate the indicators of hydrological drought. • Lack of validation due to the lack of in-situ data	
Potential improvements drivers • Additional data on vulnerability and exposure of assets is required to evaluate the impacts of some perils/hazards. • Higher spatial and temporal resolution of EO input data	
Utilisation level review	
Utilisation score	

Mean: 2.71	**STD:** 0.70

No utilisation

Low utilisation

- Higher cost of using the commercial EO product.
- Unawareness of the existence of commercial EO products with better specifications.
- The complexity of monitoring the steps of the hydrological cycle using only EO.

Medium utilisation

- Unawareness of the existence of the best available commercial EO product with better specifications .
- Variability of the product by location.

High utilisation

Critical gaps related to relevant user needs

Guideline gap

UN37: Projection of risk to portfolio assets into the future.

UN42: Need to monitor the impact of droughts on assets.

P22: Post wildfires monitoring (area and severity)

Maturity score

Mean: 2.8	**STD:** 0.37

Constraints and limitations

- Availability of pre and post-fire event images due to cloud presence.
- Smoke and haze from wildfires can affect the quality of satellite images.

Relevant user needs

UN45: Need to measure the area affected by wildfires after the fact.

UN46: Need to measure the intensity of wildfires (level of damage to assets).

R&D gaps

- Lack of VHR imagery that has Short Wave Infrared (SWIR) bands, which are necessary to calculate the Normalized Burn Ratio (NBR) that is being used to calculate the area and severity of wildfires.
- Limitations in monitoring fire spread as quickly as required.

Potential improvements drivers

- Missions for real-time monitoring of the behaviour of wildfires.

Utilisation level review

Utilisation score	
Mean: 3.00	**STD:** 0.82

No utilisation

Low utilisation

- Higher cost of using the commercial EO product
- The product already satisfies the technical and usability requirements.

Medium utilisation

- Unawareness of the existence of the best available commercial EO product with better specifications.
- Ground-truth data is still considered a vital component alongside EO / geoinformation inputs.

High utilisation

Only this product satisfies the technical and usability requirements.

Critical gaps related to relevant user needs

Guideline gap

UN45: Need to measure the area affected by wildfires after the fact.

UN46: Need to measure the intensity of wildfires (level of damage to assets).

P23: Wildfire danger forecasting (Global Wildfire Information System (GWIS))	
Maturity score	
Mean: 2.5	**STD:** 0.63

Constraints and limitations

- The vegetation state which is the main indicator of fuel type is not used for the Fire Weather Index Rating System (FWI), so this index lacks such important information for forest fire forecasting.
- Fuel conditions used for the Ignition Component (IC) and the Fire Danger Index (FDI) have been provided in a mean climatological way and might not be accurate enough.
- For fire danger, it is necessary to handle human behaviour data.
- The many factors approaching fire danger/risk are not universally interpreted in the same way.

Relevant user needs

UN12: analysis of potential risks in specific regions.

UN13: need to geo-map clients.

UN14: need to screen the feasibility of projects against different hazards criteria.

UN44: need to measure the area vulnerable to wildfires before events.

R&D gaps • Low spatial resolution (8km) • Only up to 10 days of forecasting.
Potential improvements drivers New products with higher resolution and long forecasting
Utilisation level review
Utilisation score
Mean: 2.71 | **STD:** 0.70
No utilisation **Low utilisation** • The product is already satisfying the technical and usability requirements. **Medium utilisation** • Unawareness of the existence of the best available commercial EO product with better specifications. Higher use in developed, and low in emerging countries. **High utilisation**
Critical gaps related to relevant user needs

P24: Identification of flood hazard areas
Maturity score
Mean: 2.7 | **STD:** 0.61
Constraints and limitations • False positives from the changes on the land surface, not caused by flooding. • Difficulties in detecting floods in urban or densely vegetated areas. • False positives caused by differences in relative orbits of Sentinel-1 • Complex in areas of local hydrology • Limitations in detecting water under vegetation, • Discrimination of "Artificial flooding" from irrigated fields (E.g. rice paddy fields).
Relevant user needs UN12: Analysis of potential risks in specific regions. UN13: Need to geo-map clients. UN14: Need to screen the feasibility of projects against different hazard criteria. UN37: Projection of risk to portfolio assets into the future.

