Evaluation of the Impact of Earth Observation in Forest Management

Earth Observation for Sustainable Development Forest Management Project

September 2024

Caribou Space

GAFAG

an e-GEOS (ASI / Telespazio) Company

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Executive summary

Executive summary

The Earth Observation for Sustainable Development Forest Management activity (EO4SD-FM), financed by the European Space Agency (ESA) and led by GAF AG (Germany) and a consortium of partners, seeks to harness Earth Observation (EO) technologies to enhance forest management globally, particularly in regions like Latin America, Southeast Asia, and Africa. The activity focuses on delivering a suite of quality-assured EO products tailored to the diverse and specific needs of International Financial Institutions (IFIs) and their Client States (CSs).

Activity overview. The EO4SD-FM activity has delivered a comprehensive range of EO products aimed at addressing various aspects of forest management. These include tools for monitoring tree cover density, forest area changes, and real-time canopy disturbances. A central aspect of the activity has been capacity building, which is delivered through a series of multilingual webinars and hands-on workshops designed to enhance the adoption of EO technologies.

Impact assessment. Evidence indicates that the activity has improved the capabilities of IFIs and CSs to utilise and integrate EO technologies effectively. Key outcomes include:

- Enhanced capacity and skills among forest management professionals through targeted training initiatives.
- Increased awareness and understanding of the benefits and applications of EO products.
- Integration of EO Information into existing forest management and planning frameworks.

Despite its successes, the activity faces ongoing challenges including technical and financial barriers, the rapid pace of technological advancement, and the need for continuous system updates. Moreover, stakeholder engagement and operational transparency are critical areas requiring further attention to maximise the benefits of EO technologies.

Contextual factors, enablers, and barriers. The successful integration and utilisation of EO technologies are significantly influenced by a range of contextual factors, enablers, and barriers. Strategic importance in IFIs, increasing recognition of EO's role in regulatory frameworks, and technological advancements facilitate the adoption of EO solutions. However, significant barriers such as the lack of technical expertise and challenges integrating EO into existing forest management frameworks remain. These issues necessitate concerted efforts to develop and refine operational practices that can fully leverage EO capabilities in forest management.

Recommendations. To overcome these challenges and leverage opportunities, we outline the following strategic actions, as a result of the lessons learned and feedback from stakeholders.

1 Capacity and skills development: Implement targeted training programmes and provide continuous learning opportunities to improve practical skills in EO technology for forest management.

2 Stakeholder involvement and operational transparency: Involve local experts in the development of EO projects, ensure transparency of methodologies, and facilitate the integration of EO Information with existing management systems.

3 Regulatory compliance and global collaboration: Align EO applications with international standards and use global climate agreements to expand the use of EO in forest management.

List of abbreviations

ADB	Asian Development Bank
AOI	Area of Interest
ASM	Artisanal Small-scale
COP	UN Climate Change Conference
CS	Client State
EO	Earth Observation
EO4SD-FM	Earth Observation for Sustainable Development Forest Management
ESA	European Space Agency
GHG	Greenhouse Gases
IFI	International Financial Institution
MRV	Monitoring, Reporting, and Verification
NICFI	Norwegian International Climate and Forest Initiative
NRT	Near Real-Time
ODA	Official Development Assistance
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SDG	UN Sustainable Development Goal
TOC	Theory of Change
UNCBD	UN Convention on Biological Diversity
UNFCCC	UN Convention on Climate Change
WB	World Bank

Background

Background

Forests serve as critical habitats, providing various functions and playing a central role as global carbon sinks. These vast green expanses are crucial in the fight against climate change, providing natural solutions to mitigate its effects. However, the sustainability of forests is increasingly threatened by pressures such as illegal deforestation, expansion of agricultural land, and consequent loss of habitat and biodiversity. These pressures not only threaten the ecological balance, but also negatively affect the livelihoods of forest-dependent communities.

In response to these challenges, numerous international conventions and policy frameworks have been developed to safeguard forests and improve their management. In particular, the United Nations Convention on Climate Change (UNFCCC) introduced the Reducing Emissions from Deforestation and Forest Degradation (REDD+) policy process and the Paris Agreement, along with the UN Convention on Biological Diversity (UNCBD). Moreover, in 2015 the UN introduced Agenda 2030, which includes UN Sustainable Development Goals (SDGs) 13 and 15 focusing on Climate Action and Life on Land, respectively.

Despite the crucial need for accurate information and monitoring systems to support countries in the management and monitoring of forested areas, operational challenges persist. Forests, which cover extensive and often inaccessible territory, present significant obstacles to conventional monitoring by human teams. The vastness and inaccessibility of these areas require a more feasible and effective approach to observation.

Earth Observation (EO) technologies present themselves as the only cost-effective solution to this situation, offering global coverage and the ability to provide comprehensive, accurate, repeatable, and timely data. This makes EO indispensable for the planning and execution of forest management activities. In particular, EO technologies play a crucial role in supporting important global forest management issues, including the REDD+ process, assessment of drivers of deforestation and forest degradation, community-based REDD+, mangrove protection, and forest landscape restoration.

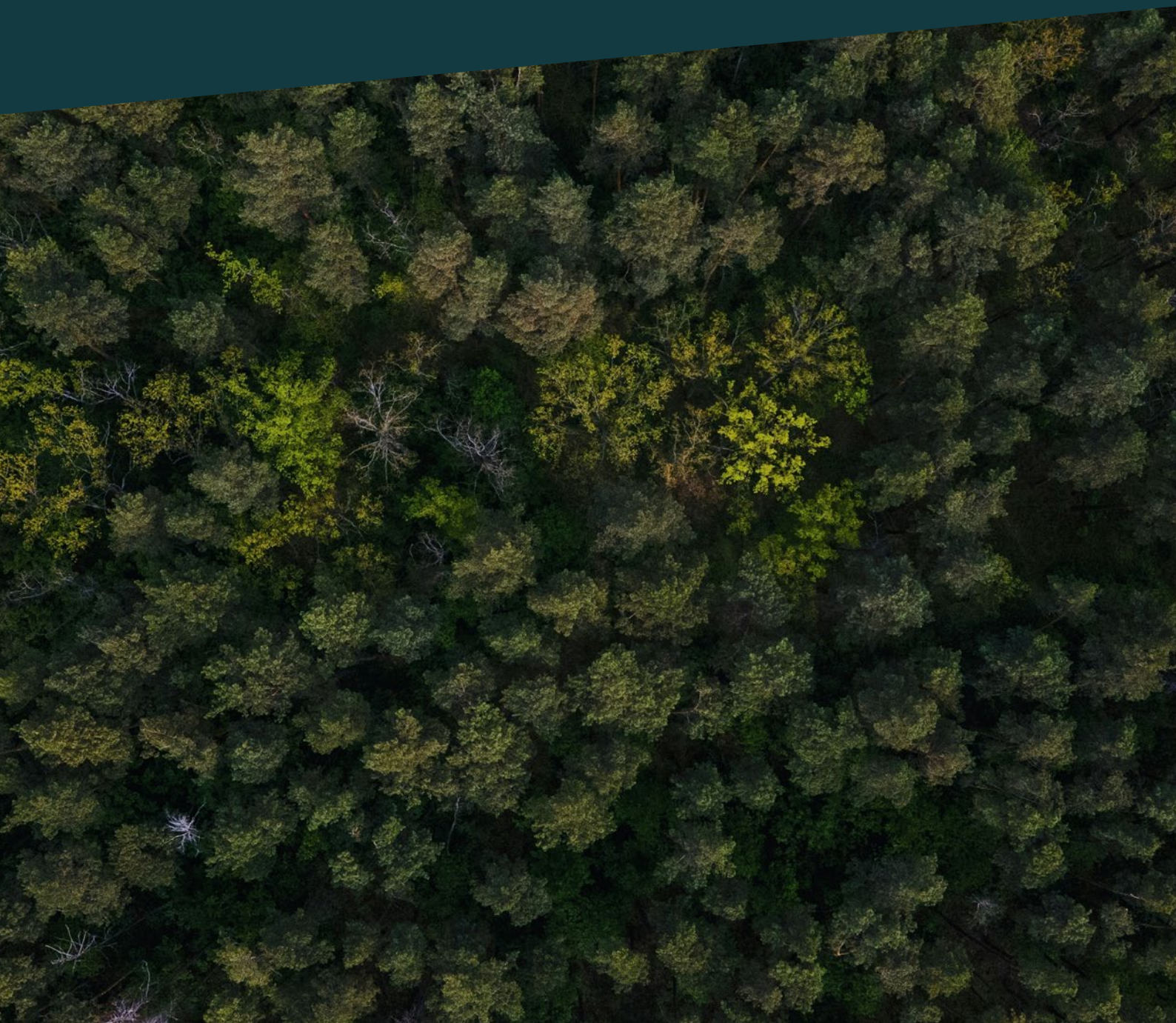
Despite increased financial support to low- and middle-income countries through development cooperation or official development assistance (ODA) since 2000, the operationalisation of EO Information for forest monitoring in these regions still faces resource and technological challenges. In this context, International Financial Institutions (IFIs) that fund development cooperation programmes have a key role to play in facilitating the integration of EO technology into their working practices, with the aim of improving forest management and contributing to the global effort against climate change.