UN43: Need to monitor changing precipitation patterns and flood risk in the vicinity of vulnerable assets.
R&D gaps • Limitations of revisit time-frequency (potentially missing flood events or max flood peak) • Unavailability of global high-resolution DEM
Potential improvements drivers • More revisit time of SAR data. • Additional data on vulnerability and exposure is required to evaluate the impacts of some perils/hazards. • Global high-resolution DEM.
Utilisation level review
Utilisation score
Mean: 3.13 | **STD:** 0.60
No utilisation **Low utilisation** **Medium utilisation** • The product is already satisfying the technical and usability requirements. • Lack of a single database, costs, and the need may not be as crucial in some sectors like the asset management space (different story for insurance, and re-insurance companies which need this product) • Efforts to use this EO product more are ongoing in academic literature. Higher utilisation is blocked because of a lack of data to combine with this EO product - e.g., the boundary locations of assets, buildings, and other properties. **High utilisation**
Critical gaps related to relevant user needs
Guideline gap UN37: Projection of risk to portfolio assets into the future.

P25: Identification of trends related to shifts in rainfall patterns
Maturity score
Mean: 2.4 | **STD:** 0.70
Constraints and limitations • Uncertainties related to precipitation estimation of the products due to the sensors, or the methodology of calculation the amount of precipitation. • Lack of in-situ data to evaluate the products.
Relevant user needs

UN12: Analysis of potential risks in specific regions. UN13: Need to geo-map clients. UN14: Need to screen the feasibility of projects against different hazard criteria. UN43: Need to monitor changing precipitation patterns and flood risk in the **v**icinity of vulnerable assets.
R&D gaps • Low spatial resolutions of the precipitation products. • Vulnerability assessment of assets is missing
Potential improvements drivers • Climate trends of rainfall are available. Work on displaying and quantifying movements from those trends over time is something that could possibly be developed based on the categorization of annual rainfall seasons. • New precipitation products with higher spatial resolution • Additional data on vulnerability and exposure is required to evaluate the impacts
Utilisation level review
Utilisation score
Mean: 2.60 | **STD:** 1.02
No utilisation • Users' lack of EO knowledge and skills to utilize the EO product. • Unawareness of the existence of this EO product. **Low utilisation** • Unawareness of the existence of commercial EO products with better specifications. • Do not have proper skills and knowledge internally. **Medium utilisation** • Higher cost of using the best available commercial EO product. • The product is already satisfying the technical and usability requirements. **High utilisation**
Critical gaps related to relevant user needs

P26: GHG emissions monitoring
Maturity score
Mean: 2.3 | **STD:** 0.78
Constraints and limitations • Cloud presence

- Distinguishing between anthropogenic (human-caused) GHG emissions and natural sources (e.g., wetlands, volcanic activity) can be complex

Relevant user needs

UN15: Need to monitor the carbon intensity of portfolio assets.

UN26: Need to monitor GHG emissions of projects funded.

R&D gaps

- Satellite sensors may have limitations in spatial resolution, making it challenging to capture emissions from small sources or accurately distinguish between localized emissions and background levels.
- Vertical sensitivity as satellite measurements generally provides information on total column concentrations of GHGs. While this is useful for many applications, it may not provide a complete understanding of vertical distributions, which are essential for certain scientific studies and policy decisions.
- Current missions are not capable of monitoring emission points.
- The monitoring system in place does not answer the possibility of assessing the GHG emitted or C intensity of the funded projects.

Potential improvements drivers

- Complementary use of commercial datasets to derive GHG emissions.
- New missions are required to capture GHG emissions at a project level.
- Improved monitoring capabilities for reliable observations over emission points at high spatial resolution
- Longer archive

Utilisation level review

Utilisation score

Mean: 2.33	**STD:** 0.94

No utilisation

- Users' lack of EO knowledge and skills to utilize the EO product.

Low utilisation

- Unawareness of the existence of commercial EO products with better specifications
- Higher cost of using the commercial EO product
- Only aware of its use as a proxy of macro-economic indicators. There were trials of using it to track emissions of specific assets, but it was difficult to reconcile the results against the reference estimations.

Medium utilisation

- This EO product is still being refined so utilisation is not high yet.

High utilisation

Critical gaps related to relevant user needs

R&D gap

UN15: Need to monitor carbon intensity of portfolio assets.

UN26: Need to monitor GHG emissions of projects funded.