The Earth Observation for Sustainable Development (EO4SD) activity, led by the European Space Agency (ESA), GAF AG (Germany), and a consortium of partners, exemplifies this commitment. Aimed at enhancing the capabilities of IFIs and their Client States (CSs), the EO4SD-Forest Management (EO4SD-FM) activity, active from 2020 to 2024, showcases the transformative potential of EO technologies in sustainable forest management. By providing a portfolio of quality-assured geospatial products tailored to the needs of regions like Latin America, Southeast Asia, and Africa, the activity underscores the benefits of integrating EO-based solutions into forest management strategies.

Central to the EO4SD-FM activity is a user-oriented approach, ensuring stakeholder engagement from inception to conclusion and focusing on the validation of geospatial products for effective integration into existing practices. A crucial aspect of the activity is technology transfer, with comprehensive capacity-building exercises designed to empower IFIs and CSs, equipping them with the necessary tools and knowledge to harness EO technologies effectively.

In combining the discussion of the challenges faced by forest management with the targeted solutions offered by the EO4SD-FM activity, it becomes clear that EO technologies are not just tools for monitoring and assessment but are vital for the future of sustainable forest management globally.

Evaluation of the EO4SD-FM activity



Overview of the EO4SD-FM activity

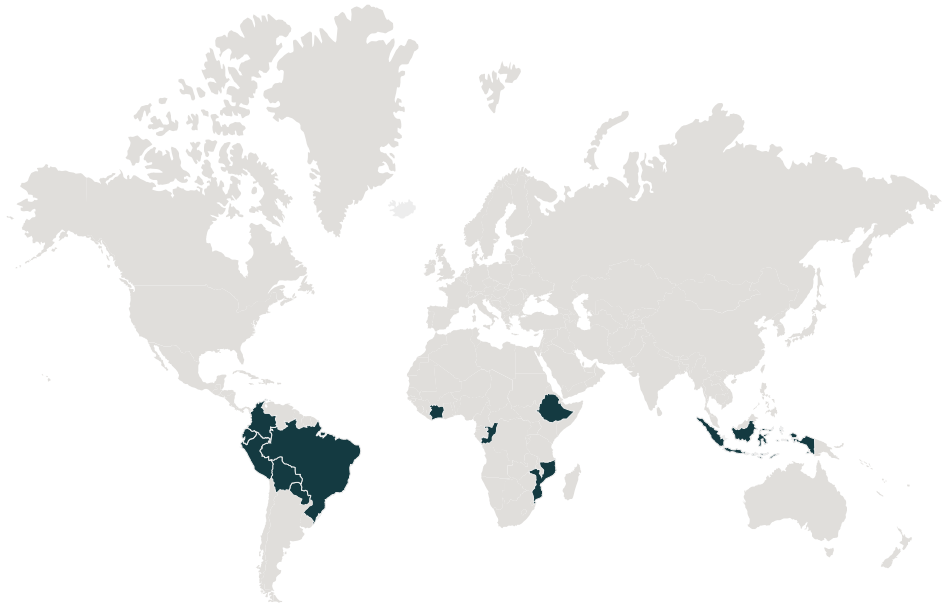
Key points

This section provides a summary of the EO4SD-FM activity, supported by ESA.

- EO4SD-FM is a four-year activity aimed at demonstrating the utility and integration of EO technologies in forest management and development programmes with IFIs.
- The activity supported IFIs in 9 projects in 11 countries by providing a portfolio of 7 EO product types tailored to address different forest management challenges.
- Capacity building has been a priority, mainly implemented through webinars that covered both awareness-raising and technical training on EO applications in forest management. The training workshops provided technical staff with hands-on experience with EO products, further contributing to the achievement of activity objectives.

The EO4SD-FM activity delivered a total of 167 EO products, which covered an estimated 2.1 million km^2 and supported 9 IFI projects across 11 countries (Figure 1).

FIGURE 1: Map of Supported Projects



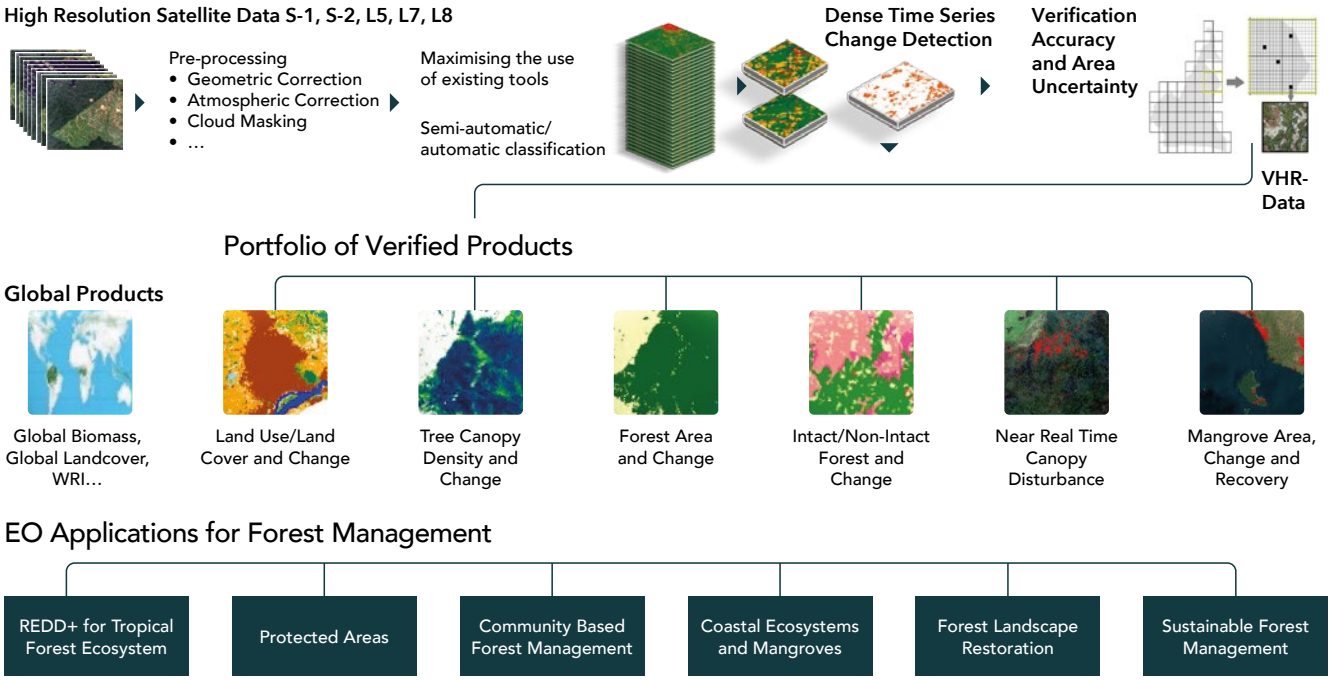


FIGURE 2: Information-Based Products and Service Portfolio of EO4SD-FM

EO4SD-Forest Management product portfolio

The EO4SD-FM provided seven EO-based product types for a wide range of forest management challenges, as shown in Figure 2. The EO products are described briefly below,

1 **Global Surface Biomass**: This product shows the distribution of living woody biomass per pixel using Sentinel-1 and ALOS-2 PALSAR-2 data. This product is crucial for estimating emissions from forest changes, supporting various forest management and conservation efforts.

2 **Land Use/Land Cover and Change**: This product provides detailed mapping of land use and land cover changes based on high-resolution satellite data, supporting hierarchical classification schemes that can be customised. It highlights transitions between land use classes over time, facilitating landscape management and planning.

3 **Tree Cover Density**: This product maps the location and coverage of tree crowns per unit area, derived from high-resolution satellite data. It quantifies canopy cover from 0 to 100 percent without distinguishing between land use types, and can be customised to include specific criteria such as tree patch size or proximity to infrastructure.

4 **Forest Area and Change**: Using land use definitions and thresholds, this product differentiates forest land from other areas. It provides maps of forest area and change adapted to user-specific forest definitions, supporting REDD+ and other forest management initiatives with adapted national forest parameters.

5 **Intact and Non-Intact Forests**: Identifies the degraded state of forests using direct disturbance detection or indirect analysis based on proximity to human activities. The indirect approach is preferred when direct detection is hampered by data limitations or rapid regrowth, facilitating the distinction between intact and degraded forests.

6 **Near Real-time (NRT) Canopy Disturbance Detection**: This product provides timely updates on new forest disturbances using a continuously operating system that processes EO Information as soon as it is available. The frequency of updates depends on the EO sensors used, enabling timely forest monitoring.

7 **Mangrove Area, Change and Recovery**: These three interconnected products assess the biophysical characteristics of mangrove ecosystems and their changes over time. It uses machine learning algorithms to map mangrove extent, condition, and change, supporting mangrove restoration efforts with high-resolution images.

Capacity building delivered in EO4SD-FM

A key facet of the EO4SD-FM activity involves empowering stakeholders to sustainably use the potential of geospatial products. Consequently, developing the capacity of stakeholders within IFIs, as well as governmental and nongovernmental organisations in CSs, stands as a pivotal element of the project's activities. Two capacity-building mechanisms were used in the second phase of the activity for both IFI experts and counterpart users in CSs:

— *Webinars*

This series was strategically designed to ensure a wide reach in a cost-effective manner, successfully completing the nine scheduled sessions. It included **two awareness-raising webinars** to introduce EO4SD-FM, its objectives, and the usefulness of EO products in forest management. The series also included **seven technical webinars** covering various EO products and services, offering in-depth knowledge on topics such as tree canopy and forest area mapping, artisanal small-scale (ASM) alerts, forest biomass mapping, canopy disturbance and NRT emission detection, mangrove mapping, and land use and land cover mapping. To cater to a diverse audience, these webinars were offered in English, Spanish, and French, for a total of 16 sessions. All webinars were recorded and are accessible on the project's YouTube channel,[1] providing a valuable ongoing resource for IFI programme managers, technical staff, and wider audiences interested in EO applications in forest management.

— *Training workshops*

The second key component of capacity building within the EO4SD-FM activity involves **regional training session**s focused on the technical staff of each use case. These sessions aimed to enhance the adoption of EO products and services in forest management programmes by providing in-depth insights into EO Information inputs, production processes, quality assurance, and the practical strengths and limitations of each product. The training also explored the integration of these products with existing information sources for each use case. A significant feature of these sessions is the practical, hands-on exercises that allow participants to directly engage with EO products, fostering a deeper understanding and encouraging their effective application in forest management practices. A total of eight training workshops were held (three in person, five online).

1 EO4SD-FM, YouTube, www.youtube.com/@EO4SD-Forest

Evidence of impact from EO4SD-FM

Key points

This section assesses the progress the consortium made towards increasing IFI and CS capacity to effectively use and integrate EO products into their forest management cycles.

— EO product delivery

- The EO product delivery was effective and efficient, aligning well with stakeholders' expectations.
- The quality of the EO products met IFI and CS expectations.

— Awareness

- The EO4SD-FM website supports the awareness-raising process of the applications, capabilities, and benefits of EO products for forest management.
- The awareness of EO products increased, though improvements varied among users.

— Capacity building

- IFIs and CSs show different interests and training needs, with a preference for satellite image interpretation and geospatial analysis for decision-making.
- Multilingual webinars and workshops improved global professionals' skills and accessibility to EO products for forest management.
- IFI and CS representatives stress the importance of understanding EO product methodologies to effectively integrate and replicate them in their projects.
- Involving local experts in EO product development ensures usability, relevance, and capacity building.

— Value proposition

- EO products excel in quality, precision, and detail but vary in coverage and frequency of updates.
- EO technology offers unique insights but can be improved with ground truthing and the knowledge of the local community, which are essential for understanding environmental dynamics.

— Early impacts and uptake

- Progress in EO4SD-FM product uptake varies across IFI-supported projects, sometimes hindered by timing of product delivery.
- Initial usage of EO4SD-FM products improved data analysis in national projects, improving accuracy and decision-making.
- EO4SD-FM products are likely to integrate into IFI operations and country loans or grant programmes within a medium time period.
- Skill gaps, budget constraints, and data quality are the key challenges to EO products uptake.
- Ongoing support, training, and partnerships enhance EO product uptake and adoption.

The EO4SD-FM activity aims to improve the understanding and integration of EO tools in forest management among IFIs and CSs. The consortium is dedicated to raising awareness of the capabilities and benefits of EO4SD-FM through accessible and relevant communication materials and targeted demonstrations for some specific forest management applications. In addition, customised capacity-building activities enable IFIs and CSs to effectively incorporate EO applications into their core operations. Through these efforts, the consortium ensures the delivery of customised EO products that meet stringent user requirements and service specifications, equipping stakeholders with the tools they need to improve decision-making and operational efficiency.

This section assesses the progress the consortium made towards increasing IFI and CS capacity to effectively use and integrate EO products into their forest management cycles and ensure they realise tangible benefits from EO4SD-FM applications.

EO products delivery

— *The EO product delivery was effective and efficient, aligning well with stakeholders' expectations.*

Feedback collected through a survey reflects high satisfaction among IFI representatives and CSs on the service delivery of the EO4SD-FM activity, with responsiveness and efficiency consistently rated between very good and excellent. Although there were occasional time misalignments—services were sometimes delivered later than anticipated (see section *Early impacts and uptake for further details*)—general timeliness aligned well with stakeholders' expectations, often described as "more or less on time."