P27: Estimation of above-ground carbon stocks in forests	
Maturity score	
Mean: 2.4	**STD:** 0.64

Constraints and limitations

- Cloud presence
- Satellite data might not provide direct measurements of biomass, requiring the use of models and assumptions that can introduce uncertainties.
- Rely on reference data

Relevant user needs

UN30: Need for monitoring with accurate measurements the growth and health of trees.

UN32: Need to periodically estimate the growth of above-ground carbon stocks (in forests).

R&D gaps

- Lack of ground truth data about tree height and structures obtained from filed work or LIDAR.
- In-situ data is very important for accurate estimations, especially, with certain sensors that reach saturation.

Potential improvements drivers

- Training datasets of tree inventory
- Missions provide biomass directly

Utilisation level review

Utilisation score

Mean: 2.29	**STD:** 0.88

No utilisation

- Users' lack of EO knowledge and skills to utilize the EO product.
- Unawareness of the existence of this EO product

Low utilisation

- Unawareness of the existence of commercial EO products with better specifications
- Higher cost of using the commercial EO product
- Only aware of its use as a proxy of macro-economic indicators. There were trials of using it to track emissions of specific assets, but it was difficult to reconcile the results against the reference estimations .

Medium utilisation

- Higher cost of using the best available commercial EO product.
- Most data providers used by financial institutions seem to rely on open EO data .
- Unawareness of the existence of the best available commercial EO product with better specifications.

High utilisation

Critical gaps related to relevant user needs

Utilisation gap
UN30: Need for monitoring with accurate measurements the growth and health of trees.
UN32: Need to periodically estimate the growth of above-ground carbon stocks (in forests).

P28: Impact of increased temperatures on soil moisture and vegetation condition	
Maturity score	
Mean: 2.3	**STD:** 0.75
Constraints and limitations • Cloud presence • Ground truth data is important for validation purposes	
Relevant user needs UN41: Need to monitor the impact of increased temperatures on assets.	
R&D gaps • The low spatial resolution of products for temperature and soil moisture • Lack of long multitemporal EO series	
Potential improvements drivers • Higher spatial and temporal resolutions EO data for temperature and soil moisture data • More validation of the product is required	
Utilisation level review	
Utilisation score	
Mean: 2.20	**STD:** 0.75
No utilisation • Unawareness of the existence of this EO product **Low utilisation** • Unawareness of the existence of commercial EO products with better specifications • estimations **Medium utilisation** • Unawareness of the existence of the best available commercial EO product with better specifications. **High utilisation**	
Critical gaps related to relevant user needs	
Guideline gap UN41: Need to monitor the impact of increased temperatures on assets	

P29: Heat hazard maps	
Maturity score	
Mean: 2.6	**STD:** 0.80
Constraints and limitations • Cloud presence • Land Surface Temperature (LST) data can be influenced by atmospheric conditions, such as clouds, aerosols, and water vapour. These factors can introduce inaccuracies in temperature measurements, especially in cloudy regions.	
Relevant user needs UN12: Analysis of potential risks in specific regions. UN14: Need to screen the feasibility of projects against different hazard criteria. UN41: Need to monitor the impact of increased temperatures on assets.	
R&D gaps • The unavailability of higher spatial resolution thermal sensors with high revisit frequency.	
Potential improvements drivers • New missions with high spatial and temporal resolutions of the thermal sensor	
Utilisation level review	
Utilisation score	
Mean: 2.80	**STD:** 0.98
No utilisation • Unawareness of the existence of this EO product. **Low utilisation** **Medium utilisation** • Higher cost of using the best available commercial EO product, • Unawareness of the existence of the best available commercial EO product with better specifications. **High utilisation**	
Critical gaps related to relevant user needs	
Guideline gap UN41: Need to monitor the impact of increased temperatures on assets	