> *"I really like how [the consortium] shared with us all the details of the products. They made them available online for us to download and they were very open also to answer questions from the countries."*
>
> **Diana Paredes**, WB project representative, 2024

— *The quality of EO products met IFI and CS expectations.*

IFI and CS stakeholders expressed a high degree of satisfaction with the quality of EO products, consistently rating their standards and expectations between "very good" and "excellent." The technical aspects of the activity—including product specifications, validation, accuracy assessment, and clarity of technical information—were particularly appreciated, receiving "excellent" and "very good" ratings.

> *"We were very pleased with the discussions we had with the CLS team, the work they did for us and the quality of the results we achieved. … We were really seduced by these results."*
>
> **Elie Kouman**, Côte d'Ivoire representative, 2024

Awareness

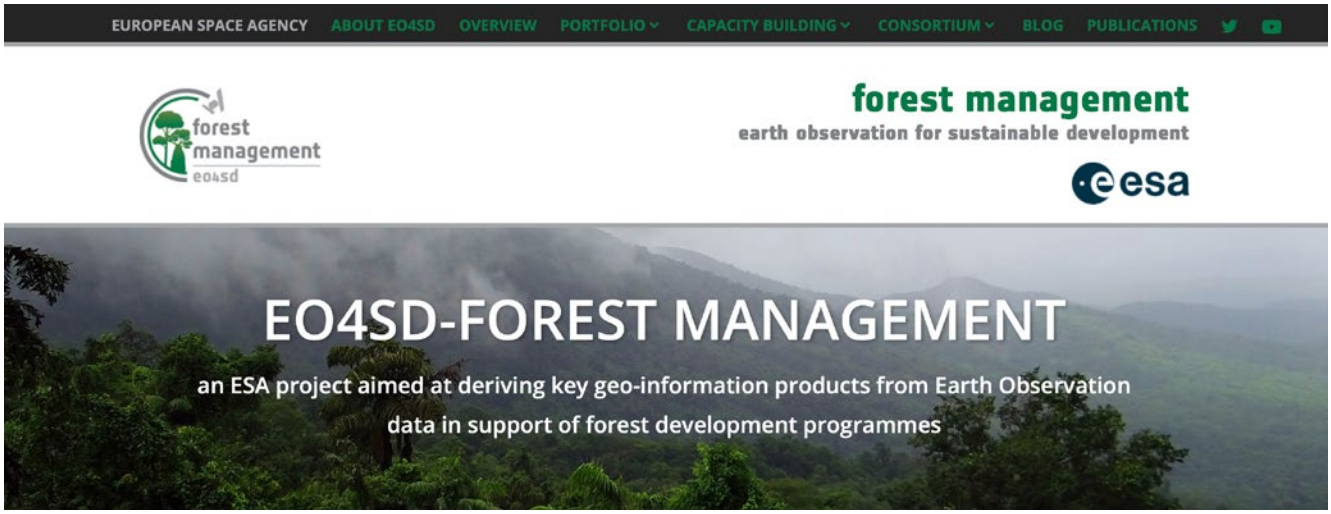
— *The EO4SD-FM website supports the awareness-raising process of the applications, capabilities, and benefits of EO products for forest management.*

Among the desired outcomes of the EO4SD-FM activity is raising awareness of the applications, capabilities, and benefits of EO products for forest management. The EO4SD-FM website[2] contributes to this outcome by serving as a hub containing different communication materials such as brochures,[3] flyers,[4] product descriptions,[5] videos,[6] and training materials.[7] The rich resources on the website include a series of blogs on use cases presented in ArcGIS StoryMap format,[8] aiming to broaden understanding of the benefits of using EO products in forest management through non-technical and accessible language. These efforts are complemented by videos that briefly summarise the applications and benefits of EO products in various projects and countries. The website demonstrated significant user engagement growth from its launch in December 2020 through June 2024. During this period, the website attracted more than 16,000 visitors and recorded almost 50,000 page views.

— *Awareness of EO products increased, though improvements varied among users.*

The results of the survey to the IFI and CS representatives revealed a significant increase in awareness of the applications of EO resources among IFIs and CSs, with most participants reporting an "increased" level of awareness. While the majority observed a significant improvement, some indicated only a "modest increase" or reported "no change". This variability could depend on the level of expertise of various stakeholders, as some of them had rated their skills as "intermediate" in EO Information processing, analysis, and utilisation (40% of respondents), and in computing and processing capacities (48% of respondents) during a self-assessment of capacity to analyse the requirement for capacity-building activities.

FIGURE 2: EO4SD-FM Website Homepage



2 EO4SD-FM (website), https://www.eo4sd-forest.info/

3 EO4SD-FM (brochure), https://www.eo4sd-forest.info/wp-content/uploads/2021/08/EO4SD-Forest-Management_Brochure_2021_1_0.pdf

4 EO4SD-FM (flyer), https://www.eo4sd-forest.info/wp-content/uploads/2021/06/EO4SD_FM_Flyer_2021.pdf

5 EO4SD-FM, Product portfolio, https://www.eo4sd-forest.info/portfolio/

6 EO4SD-FM, How can Earth Observation (EO) improve Forest Management? (video), https://www.eo4sd-forest.info/

7 Training material, EO4SD-FM, https://www.eo4sd-forest.info/training-material/

8 For an example of a blog in ArcGIS StoryMap format, see Charting a sustainable path for the Amazon, EO4SD-FM, https://www.eo4sd-forest.info/asl/

Capacity building

This section describes the progress towards capacity-building activities, highlighting advancements and requirements for improving CSs' usability and understanding of EO products for forest management.

— *IFIs and CSs show different interests and training needs, with a preference for satellite image interpretation and geospatial analysis for decision-making.*

Through a questionnaire, the consortium identified various training needs among IFI and CS project managers, government officials, and forest management personnel. The analysis revealed a wide range of training interests, with the most common being "interpret satellite imagery" (69%), "decision-making based on geospatial analysis" (59%), and "prepare thematic maps" (56%). Other specific training needs highlighted were programming in Python and Google Earth Engine, advanced analysis such as machine learning, and experience in carbon stock variation. Demand for training varied regionally, with Latin America showing different needs, while Africa and Asia showed greater demand for advanced skills.

— *Multilingual webinars and workshops improved global professionals' skills and accessibility to EO products for forest management.*

The capacity-building activities conducted by the consortium, held in multiple languages (English, French, and Spanish), were significantly attended by professionals from several countries, including Cameroon, Peru, and Colombia. In addition to live online sessions, in-person workshops provided targeted training, such as mangrove mapping in Indonesia and programme support in Mozambique. The sessions were well received, with positive feedback emphasising the improvement in participants' skills and understanding. To ensure the accessibility of the training materials, recordings of the webinars were made available on EO4SD-FM's YouTube channel, supplemented by an archive of learning resources.

— *IFI and CS representatives stress the importance of understanding EO product methodologies to effectively integrate and replicate them in their projects.*

Feedback from interviews with IFI and CS representatives emphasised the importance of understanding the methodologies used to create EO products. Interviewees expressed a strong desire to fully understand production methodologies, which would enable them to replicate the analyses and integrate these insights more effectively into their own projects.

> *"We liked the idea of benefiting from this exchange in terms of capacity building so that we could reproduce the products ourselves and integrate them into our processes. ... We really want to be able to learn the methodological process that goes into developing the product."*
>
> **Elie Kouman**, Côte d'Ivoire representative, 2024

Simply receiving a finished product is not enough for successful implementation; final users need to have a thorough understanding of the data sources, methodologies, and tools used in the creation process. This understanding fosters greater commitment and expertise, which are crucial when data is used for critical tasks such as developing reference levels or conducting detailed sampling. Knowledge of the methodology increases the transparency of data, enabling teams to assess the reliability of information and its applicability to their specific environmental and operational contexts.

> *"[We need to] understand the methodologies used in this project, because when we're introduced with just a finished product that has been developed by other structures that we have to use, it's not very interesting for us. We need to understand the sources, the data used, the input data, the methodologies used and the tools to feel more involved. That's the capacity building we want to have."*
>
> **Carine Saturnine Milandou**, Republic of Congo representative, 2024

— *Involving local experts in EO product development ensures usability, relevance, and capacity building.*

The need to involve local experts and stakeholders in the product development process was also raised. This involvement ensures that products are not only adapted to local needs but are also understood by those who use them. Participants indicated that such collaborative approaches in EO product development ensure that methodologies are appropriate, and that data can be reused with confidence in future projects. Engagement in the production process not only builds local capacity, but also ensures that data and products are more aligned with the specific requirements and contexts of the projects they are intended to support.

> *"When it comes to delivering products, you always have to involve the country. … It is very important as it will allow us … to use the data. We can say what project provided us with such and such data. It's important for the work we're doing. But if we don't even know how this work was done, the applied methodology, it would be a bit complicated for us to be able to reuse this. So, you always have to involve the country's experts when it comes to making a product."*
>
> **Leslie Bouetou Kadilamio**, Republic of Congo representative, 2024

Value proposition

This section discusses IFI and CS perception of EO's value in forest management, acknowledging both the strengths and limitations of EO technology for comprehensive environmental analysis.

— *IFI and CS stakeholders value EO Information for its quality, precision, and cost-effectiveness in forest management.*

The perception of the value of EO-based information services showed a predominantly positive shift, with most stakeholders recognising their significant role in forest management.

Compared to existing information sources, representatives of IFIs and CSs rated particularly highly the quality, accuracy, precision, and scalability at national level of EO products. The level of detail and adherence to standards were also consistently recognised, underlining the robustness of the products and their compliance with international or national criteria.

Furthermore, the cost-effectiveness of using satellite EO Information has been highlighted as one of its main advantages. Especially when using open-source, free, and easily accessible data, the transparency and cost savings compared to traditional field missions are significant. For example, the use of satellite data for the initial photo interpretation of deforestation warnings can significantly reduce costs and speed up the verification process, offering a compelling alternative to more resource-intensive methods.

> *"In terms of cost … I think [using satellite EO Information] is one of the best opportunities, as long as we manage to use open-source data that is free, available and very easy to use"*
>
> **Abraham Bio**, Côte d'Ivoire representative, 2024

— *EO technology offers unique insights but can be improved in combination with ground truthing and the knowledge of the local community, which are essential for understanding environmental dynamics.*

Although EO technology offers unique insights in comparison to traditional sources of information, its limitations must be recognised. For example, although EO Information is effective for monitoring broad geographic changes, such as changes in deforestation patterns, it often require ground investigation, such as field surveys, to understand underlying causes. Satellite data can indicate where changes are occurring but cannot always explain why. For example, if deforestation moves to new areas after the intervention, this data alone cannot uncover the socioeconomic or ecological reasons behind these shifts. Therefore, although EO is a powerful tool within a larger information system, it is not definitive. Ground truthing remains essential to transform observational data into actionable knowledge, ensuring that interventions are based on a comprehensive understanding of environmental dynamics.

> *"These data sets clearly help visualise those things [shift in deforestation], although they will not help us understand really what's happening on the ground because it's circumstantial evidence, right? So, we just see that things are moving, but [with regard to] the causes for that, you have to go into the ground and assess them."*
>
> **Naikoa Aguilar Amuchastegui**, WB representative, 2024

Furthermore, it is important to recognise the value of integrating EO Information with other sources of information and involving local communities to gain different perspectives on their use. This integration increases the usefulness of EO Information, making them part of a broader system of knowledge management and decision-making tools that are essential to promote effective natural resource management in different regions and communities.

> *"There is a lot of power in having this kind of information as part of a set of data to allow for decision-making … However, it's important to bear in mind that this [EO Information] should be integrated with other sources of information. Yours is coming beyond the sky, but if you ask the fishermen about the status of their farm or basin, or if you ask the indigenous leaders how they foresee the basin's status, the information will be completely different—not better, not worse, just different. And together, they will give you a better picture."*
>
> **Ana Maria Gonzalez Velosa**, WB representative, 2024

Early impacts and uptake

This section describes the early impacts and progress made toward the uptake of EO4SD-FM products within IFI and CS operations, also highlighting the challenges to and the enablers of such uptake.

— *Progress in EO4SD-Forest Management product uptake varies across IFI-supported projects, sometimes hindered by timing of data delivery.*

The level of usage of EO4SD-FM products varies across different IFI-supported projects. Some projects utilised these products for rapid assessments, such as tracking deforestation events, before detailed, post-processed data became available.

> *"[EO4SD-FM products] are used as a first proxy to try to understand what we can expect from the actual data that will be reported by the country in a specific location. Because these come out faster, [whereas] the post processing that the country does takes a long time."*
>
> **Naikoa Aguilar Amuchastegui**, WB representative, 2024

Other projects employed EO products to conduct comparative analyses essential for specific environmental management activities:

> *"On the positive side, this product can help us to make a comparison, for example with the biomass map, the disturbance map, and the density map. These different products could enable us to make a comparison in the long run, because we already had a biomass map [developed outside of EO4SD] used for factors and emissions calculations in the first monitoring report."*
>
> **Leslie Bouetou Kadilamio**, Republic of Congo representative, 2024

However, sometimes the EO products could not be integrated into critical reports due to time discrepancies between the progress of the IFI project and the delivery of the updated EO product from the consortium.

> *"The Near Real-Time [Canopy Disturbance Detection] product didn't really come out on time because there were a lot of technical exchanges … so that we could include it in the methodological process that we used in the framework of the [Forest Carbon Partnership Facility]."*
>
> **Elie Kouman**, Côte d'Ivoire representative, 2024

— *Initial usage of EO4SD-FM products improved data analysis in national projects, improving accuracy and decision-making.*

The initial impact of using EO4SD-FM products was the improvement of data analysis processes in various national projects. In particular, the integration of NRT products with global datasets has significantly improved labelling and surveying processes. The fusion of NRT and global data allows for more accurate and detailed analysis, offering a substantial advantage in the interpretation of changes at the national level, which often contain more specific data than generic global datasets. This increased capacity is key to improving the accuracy and usefulness of environmental data, facilitating more informed decision-making.

> *"Integrating the NRT product into the global data … We realised that this gives us a greater advantage in the automatic labelling of these different samples, especially as the data is limited to the country level and is more specific than the global data we use. So, incorporating this additional data really adds a lot of value to the automatic detection before the interpretation. That's why we really want to integrate this product [in our day-to-day processes], because it adds considerable value to the results"*
>
> **Elie Kouman**, Côte d'Ivoire representative, 2024

As a result, these integrated data products are not only useful for initial comparisons and assessments but are also actively integrated into ongoing data production and analysis frameworks, marking a key step in improving the operational effectiveness and responsiveness of environmental management strategies.

> *"These products are useful for us in terms of comparison and improvement and for assessing uncertainties. So, these are the country's data that are important to us and that we're going to use. We're going to integrate them into our data production and data analysis processes."*
>
> **Carine Saturnine Milandou**, Côte d'Ivoire representative, 2024

— *EO4SD-FM products are likely to integrate into IFI operations and country-specific loans or grant programmes in the medium term.*

The survey included responses from a number of IFI representatives, who rated the integration of EO4SD-FM products into IFI operations as remarkably positive. They considered the adoption of EO products within banks' workflows and decision-making processes as very likely, with a high potential indicated for their inclusion. Similarly, the integration of EO4SD-FM products into country-specific loan or grant programmes is also seen as highly likely. However, the timeframe for such integration, including budget allocations for these products and services within the IFIs' programmes, is extended to three years. This reflects the strategic commitment to integrate EO4SD-FM products to improve the operational effectiveness of IFI projects, but also recognises the time needed to implement these integrations.