P30: Satellite-derived bathymetry for port and coastal monitoring	
Maturity score	
Mean: 2.2	**STD:** 0.40
Constraints and limitations • Cloud presence • Proximity with effluents can make the task more complex. • Limited to estimate water depth up to max 20 m	
Relevant user needs UN12: Analysis of potential risks in specific regions.	
R&D gaps • Lack of local in-situ data like LIDAR or Echo-Sounder data • The optical-based products depend on the turbidity and the specificities of the location, meaning that worldwide coverage is difficult.	
Potential improvements drivers • Fusion, with in-situ sensors, long time series of data to model the specificities of the location, combination with other satellite sensors, hyperspectral, SAR, but they need to be acquired at exactly the same time!	
Utilisation level review	
Utilisation score	
Mean: 2.50	**STD:** 0.87
No utilisation **Low utilisation** • Higher cost of using the commercial EO product. • Unawareness of the existence of commercial EO products with better specifications. **Medium utilisation** **High utilisation** • High importance and relatively accurate versus comparable methods of gathering this type of information.	
Critical gaps related to relevant user needs	
Utilisation gap UN12: Analysis of potential risks in specific regions	

P31: Coastal erosion	
Maturity score	
Mean: 2.6	**STD:** 0.64

Constraints and limitations

- Cloud presence
- Variability in sea level due to tides, storm surges, and other factors can introduce noise and uncertainty in detecting shoreline shifts.
- Subpixel changes in shoreline positions might be challenging to detect and measure accurately, impacting erosion rate calculations.

Relevant user needs

UN12: Analysis of potential risks in specific regions.

UN14: Need to screen the feasibility of projects against different hazard criteria.

UN37: Projection of risk to portfolio assets into the future.

UN40: Need to monitor the risk of sea level rise threatening coastal property, infrastructure, and supply chains.

R&D gaps

- Limitation of high spatial and temporal resolution historical satellite imagery.

Potential improvements drivers

- Global data of shoreline change rate

Utilisation level review	
Utilisation score	
Mean: 2.17	**STD:** 1.07

No utilisation

- Unavailability of freely available sources of the EO product.
- Unacceptable reliability and accuracy of the EO product.

Low utilisation

- Unawareness of the existence of commercial EO products with better specifications.

Medium utilisation

- Unawareness of the existence of the best available commercial EO product with better specifications.

High utilisation

Critical gaps related to relevant user needs

Guideline gap

UN37: Projection of risk to portfolio assets into the future.

Utilisation gap

UN12: Analysis of potential risks in specific regions

UN14: Need to screen the feasibility of projects against different hazard criteria. UN40: Need to monitor the risk of sea level rise threatening coastal property, infrastructure, and supply chains

P32: Fish stock assessment	
Maturity score	
Mean: 2.00	**STD:** 0.00
Constraints and limitations • Cloud presence • It is more an assessment of the probability of finding some fish than a stock assessment. • EO data primarily focuses on the sea surface, which may not provide information about fish species that inhabit deeper waters. • The data may not distinguish between mixed species.	
Relevant user needs UN9: Understanding stock levels and monitoring supply chains	
R&D gaps • Lack of training datasets as companies will not share the information of fish stock's locations due to its commercial sensitivity.	
Potential improvements drivers • Privacy Enhancement Technologies can help to overcome the barriers, to training better models.	
Utilisation level review	
Utilisation score	
Mean: 1.4	**STD:** 0.49
No utilisation • Unavailability of freely available sources of the EO product. • Unacceptable reliability and accuracy of the EO product. • Unawareness of the existence of this EO product. • Understand fishing locations have not been pointed out as interest in the finance sector. **Low utilisation** **Medium utilisation** **High utilisation**	
Critical gaps related to relevant user needs	
Guideline gap	

P33: Oil spill detection	
Maturity score	
Mean: 3.00	**STD:** 0.00

Constraints and limitations

- Radar detection of oil is difficult in low or high-wind areas. Due to the low difference between backscattering between oil and surrounding water in low wind conditions, and the strong backscatter of water's surface in high wind conditions overwhelming the weak signals from the oil spill.
- Thin oil films may not produce strong enough signals to be easily distinguishable from the surrounding water.
- SAR may have limitations in detecting small or localized oil spills, especially when the slick size is below the resolution capability of the radar.

Relevant user needs

UN39: Need to assess the potential impact of business activities or investments on ecosystems and biodiversity.

R&D gaps

- The product focuses on detection, not impacts.

Potential improvements drivers

- More investigation of the effect of oil spills on the blue ecosystem.

Utilisation level review	
Utilisation score	
Mean: 2.25	**STD:** 0.83

No utilisation

Low utilisation

Medium utilisation

- Tasking time and refresh rate make identifying and live tracking more difficult than it would be from e.g., drones. Only useful for remote areas or where good EO coverage is already possible.

High utilisation

Critical gaps related to relevant user needs

Guideline gap

UN39: Need to assess the potential impact of business activities or investments on ecosystems and biodiversity.

P34: Ship detection and categorization	
Maturity score	
Mean: 2.7	**STD:** 0.47

Constraints and limitations

- Smaller vessels and low-profile ships may be challenging to detect or classify.
- Cloud presence but it can be overcome by using SAR imagery.
- Challenging to separate individual vessels in overcrowded ports or regions with high maritime traffic.

Relevant user needs

UN17: Need near real-time tracking of marine vessels to understand their routes and estimate fuel usage

R&D gaps

- High cost of VHR satellite imagery
- For near-real time, Automatic Identification System (AIS) data is needed. EO is a complement to permit detecting unreported ships, but real-time tracking is not possible yet with the current technology

Potential improvements drivers

- Price models
- More investigation of fusing EO with AIS data

Utilisation level review	
Utilisation score	
Mean: 2.00	**STD:** 1.26

No utilisation

- Unavailability of freely available sources of the EO product.
- Unacceptable reliability and accuracy of the EO product.
- Users' lack of EO knowledge and skills to utilize the EO product.
- Unawareness of the existence of this EO product.

Low utilisation

Medium utilisation

- We would not state full technical and usability requirements are met. This remains viable depending on the financial offer and use case.

High utilisation

- Only this product satisfies the technical and usability requirements.

Critical gaps related to relevant user needs

Utilisation gap

UN17: Need near real-time tracking of marine vessels to understand their routes and estimate fuel usage.

P35: Monitor slow-moving subsidence	
Maturity score	
Mean: 2.5	**STD:** 0.66

Constraints and limitations

- In areas with varied topography and dense vegetation cover, analysing subsidence can be challenging due to the influence of terrain on measurements.
- Local factors like soil composition, water table fluctuations, and geologic conditions can influence subsidence rates, leading to complexities in interpretation.

Relevant user needs

UN37: Projection of risk to portfolio assets into the future.

R&D gaps

- Not cost-effective as needs very detailed height data and an understanding of subsidence risks

Potential improvements drivers

- Develop automated algorithms and systems for the detection of slow-moving subsidence. These algorithms can process large datasets quickly and provide real-time or near-real-time alerts to users when subsidence is detected, enabling prompt responses.
- Provide tools and services for long-term trend analysis, enabling users to assess subsidence patterns over extended periods.

Utilisation level review	
Utilisation score	
Mean: 2.00	**STD:** 0.82

No utilisation

- Unawareness of the existence of this EO product

Low utilisation

Medium utilisation

- Higher cost of using the best available commercial EO product.

High utilisation

Critical gaps related to relevant user needs

Guideline gap

UN37: Projection of risk to portfolio assets into the future.

P36: Monitoring highway and railway networks	
Maturity score	
Mean: 2.5	**STD:** 0.66
Constraints and limitations • SAR signals have limited penetration through certain materials, which can obstruct the measurements of ground movement beneath these surfaces.	
Relevant user needs UN37: Projection of risk to portfolio assets into the future.	
R&D gaps • Not cost-effective as need very detailed height data and an understanding of subsidence risks	
Potential improvements drivers • Develop automated algorithms and systems for the detection of any subsidence. These algorithms can process large datasets quickly and provide real-time or near-real-time alerts to users when subsidence is detected, enabling prompt responses. • Provide tools and services for long-term trend analysis, enabling users to assess subsidence patterns over extended periods.	
Utilisation level review	
Utilisation score	
Mean: 1.80	**STD:** 0.75
No utilisation • Users' lack of EO knowledge and skills to utilize the EO product. • Unawareness of the existence of this EO product. **Low utilisation** **Medium utilisation** • Higher cost of using the best available commercial EO product. **High utilisation**	
Critical gaps related to relevant user needs	
Guideline gap UN37: Projection of risk to portfolio assets into the future.	