— *Skill gaps, budget constraints, and data quality are key challenges to EO product uptake.*

The survey revealed several barriers affecting the integration of EO Information between IFI and CS stakeholders. Skill levels within teams were identified as a significant challenge, highlighting the need for comprehensive training and a deeper understanding of EO capabilities. Budgetary constraints also emerged as a significant obstacle, with a number of responses indicating inconsistent financial support for EO initiatives across organisations. In addition, organisations' willingness to adopt EO solutions varied, with many seeing it as a high or moderate barrier, reflecting some internal resistance or lack of momentum towards EO adoption. Furthermore, while the quality of the EO products delivered is widely recognised, challenges often arise from external factors, such as the quality of data provided by CSs, which can affect the validation and accuracy of results.

> *"Technical work is very well done, cutting edge. The largest impediment was the quality of the intervention data from the client used for validation—which was not the responsibility of the EO4SD group (however, we do appreciate their efforts to improve and revise this to allow for a more accurate assessments given the limitations)."*
>
> **Anonymous**, IFI representative, User Utility Assessment, 2024

— *Ongoing support, training, and partnerships enhance EO product uptake and adoption.*

In terms of enablers to the uptake of EO products, IFI and CS representatives stressed the importance of ongoing support and development initiatives for the uptake and integration of EO Information, emphasising the role of continuous collaboration with organisations such as ESA in capacity building. They emphasised the need to integrate EO products into daily operations, backed by regular training and donor support to enable wider adoption. This evidence suggests that overcoming barriers to EO integration goes beyond technical solutions, requiring the creation of an enabling environment facilitated by strategic partnerships, continuous training, and strong support systems.

> *Question: What would enable you to continue to use EO-based information in your work? Answer: "Continue to use the products in work. Follow up training or workshop to continue adoption. Potential donor support."*
>
> **Anonymous**, CS representative, User Utility Assessment, 2024

Contextual factors, enablers, and barriers to EO and geospatial technologies in forest management

Contextual factors, enablers, and barriers to EO and geospatial technologies in forest management

Summary

This section examines contextual factors, enablers, and barriers that influence the successful realisation of the intended outcomes and impacts of EO4SD-FM, which depends significantly on how partner IFIs and CS stakeholders actively use and integrate the EO applications within their programmes and practices.

– Contextual factors

The role of forests in climate regulation and sustainable development

- Forests regulate climate by absorbing carbon, support biodiversity, and face threats from deforestation and climate change.
- Forests are central to climate change solutions and sustainable development, underlined by global agreements and SDGs.

Strategic importance of forest management in IFIs

- WB focuses on forest conservation to combat poverty, increasing investments and projects globally.
- ADB's Strategy 2030 aims for resilience and sustainability in Asia, focusing on forestry within broader climate change efforts.
- In 2023, ADB committed US$9.8 billion to climate finance, a 46% increase from the previous year, supporting sustainable forest management in Asia-Pacific.

Increasing acknowledgement of EO's role in monitoring, reporting, and verification activities

- Significant growth in EO Information use for forest management has shifted from pixel counting to a comprehensive "total evidence approach" for detailed analyses.
- EO Information supports forest management by enhancing monitoring, generating accurate statistics, and analysing biomass to meet international standards.

– Enablers

Technology advancement and data availability

- The advantages of using EO are becoming more and more tangible with increasing advancements in EO technology.
- Free high-resolution satellite data initiatives boost global forest monitoring and conservation efforts.

Global regulatory pressures

- The global forestry sector and regulatory landscape provide incentives for using EO Information.

– Barriers

Lack of technical expertise

- Adopting satellite data systems demands major investment, local expertise development, and continuous technical updates, posing significant challenges.

Integrating EO into existing forest management frameworks

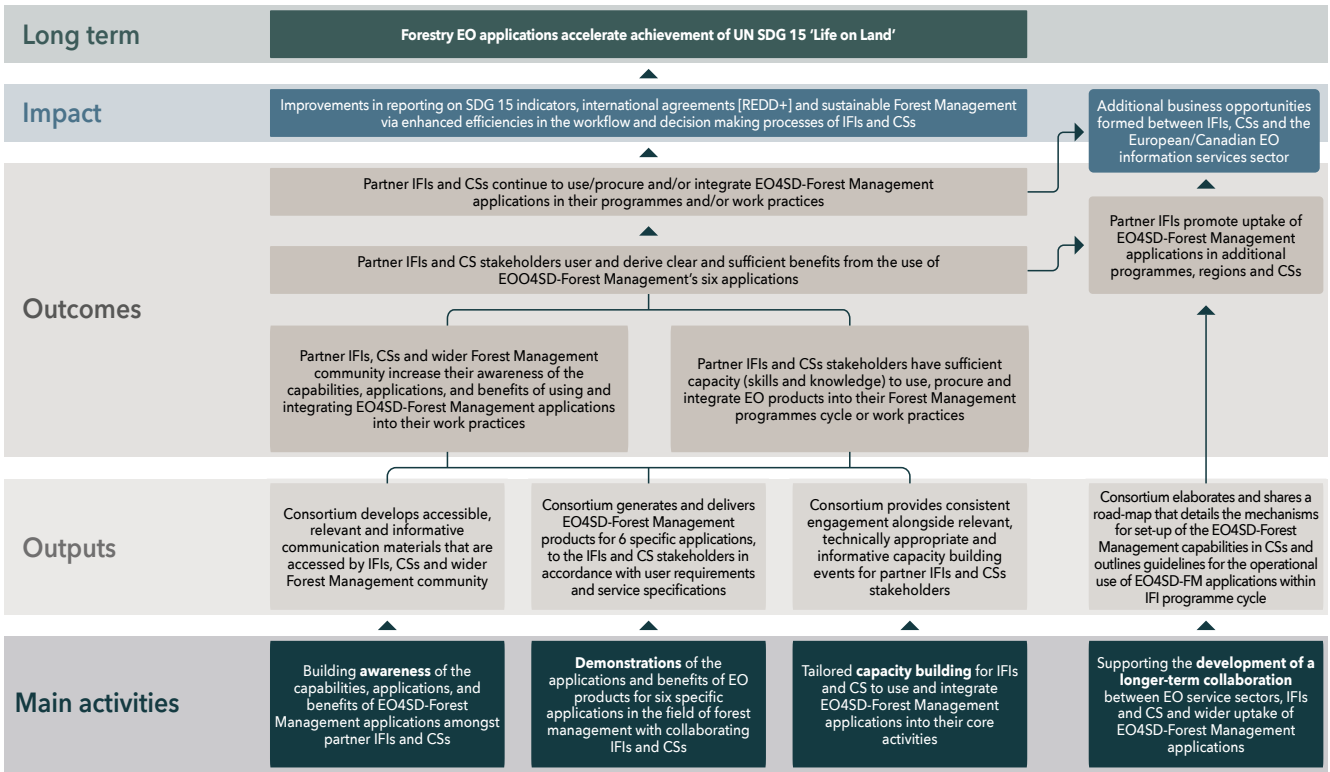
- Integrating satellite remote sensing into forest management requires significant workflow adjustments and development of integration tools.

The EO4SD-FM Theory of Change (TOC) outlines a chain of events that would take place within an overall impact pathway to deliver the intended impacts of the EO4SD-FM activity. Within this chain of events, the delivery of intended (and contracted) outputs is understood to be completely under the control of the EO4SD-FM consortium and independent from external dependencies and contextual factors. However, in later stages of the TOC impact pathway (as highlighted in Figure 4), the achievement of intended outcomes and impacts is likely to be contingent on a number of factors, including:

- The extent to which partner IFIs and CS stakeholders use applications as intended to derive clear and sufficient benefit from them.
- The applicability of EO4SD-FM applications by IFIs and CSs to reporting on UN SDG 15 indicators.
- The wider uptake of forestry-related EO applications to accelerate the achievement of UN SDG 15.

This section examines those factors, including enablers and barriers that can influence them.

FIGURE 4: EO4SD-FM Theory of Change



Contextual factors

The role of forests in climate regulation and sustainable development

— *Forests support biodiversity, regulate climate by absorbing carbon, and face threats from deforestation and climate change.*

Forests are crucial for climate regulation, as they act as the planet's lungs by absorbing and storing atmospheric carbon, thereby playing a critical role in moderating greenhouse gases (GHGs). These ecosystems are ecological treasures, as they are home to two-thirds of all terrestrial species and provide significant social and economic benefits. They support the livelihoods of many indigenous communities and underpin important industries such as timber. However, forests are significantly threatened by the increasing demand for agricultural land and development, leading to widespread deforestation. This not only accelerates carbon emissions, but also leads to loss of biodiversity, soil erosion, and destabilisation of local climates, further exacerbated by rising temperatures and changing precipitation patterns.

— *Forests are central to climate change solutions and sustainable development, underlined by global agreements and UN SDGs.*

Forests are key to addressing the twin challenges of climate change and sustainable development. Initiatives such as the Paris Agreement and the UN SDGs recognise the importance of forests, with the specific aim of improving forest management and conservation as part of global climate response strategies. SDG 15, for example, emphasises the importance of protecting, restoring, and promoting the sustainable use of terrestrial ecosystems. This growing recognition emphasises the need for increased investment in forest conservation and sophisticated monitoring systems, including the increasing use of EO technologies in forestry operations.

Strategic importance of forest management in IFIs

— *WB focuses on forest conservation to combat poverty, increasing investments and projects globally.*

The WB's commitment to sustainable environmental and natural resource management is a central pillar of its strategy to combat global poverty. Within its Environment, Natural Resources, and the Blue Economy Global Practice (ENB GP), there is a strong emphasis on forests, landscapes, and biodiversity, which are seen as vital resources for economic growth and environmental stability. In 2022, the WB notably increased its

forest-related activities, approving 27 projects with an average net investment of US$97 million, up 27% from the previous year. This growth is part of a broader trend seen over recent years; for instance, the number of active forest projects jumped from 76 in 2016 to 127 in 2022, with net investment escalating from US$1.9 billion to US$7 billion over the same period.[9] These investments reflect a strategic shift towards climate resilience, emphasising forest planting and protection as essential measures against global warming.

— *ADB's Strategy 2030 aims for resilience and sustainability in Asia, focusing on forestry within broader climate change efforts.*

In 2019, ADB introduced Strategy 2030, outlining a vision for prosperity, inclusion, resilience, and sustainability across the Asia and Pacific region. This strategy highlights seven Operational Priorities crucial for realising such a vision. Notably, while Operational Priority Three does not solely focus on forestry, it encompasses forest-related elements under its broader theme of "Tackling Climate Change, Building Climate and Disaster Resilience, and Enhancing Environmental Sustainability." This priority recognises that a significant portion of Asia-Pacific is engaged in agriculture, fisheries, and forestry—sectors that are most vulnerable to climate change. Indeed, deforestation and biodiversity loss represent pressing environmental challenges that countries in the region are increasingly confronting. To combat these issues, ADB has initiated several activities aimed at mitigating the impact of climate change.

— *In 2023, ADB committed US$9.8 billion to climate finance, a 46% increase, supporting sustainable forest management in Asia-Pacific.*

The ADB allocates a considerable amount to climate finance each year, helping member countries reduce GHG emissions and adapt to the effects of global warming. In 2023, the ADB committed as much as US$9.8 billion to these efforts, marking an increase of more than 46% over the previous year.[10] As sustainable forest management plays a crucial role in mitigating GHG emissions, it is logical that the bank undertake further initiatives to support forests in Asia-Pacific. These initiatives, which are likely to be part of larger, multi-component programmes, may not be listed individually in the ADB projects database.

Evolution and integration of EO in IFI and CS practices

— *Significant growth in EO Information use for forest management has shifted from pixel counting to a comprehensive "total evidence approach" for detailed analyses.*

Clear and significant growth has been observed in the adoption of EO to tackle forest management. In particular, EO has been used to provide data on some key indicators such as forest cover and biomass quantification, which are required by some global regulatory frameworks on forest management.

> *"I think there has been an increase in the offering [of EO Information for] forest cover, forest change, deforestation and biomass quantification."*
>
> **Diana Paredes**, WB project representative, 2024

9 Author's analysis based on information collected on WB Projects Database. Projects, World Bank Group, https://projects.worldbank.org/en/projects-operations/projects-list?sectorcode_exact=AT&title=Forestry&os=0

10 ADB, ADB Commits Record Climate Finance of Almost $10 Billion in 2023, 31 January 2024, https://www.adb.org/news/adb-commits-record-climate-finance-almost-10-billion-2023

In particular, the use of EO Information in monitoring, reporting, and verification (MRV) of REDD+ projects has evolved significantly. Initially, EO Information was used for direct pixel counts to estimate forest areas, a method that was once considered definitive. However, as scientific knowledge progressed, bias in the results was recognised, leading to a change in its application. Today, maps play a strategic role in stratification, helping to generate sampled areas for detailed analysis. This process uses a variety of remote-sensing data and contextual information to accurately interpret changes at each location. The current approach, known as the "total evidence approach," integrates different types of data and technologies, such as Sentinel imagery and radar, to form a comprehensive understanding of forest dynamics. These integrated data is crucial not only for observation, but also for improving decision-making processes by providing a nuanced view of forest changes.

— *EO Information supports forest management by enhancing monitoring, generating accurate statistics, and analysing biomass to meet international standards.*

In countries such as Côte d'Ivoire and the Republic of Congo, the use of EO Information has become an integral part of forest management strategies. Government teams mainly monitor forests using satellite imagery from platforms such as Google Earth and traditional satellites, such as Landsat, Sentinel 1, and Sentinel 2. They also focus on generating forest statistics that meet international standards, employing sophisticated statistical methods to ensure the reliability and accuracy of the data.

> *"We prioritise remote-sensing data … We're always looking for improvements, for more robust methodological approaches that are accepted internationally by the various standards. We are really committed to this approach."*
>
> **Elie Kouman**, Côte d'Ivoire Representative, 2024

In addition, the collection, analysis, and reporting of biomass data are crucial to meet national and international reporting requirements. Administrative and political dimensions are also important, as teams must defend their methodologies and results to policymakers, ensuring that their approaches are well organised and able to withstand scrutiny.

Enablers

Technology advancement and data availability

— *The advantages of using EO are becoming more and more tangible with increasing advancements in EO technology.*

Innovative methods for accessing and processing satellite data have opened up opportunities for using satellite remote sensing to enhance the monitoring and management of forests. For example, over the last ten years, ESA has launched several new missions within the EU Copernicus Programme, which are able to map natural ecosystems (including forests) at higher and higher levels of detail. Moreover, the upcoming ESA BIOMASS mission will focus specifically on the state of Earth's forests, their changes, and their role in the carbon cycle. MRV systems are also advancing, with WB investments in next-generation MRV systems (MRV 2.0) that include collecting high-quality in situ Light Detection and Ranging (LiDAR) data, developing estimation algorithms for carbon stocks and dynamics, and designing a centrally governed, digitally managed prototype MRV system in countries like Colombia and Mozambique.