P37: Dams' Safety	
Maturity score	
Mean: 2.4	**STD:** 0.80
Constraints and limitations • SAR signal coherence can be reduced in vegetated areas, making it challenging to monitor dam stability in regions with dense vegetation. • Changes in the dam environment, such as construction activity or vegetation growth can cause temporal decorrelation, reducing the coherence needed for accurate deformation measurement. • SAR data might not capture localized deformation patterns if the area of interest is smaller than the SAR pixel size.	
Relevant user needs UN37: Projection of risk to portfolio assets into the future.	
R&D gaps • High cost of VHR SAR imagery which is necessary to capture small horizontal/vertical displacements.	
Potential improvements drivers • Price models	
Utilisation level review	
Utilisation score	
Mean: 2.5	**STD:** 0.50
No utilisation **Low utilisation** **Medium utilisation** • The product is already satisfying the technical and usability requirements. • Unawareness of the existence of the best available commercial EO product with better specifications. **High utilisation**	
Critical gaps related to relevant user needs	
Guideline gap UN37: Projection of risk to portfolio assets into the future.	

P38: Surveillance of Oil and Gas Pipelines for Geohazard and Ground Subsidence Vulnerabilities	
Maturity score	
Mean: 2.6	**STD:** 0.70

Constraints and limitations

- SAR signal coherence can be reduced in vegetated areas, making it challenging to monitor dam stability in regions with dense vegetation.
- SAR signals have limited penetration through certain materials, which can obstruct the measurements of ground movement beneath these surfaces.

Relevant user needs

UN37: Projection of risk to portfolio assets into the future.

R&D gaps

- Not cost-effective as needs very detailed height data and an understanding of subsidence risks.

Potential improvements drivers

- Develop automated algorithms and systems for the detection of any subsidence. These algorithms can process large datasets quickly and provide real-time or near-real-time alerts to users when subsidence is detected, enabling prompt responses.
- Provide tools and services for long-term trend analysis, enabling users to assess subsidence patterns over extended periods.

Utilisation level review	
Utilisation score	
Mean: 2.25	**STD:** 1.09

No utilisation

- Unawareness of the existence of this EO product.

Low utilisation

Medium utilisation
High utilisation

- Only this product satisfies the technical and usability requirements.

Critical gaps related to relevant user needs

Guideline gap

UN37: Projection of risk to portfolio assets into the future.

7. FUTURE MISSIONS AND THEIR CONTRIBUTION TO FINANCIAL SECTOR'S NEEDS

In this section, we provide information about some of the EO satellite missions that will be launched in the upcoming 5 years. These missions are potentially important and relevant to the FM geo-information requirements. We provided information about nine missions, for each mission, we included a description of the missions, space agency launcher, planned launch date, design end-of-life date, measurement detailed/sensor instruments, spatial resolution, revisit time, and if the data will be open access or commercial. This information can be found in the following paragraphs and Table 10.

After describing each mission, we associate in Table 11 each mission with the relevant consolidated FM needs, along with explanations of how these missions could potentially contribute to addressing these specific requirements.

Biomass

The BIOMASS mission uses a novel P-band synthetic aperture radar to provide comprehensive measurements of global forest biomass. It aims to provide critical data to better understand the distribution, composition, and dynamics of forests worldwide. The mission is poised to significantly enhance our knowledge of how forests contribute to the global carbon cycle and, consequently, aid in climate change mitigation efforts.

Fluorescence Explorer (Flex)

The mission will provide data about the health of global vegetation. This data will be employed to enhance our knowledge of the flow of carbon between plants and the atmosphere, as well as the impact of photosynthesis on carbon and water cycles. Furthermore, this has significance not just in comprehending the worldwide carbon cycle but also in terms of agricultural administration and ensuring food security.

Copernicus Land Surface Temperature Monitoring (LSTM)

LSTM will carry a high spatial-temporal thermal-infrared sensor to deliver observations of land-surface temperature. This mission's primary goal is to address the urgent needs of the agricultural community in enhancing sustainable crop production in a world facing growing water scarcity and climatic fluctuations. It relies on the measurement of land-surface temperature and evapotranspiration to gain crucial insights into and respond to climate variations, optimize water resource management for agriculture, predict droughts, and tackle issues such as land degradation, natural disasters like fires and volcanic eruptions, as well as managing water resources in coastal and inland areas and mitigating urban heat island effects.

Copernicus Hyperspectral Imaging Mission for the Environment (CHIME)

CHIME will be equipped with a unique spectrometer that covers the visible to shortwave infrared range. It will provide regular hyperspectral observations to support improved services for sustainable agricultural practices, biodiversity management, and the characterization of soil properties. The mission will complement Copernicus Sentinel-2, particularly for tasks such as land-cover mapping.