> *"Nowadays, fortunately, there's many more things available. And now hopefully we're going to have the biomass mission will bring on board the structural data capabilities that we expect from the P-bands."*[11]
>
> **Naikoa Aguilar Amuchastegui**, WB representative, 2024

— *Free high-resolution satellite data initiatives boost global forest monitoring and conservation efforts.*

In terms of data accessibility, initiatives offering free access to commercial data, such as Planet Scope, have enabled the wider use of high-resolution satellite data for forest monitoring. A new partnership between the Norwegian International Climate and Forest Initiative (NICFI) and the Bezos Earth Fund has also committed more than US$18 million over the next four years to provide free, high-resolution satellite data of the world's rainforests.[12]

11 P-band sensors operate in the range 30 cm to 100 cm of the electromagnetic spectrum. Large wavelengths like the ones at L- or P-bands are more useful for the monitoring of forests.

12 NICFI, COP28/Dubai: NICFI and Bezos Earth Fund to provide free satellite images, 2 December 2023, https://www.nicfi.no/2023/12/02/nicfi-and-bezos-earth-fund-providing-free-satelite-images/

Global regulatory pressures

— The global forestry sector and regulatory landscape provide incentives for using EO Information.

Several key changes in the global forest industry and regulatory landscape have encouraged the adoption of EO technologies. These changes include new reporting requirements and international commitments, which have increased the likelihood of EO Information adoption.

One example is the generation of activity data for GHG reporting. Accurate and timely activity data is essential for emissions monitoring and reporting, and EO technologies provide a reliable means of collecting this information.

Renewed commitments at major climate meetings promise a further increase in the use of EO Information. COP26 in 2021 led to the Glasgow Leaders' Declaration on Forests, an ambitious commitment signed by over 100 countries to halt and reverse deforestation and land degradation by 2030. This initiative led to the launch of the Glasgow Leaders Declaration Dashboard, produced by WRI's Forests Declaration Assessment and Systems Change Lab. Also as part of COP26, the Global Forest Finance Pledge, a five-year, US$12-billion commitment, has already shown results, with 47% of the total pledged funding (US$5.7 billion) going to forest-related programmes in developing countries, according to its latest report for 2022. Similarly, in 2022 the 15th UN Convention on Biodiversity saw the adoption of the historic 30x30 Nature Target, which aims to protect at least 30% of the world's land and oceans by 2030.

Finally, several countries have announced major forest protection initiatives backed by significant financial commitments. For example, the Democratic Republic of Congo, Ghana, the Republic of Congo, and Papua New Guinea collectively secured US$242 million in funding from public, private, and civil society partners under the Forest and Climate Leaders' Partnership (FCLP). At COP26, Norway committed an additional US$100 million in results-based payments to Indonesia for reducing deforestation. The Norwegian Parliament also increased financial support for NICFI, which aims to protect tropical forests, to NOK 4 billion (US$375 million) in 2024.

> *"We feel this [regulatory] pressure and this data must be reliable, must be consistent and must be verifiable. So, if we don't have access to satellite data, it will be impossible for us to provide the information that is expected as part of the commitments that the various countries are making at international level."*
>
> **Carine Saturnine Milandou**, Republic of Congo representative, 2024

Barriers

Lack of technical expertise

— *Adopting satellite data systems demands major investment, local expertise development, and continuous technical updates, posing significant challenges.*

The adoption of satellite data systems requires significant initial investment and the development of local expertise, which can be costly and time consuming. The lack of readily available technical expertise in many areas adds further difficulties, making capacity building a critical but challenging undertaking. Furthermore, the rapid advancement of remote-sensing technology requires continuous system upgrades and training, which can be resource-intensive and may exceed the capabilities of regions with limited financial or technical support.[13]

Integrating EO into existing forest management frameworks

— *Integrating satellite remote sensing into forest management requires significant workflow adjustments and development of integration tools.*

The transition to EO technologies is not simply the adoption of new tools. It involves significant changes in established workflows and management practices. This transition requires changes to adapt to the different types of data and resolutions that remote sensing provides. In particular, the integration of the high-resolution data needed for detailed forest management at stand or tree level is a particular challenge.[14] The successful adoption of EO Information in forest management depends on the development and implementation of tools that can seamlessly integrate new satellite data with traditional field data. Without these tools and adjustments to strategic planning, the potential benefits of EO technologies in improving forest management and conservation efforts may not be fully realised.

13 WB, Satellite Monitoring for Forest Management, 2021, https://www.globallandscapesforum.org/wp-content/uploads/2021/05/GLF-Africa-2021-white-paper-Satellite-monitoring-for-forest-management.pdf; Fabian Ewald Fassnacht et al., 'Remote sensing in forestry: Current challenges, considerations and directions,' Forestry: An International Journal of Forest Research 97, no. 1 (January 2024): 11–37, https://doi.org/10.1093/forestry/cpad024

14 World Bank, Satellite Monitoring for Forest Management, 2021, https://www.globallandscapesforum.org/wp-content/uploads/2021/05/GLF-Africa-2021-white-paper-Satellite-monitoring-for-forest-management.pdf; Fabian Ewald Fassnacht et al., 'Remote sensing in forestry: Current challenges, considerations and directions,' Forestry: An International Journal of Forest Research 97, no. 1 (January 2024): 11–37, https://doi.org/10.1093/forestry/cpad024

Conclusions and recommendations

Conclusions and recommendations

The EO4SD-FM activity has made some progress in integrating EO technology into the forest management frameworks of IFIs and CSs. In particular, the activity has demonstrated its ability to improve forest management strategies through high-quality EO products that have been well received by stakeholders. As described in the section Evidence of impact from EO4SD-FM, feedback suggests that these products have directly contributed to improving the accuracy and effectiveness of forest management and conservation strategies.

A number of contextual factors are contributing to the increasing utilisation of EO, such as IFIs' increased initiatives and funding in this field. Indeed, EO technologies have become essential to support the environmental and social agendas of IFIs and governments. These tools are key to promoting transparency, accountability, and operational efficiency, highlighting the critical importance of the sector and the expected expansion of EO application and integration.

Three themes synthesise the opportunities to improve the adoption of EO for forest management: capacity building and skills development, stakeholder engagement and operational transparency, and regulatory compliance and global collaboration.

The following recommendations for increasing the adoption and integration of EO technology within forestry management practices globally are in line with these three themes.

Capacity building and skills development

- Design and implement training programmes that are closely aligned with the specific needs and conditions of the local environment, focusing on practical uses of EO Information in forest management
    - Organise workshops and field training sessions that provide hands-on experience with EO tools and data analysis to bridge the gap between theoretical knowledge and practical application.
- Offer ongoing learning opportunities and resources for professionals to keep pace with advancements in EO technology and applications in forest management.

Stakeholder involvement and operational transparency

- Actively involve local experts in the development and implementation of EO projects to ensure that the technology meets local needs and gains acceptance.
- Make methodologies, data sources, and analytical processes open and accessible to all stakeholders to build trust and encourage collaboration.

- Create and disseminate tools that facilitate the integration of EO Information with existing forest management systems, ensuring that they complement and enhance traditional methods.

Regulatory compliance and global collaboration

- Ensure that EO applications are developed in line with international environmental standards and best practices to facilitate global interoperability.
- Use the commitments of international climate agreements as a framework to support and expand the use of EO in forest management.

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