Radar Observing System in L-band (ROSE-L)

ROSE-L's objectives include geohazard monitoring, the tracking of land use, agriculture, and forestry, the provision of high-resolution soil moisture information, and the surveillance of the Arctic and cryosphere. ROSE-L will reinforce the capabilities of current Copernicus C-band SAR systems. Furthermore, it will improve imaging performance in regions densely covered by vegetation, thanks to its longer wavelength L-band radio that can penetrate through the canopy.

Carbon Dioxide Monitoring (CO2M)

The objective is to quantify the amount of carbon dioxide being emitted into the atmosphere, with a specific focus on emissions caused by human activities.

Carbon Mapper

Carbon Mapper aims to offer a comprehensive initiative to assist in understanding and mitigating worldwide emissions of methane and carbon dioxide in our atmosphere. This program will provide 30-meter resolution satellite imagery and tackle the pressing concerns of greenhouse gas emissions and climate change on a global scale. Additionally, Carbon Mapper will supply over 25 other environmental and carbon-related indicators to help address and reduce emissions in both our atmosphere and ecosystems.

NASA Multi-Angle Imager for Aerosols (MAIA):

MAIA provides information about the sizes, compositions, and quantities of particulate matter in air pollution. As a component of the MAIA investigation, scientists will integrate MAIA data with population health records to enhance their understanding of the links between aerosol pollutants and health issues, including negative birth outcomes, cardiovascular and respiratory diseases, and untimely mortality.

NASA-Indian Space Research Organisation (ISRO) Synthetic Aperture Radar (NISAR):

The NISAR satellite is equipped with advanced radar imaging technology that will offer an unprecedented, intricate perspective of Earth. Its purpose is to monitor and collect data on some of the planet's most intricate phenomena, including disruptions in ecosystems, the disintegration of ice sheets, sea level rise, groundwater, and natural hazards such as earthquakes, volcanic activity, coastal sinking, and landslides.

Table 10 Some EO satellite missions that will be launched in the upcoming 5 years.

Mission	Agency	Planned launch date	Designed end-of-life date	Measurement Detailed/Instruments	Spatial resolution	Revisit time	Data access
Biomass	ESA	2024	2029	Vegetation Canopy (cover and height), Above Ground Biomass (AGB)	200 m	25-45 days	Open source
Flex	ESA	2024	2027	Chlorophyll Fluorescence from Vegetation on Land	300 m	27 days	Open source
LSTM	ESA and commercial partners	2028	2036	Land surface temperature	50 m	1-3 days	Open source
CHIME	ESA and commercial partners	2028	2036	Bands over the Visible, Near Infrared (NIR), and SWIR spectrum at a spectral bandwidth of less than 10 nm.	30 m	25 days	Open source
ROSE-L	ESA and commercial partners	2028	2035	L-band SAR	• 5 - 10 m for geo-hazard monitoring • Volumetric soil moisture products, with a spatial resolution of 25 m2 when imaging on a regional scale, and a resolution of 50 m2 on a global scale. • Geospatial maps of sea ice development, at a resolution of 20 m	3 or 6 days	Open source
CO2M	ESA, commercial partners, and EUMETSAT	2025	2034	CO2, CH4 and NO2	2 km	11 days	Open source
Carbon Mapper	NASA with commercial and academic partners	early 2024	no information found	CO2, and CH4	30 m	1-7 days	Open source and Paid subscription for certain services
MAIA	NASA and the Italian Space Agency	2025	2028	Air pollution	1 km	≤ 1 day	Open source
NISAR	NASA and ISRO	2024	2027	L-band and S-band	3–10 m mode-dependent	12 days	Open source

Table 11 Contribution of future missions in the following 5 years to the financial management geo-information needs.

Mission	User needs that can benefit from the mission				Contribution of the mission to the user needs
	Investment Management	Green Finance	Risk Analysis	Insurance Management	
BIOMASS		**UN30:** Need for monitoring with accurate measurements of the growth and health of trees and verifying the sustainability of forest management practices. **UN32**: Need to periodically estimate the growth of above-ground and soil carbon stocks (in forests).	**UN39:** Need to assess the potential impact of business activities or investments on ecosystems and biodiversity		• BIOMASS provides global coverage. • Frequent and consistent measurements over time • Easy access to the data without a need to obtain and analyse raw data, which reduces time and cost.
Flex	**UN18:** Need to monitor crop productivity	**UN28:** Need to classify the types of crops being grown in order to assess the Sustainability and Environmental impact of agricultural investments. **UN30:** Need for monitoring with accurate measurements of the growth and health of trees and verifying the sustainability of forest management practices.	**UN39:** Need to assess the potential impact of business activities or investments on ecosystems and biodiversity.	**UN55:** Detecting crop damage at the level of individual farms/fields	• Complementary to Sentinel-2 by adding a new dimension by measuring fluorescence, which offers complementary information for agriculture, ecology, and land management. • FLEX data can enhance the monitoring of crop health and stress. • It aids in understanding the responses of different ecosystems to environmental changes and human impacts.
LSTM	**UN12:** Analysis of potential risks in specific regions		**UN41:** Need to monitor the impact of increased temperatures on assets		Higher spatial resolution and revisit time for land surface temperature compared to currently available data
CHIME	**UN18:** Need to monitor crop productivity. **UN19:** Identifying types of crops being grown is essential	**UN28:** Need to classify the types of crops being grown in order to assess the Sustainability and	**UN39:** Need to assess the potential impact of business activities or investments on ecosystems and biodiversity.	**UN55:** Detecting crop damage at the level of individual farms/fields.	• Complementing Sentinel-2, as hyperspectral data at appropriate spatial resolution and revisit time will add value in agricultural activities. This will enhance crop type and disease classification.

		Environmental impact of agricultural investments.			• It will add value to biodiversity management and the characterization of soil properties.
ROSE-L			**UN37:** Projection of risk to portfolio assets into the future.		ROSE-L will reinforce the capabilities of current Copernicus C-band SAR systems as it will improve imaging performance in regions densely covered by vegetation, thanks to its longer wavelength L-band radio that can penetrate through the canopy.
CO2M	**UN15:** Need to monitor carbon intensity of portfolio assets	**UN26:** Need to monitor GHG emissions of projects funded			Global Carbon Monitoring at appropriate spatial resolution (2 km) and revisit time (11 days) at a global scale.
Carbon mapper	**UN15:** Need to monitor carbon intensity of portfolio assets	**UN26:** Need to monitor GHG emissions of projects funded			The relatively high resolution (30 m) and revisit time (1-7 days) for GHG monitoring at a global scale.
MAIA			**UN37:** Projection of risk to portfolio assets into the future. **UN39:** Need to assess the potential impact of business activities or investments on ecosystems and biodiversity.		• Provides global information about the sizes, compositions, and quantities of particulate matter in air pollution with appropriate spatial resolution (1km, and 300 m over some regions) and revisit time (≤ 1 day). • Integrate MAIA data with population health records
NISAR			**UN37:** Projection of risk to portfolio assets into the future.		Using both L-band and S-band with appropriate spatial resolution and revisit time.

8. CONCLUSION

This report presents a comprehensive gap analysis resulting from comparing the consolidated 32 FM geo-information needs (documented in the D1.2 Geo-Information Requirements report) with the consolidated of 38 EO products to address these needs (documented in D2.1 Current EO Capabilities report).

The report identifies three main categories of gaps: Guideline gaps, Utilisation gaps, and R&D gaps, each possessing its own unique characteristics and implications. Furthermore, we pinpointed critical gaps which underscores the urgency and significance of addressing specific challenged that prevent the FM sector from leveraging EO capabilities.

We also encapsulated the gap analysis for each EO product in dedicated tables, which provides a structured and accessible reference for stakeholders in both the FM and EO sectors. These tables offer a clear view of the specific gaps associated with each product and enable focused action plans for improvement.

A forward-looking aspect of this report is the exploration of upcoming EO satellite missions over the next five years and how these missions can be harnessed to address the geo-information needs of the FM sector. This underscores the potential for collaboration and innovation in leveraging cutting-edge technology to bridge existing gaps and optimize the utility of EO products.

In summary, this gap analysis report is a valuable resource for all stakeholders involved. It not only delineates the current challenges but also points the way towards promising solutions and areas of improvement. By addressing the identified gaps and maximizing the potential of upcoming satellite missions, we can collectively enhance the capabilities of EO products to better serve the geo-information needs of the financial management sector.

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